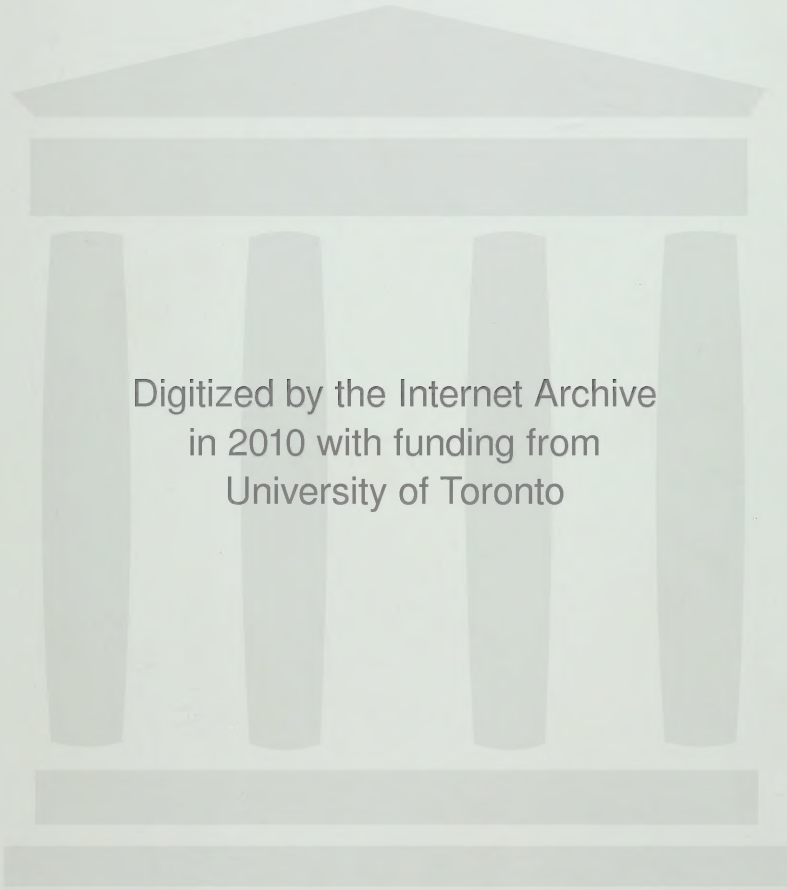


Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/iecindustrialeng10amer

457

The Journal of Industrial and Engineering Chemistry

PUBLISHED BY

The American Chemical Society

VOLUME X, 1918

15 15 42
12 | 8 | 19

Board of Editors

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD *Advertising Manager:* G. W. NOTT

Advisory Board

H. E. Barnard H. K. Benson F. K. Cameron B. C. Hesse
A. D. Little A. V. H. Mory

EASTON, PA.
ESCHENBACH PRINTING COMPANY
1918

TP
1
I13
v.10

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | JANUARY 1, 1918 | No. 1

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY, M. C. WHITAKER

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- The Chemical Service Section of the National Army... 2
- A Chemists' Club for France... 2
- The Chemical Alliance... 3
- Progress in Selective Service... 3
- Spruce Turpentine... 4
- A Regrettable Decision of the Directors... 4
- The Missing Five Thousand... 5

ORIGINAL PAPERS:
- Recovery of Potash from Greensand. H. W. Charlton. 6
- Toluol by Cracking Solvent Naphtha in the Presence of Blue Gas. Gustav Egloff... 8
- The Estimation of Phenol in the Presence of the Three Cresols. G. W. Knight, C. T. Lincoln, G. Formanek and H. L. Follett... 9
- The Determination of Manganese in Steel in the Presence of Chromium and Vanadium by Electrometric Titration. G. L. Kelley, M. G. Spencer, C. B. Illingworth and T. Gray... 19
- Reagents for Use in Gas Analysis. VI—The Absorption of Hydrogen by Sodium Oleate. R. P. Anderson and M. H. Katz... 23
- Reagents for Use in Gas Analysis. VII—The Determination of Benzene Vapor. R. P. Anderson... 25
- Research on the Detection of Added Water in Milk. Halsey Durand and Reston Stevenson... 26
- The Loganberry and the Acid Content of Its Juice. Milo Reason Daughters... 30
- Reaction of Hawaiian Soils with Calcium Bicarbonate Solutions, Its Relation to the Determination of Lime Requirements of Soils, and a Rapid Approximate Method for the Determination of Lime Requirements of Soils. Maxwell O. Johnson... 31
- Reverted Phosphate. Carlton C. James... 33
- Electric Furnace Smelting of Phosphate Rock and Use of the Cottrell Precipitator in Collecting the Volatilized Phosphoric Acid. J. N. Carothers... 35

LABORATORY AND PLANT:
- A Constant Temperature and Humidity Room for the Testing of Paper, Textiles, Etc. F. P. Veitch and E. O. Reed... 38
- A Method for Determining the Absorbency of Paper. E. O. Reed... 44
- The Use of Textile Fibers in Microscopic Qualitative Chemical Analysis. E. M. Chamot and H. I. Cole.. 48
- A Proximate Quantitative Method for the Determination of Rubidium and Caesium in Plant Ash. W. O. Robinson... 50
- A Quick Method for Lime Cake Analysis. Alfred N. Clark... 51

RECOVERY OF LIGHT OILS AND REFINING OF TOLUOL... 51

ADDRESSES:
- Chemical Microscopy. E. M. Chamot... 60
- The Bureau of Markets in Its Relation to the Conservation of Foods. Charles J. Brand... 66
- The Canning Industry—Some Accomplishments and Opportunities along Technical Lines. H. A. Baker. 69
- Edible Fats, in War and Law. David Wesson... 71

CURRENT INDUSTRIAL NEWS:
- Perfumery for Siam; Desulfuration of Hydrocarbons; Lampblack Manufacture; Boric Acid and Borax; Power from Refuse; Mineral Production in Canada; Copper Amalgam as Metal Cement; Jute Sacks for Argentina; Japan Peppermint Cultivation; Non-Inflammable Plastic Material; Electric Lamp Trade in Japan; Imitation Leather for Switzerland; New Magnesium Alloy; Electro-Steel Works in Germany; Fats and Oils; New British Dye; Water-proof Goods for South America; Japanese Glycerine; Water-proof and Dust-proof Fabrics; Recovery of Platinum Metals from Canadian Nickel; Gutta-Percha from the Shea Butter Tree; British Paper Exports; Low-Grade Ore Utilization; Swedish Industrial Developments; British Board of Trade... 73

SCIENTIFIC SOCIETIES:
- Decennial Index Patrons; Tenth Annual Meeting American Institute of Chemical Engineers, St. Louis, Mo., December 5–8, 1917; American Chemical Society Pin; The Nichols Medal Award; The Perkin Medal Award. 77

WASHINGTON LETTER... 80
PERSONAL NOTES... 81
INDUSTRIAL NOTES... 82
GOVERNMENT PUBLICATIONS... 84
BOOK REVIEWS... 88
NEW PUBLICATIONS... 89
MARKET REPORT... 90

EDITORIALS

THE CHEMICAL SERVICE SECTION OF THE NATIONAL ARMY

The importance of chemistry in the conduct of the war has received a gratifying endorsement from the War Department in the establishment of a new division attached to the General Staff and designated the Chemical Service Section of the National Army.

The two immediate purposes to be accomplished by the formation of this division are, *first*, the unification and more comprehensive development of the various research activities now being conducted for the War Department, and *second*, the creation of a chemical organization, complete in personnel and equipment, for service with the American Expeditionary Forces in France.

The most significant feature in the formation of this Section is the growing appreciation on the part of the heads of the departments of the Army of the value and necessity of chemistry in modern warfare. General Pershing has urgently requested that a chemical unit be organized and sent to France at the earliest possible moment to care for the emergency problems of vital importance which are constantly arising in the conduct of the war. Both the personnel and laboratory equipment of this force are being prepared upon the basis that the American armies in France have a right to the service of our ablest scientific minds and the most complete and adequate facilities for the work which it is possible for the United States Government to supply.

This chemical unit will serve as adviser to General Pershing on all chemical matters pertaining to the war, and will be attached to his staff through Colonel A. A. Fries, head of the Gas Warfare Division. It will also act as the chemical eyes of the unit in this country, transmitting information relative to chemical problems of the war to the men at work here. Able scientists throughout the country have responded eagerly to this call to national service. The unit will probably have sailed by the time this issue appears. The following have been recommended for commissions:

LIEUTENANT-COLONEL

Raymond F. Bacon

MAJORS

Gilbert N. Lewis — William A. Hamor

CAPTAINS

H. H. Hanson — J. H. Hildebrand
B. H. Nicolet — F. G. Keyes

FIRST LIEUTENANTS

A. R. Norton — L. H. Cretcher
L. V. Walker — P. R. Parmelee
J. K. Senior — W. L. Argo
T. D. Stewart

SECOND LIEUTENANTS

P. G. Woodward — J. W. MacNaugher
A. H. Hooker, Jr. — E. B. Peck
H. W. Nichols, Jr. — N. F. Hall
L. H. Ashe — R. B. Hall
G. S. Skinner — Allen Abrams
D. H. McMurtrie — C. B. Spofford, Jr.
J. J. Hast — A. R. Olsen

About twenty-five enlisted men, including some of the best of the younger chemists of the country, make up the remaining personnel as at present organized. The names of these enlisted men are not yet available; they will be published in a future issue. As the work develops, more men will be added so that the laboratory will be in position to solve quickly the many problems which the constant changes in the methods and munitions of the war introduce.

In order that the information collected by this force of scientific men may be of the greatest aid to the research work now being conducted in this country, Dr. William H. Walker, of the Massachusetts Institute of Technology, has been commissioned a Lieutenant-Colonel, and will have charge of the unification and coördination of many lines of research now being so ably carried on here. It is not expedient to discuss the activities of these research groups, but it is gratifying to know that real progress is being made in practically every field.

The organization of this Chemical Service Section will provide a means by which men drafted into the service, and having special research ability, may be enabled to serve the country as scientists in a way which will produce results of the very highest value.

A CHEMISTS' CLUB FOR FRANCE

The war has effected in France, as in this country, a remarkable stimulation of the chemical industries. This has reflected itself during the past year in the organization of a French Society of Chemical Industry. The strong bonds of a common endeavor in the struggle against the Teutonic menace has led many of our chemists to join gladly in the formation of an American section of that organization of French industrial chemists.

Another evidence of that same activity has just been received in the announcement of the organization of the Cercle de la Chimie, located at 54 rue de Turbigo, Paris, 3e.

The association is composed, to quote from its constitution, "de membres titulaires recrutés parmi les chimistes de carrière, les industriels, les négociants, les représentants de l'industrie chimique, les constructeurs et toutes les personnes s'intéressant au développement de la Chimie."

The Association has for its object, to quote again, "de permettre à tous ses adhérents de discuter en commun de leurs intérêts matériels et moraux et de

s'intéresser au développement de la science et de l'industrie chimiques françaises."

The *Revue des Produits Chimiques* will be the official organ of the Cercle de la Chimie. The club building will contain a reading room, a writing room, a lounge room, indeed all the conveniences and comforts of a modern club. Provision is made for the holding of scientific meetings, and extensive literature will be available.

To those of our chemists who will soon be in France and to that still larger number who will go as the American Expeditionary Forces increase, the prospect of visiting such a chemistry home will indeed be delightful. Opportunity will there be offered for meeting the distinguished chemists of France and for that fraternization among French and American chemists which so quickly and so naturally develops whenever representatives of the two countries meet. For our own part, we could desire no stronger attraction to such a spot nor need more certain guarantee of the genial atmosphere which will abound than is afforded by the presence of the name of Lieutenant René Engel in the list of the charter members of the Cercle. During the days of his connection with the French Mission in this country Lieutenant Engel won a warm place in the hearts of American chemists.

THE CHEMICAL ALLIANCE

One of the most interesting developments of the past month has been the resuscitation of the Chemical Alliance. This organization, formed at the suggestion of the Department of Commerce, was incorporated during the past summer. Its primary object was to assist in the clearing up of questions connected with the importation of pyrites, a situation so acute at that time. The Alliance, however, was not called upon for this particular service. As originally organized, it consisted of the chairmen of the sub-committees of the Committee on Chemicals, provision being made for associate members of allied groups. The officers were Wm. H. Nichols, *President*, Horace Bowker, *Vice-President*, and J. D. Cameron Bradley, *Secretary*.

With the gradual evolution of the war machine in Washington all of the semi-official committees, such as the Committee on Chemicals, have been discontinued. However, industrial advice is needed by the War Industries Board, so each group has been asked to organize a trade association, without any official government connection, to which that Board can turn for expert advice. To meet this situation the Chemical Alliance has been revived. Dr. Nichols having resigned the presidency of the original organization, a meeting was held recently at which the following officers were elected: Horace Bowker, *President*, Henry Howard, *Vice-President*, and J. D. Cameron Bradley, *Secretary* and *Treasurer*. These officers, together with A. H. Weed, Secretary of the Manufacturing Chemists' Association, are now engaged in drafting a constitution and by-laws for the new organization. For the present, the Board of Directors consists of the original members of the Committee on Chemicals. All manufacturers of chemicals are eligible for membership and it is confidently hoped that all such will become members at once. The members are to be classified in groups, and at a meeting to be held soon each of the groups will elect a director.

Such a representative organization of chemical manufacturers has within itself great potentialities for usefulness. It can act as a clearing house for priority matters, and its recommendations may form the basis of action by the War Industries Board, though accorded no recognition in the form of official approval. Furthermore, this close union in national service suggests the approach of a day of more coördinated effort in a rapidly expanding industry, a coördination which must be effected if the industry is to withstand squarely the shock of the intense competition which will assuredly have to be met in the days to come. Individual effort has been able to accomplish much under the unique conditions of a war period, but thoroughly coördinated and coöperative effort can alone safeguard the future.

PROGRESS IN SELECTIVE SERVICE

In so far as it applies to the wise utilization of chemists, some semblance of order seems to be arising out of the confusion incident to the immediate expansion of the military forces through both voluntary enlistment and the operation of the draft law. Many chemists have been transferred from the line to chemical service. In effecting these transfers splendid service has been rendered by Dr. Charles L. Parsons. In the next draft the new classifications issued by the Provost-Marshall, General Crowder, give assurance that the selective principle originally contemplated in the enactment of the legislation will be substituted for the lottery system which prevailed in the hurried and inexperienced application of the first draft. The regulations recently issued by the same officer remanding drafted engineering students to their universities for completion of their courses partly insures a reserve of better trained chemical engineers. The organization of the Chemical Service Section of the National Army furnishes an official medium for collecting the scattered chemical forces. Finally, we have been informed, though not directly, that the Secretary of War grasps clearly the importance of rôle the chemist must play in the great army we are preparing to send abroad.

The disintegration of the Russian forces along the Eastern front and the Italian reverses in the South have brought clear conviction to this Nation that we must prepare for a long war and on a great scale. With characteristic American pluck our people have accepted this situation, and with grim determination have set themselves to the task of contributing the maximum of men and means of which this country is capable.

If this conviction should prove correct, and no one to-day doubts it, every possible means should be resorted to for preserving the present inadequate supply of chemists and insuring full training of the younger men now preparing for the profession of chemistry.

To meet these two points we wish to urge upon the military authorities careful consideration of the following suggestions:

First—It will be unfortunate if a literal application of the term "chemical engineer" is made in applying the new ruling as to return of engineering students to their universities for completion of the course necessary to graduation. In many institutions the technical "chemical engineering" is not used to describe courses preëminently designed to supply chemists trained for such engineering work as the country needs. Moreover, chemists, just as much as, or even more than, chemical engineers, will be needed in the future for Government war work.

Second—For the training of these young chemists and chemical engineers, competent instruction is a prerequisite. The situation to-day is that many of the ablest professors in our universities have been detached from university work and are now engaged upon special lines of research for the government, while in the operation of the draft law, under the first call, no consideration seems to have been given to the question of exempting such instructors in chemistry departments as are best qualified to carry on the work of training the chemistry reserves.

Third—Many competent chemists are now in the Army, serving as commissioned officers in the line. The chemical ability of such men should be utilized before further inroads are made for Government chemical service upon the chemists now connected with industrial establishments or upon the instruction staffs of educational institutions. For most of these men no record exists in the census of chemists compiled by the Bureau of Mines and the American Chemical Society. The census, however, which is now being compiled in each camp or cantonment by the military authorities will doubtless contain the information which would make such men available.

Fourth—May we not hope that the War Department will issue some general order directing all commanding officers to facilitate the transfer of chemists, now serving in the line, to those branches of the service needing men for chemical work!

If these four steps could be taken immediately the future, in so far as it will be affected by chemists, could be viewed with far greater equanimity than is now the case.

SPRUCE TURPENTINE

From 1,500,000 to 2,000,000 gallons of "spruce turpentine" (sulfite turpentine) are going to waste annually in the mills of the United States and Canada using spruce pine for wood pulp. This oil is formed during the cooking of the chips in the sulfite digesters and escapes with the steam in the blowing out process. The term "turpentine," as applied to this material, is a misnomer, for it contains only traces of terpenes; the chief constituent, approximating ninety per cent., is cymene. Recovery of the crude product has been carried out in a few mills, but no market was developed sufficient to justify the expense of recovery. This material assumes at the present time a greater importance than hitherto accorded it because of its possibilities as a source of toluol.

Patents have recently been issued to R. H. McKee for a process in which the dried spruce turpentine is heated with aluminum chloride to about the boiling point of the turpentine. The products formed are toluol, propane and a small amount of tar. We are informed that there is a plant in Philadelphia carrying on this process, but so far only turpentine has been obtained to run about one day a week; the sulfite mills have been unwilling to take the trouble to collect and ship the turpentine.

Moore and Egloff (*Met. and Chem. Eng.*, Vol. 17 (1917), 66), studying the action of aluminum chloride on pure aromatic hydrocarbons, obtained a yield of 14.3 per cent of toluol from cymene.

Schorger (*J. Am. Chem. Soc.*, Vol. 39 (1917), 2671) studied the action of aluminum chloride on cymene under varying conditions of temperature, time, amount of reagent, etc. He mentions the interesting fact that B. T. Brooks, by removing the light, low-boiling reaction products as rapidly as they are formed, obtained forty per cent of toluol by treatment of cymene with seven per cent of aluminum chloride.

A still more interesting possibility is suggested by the work of Boedtke and Halse (*Bull. de la Soc. chim.*, Vol. 19 (1916), 444). By heating cymene, dissolved in ten times its weight of benzene, with aluminum chloride a true reversal of the Friedel-Crafts reaction was obtained. Ninety grams of cymene yielded forty-four grams of toluol and sixty-eight grams of cumene (eighty and eighty-five per cent, respectively of the theoretical yield).

If these results hold true on a commercial scale, a new source of toluol for munitions and dyestuffs is indicated. Furthermore, the ease of oxidation of cumene to benzoic acid suggests the release of the toluol which is now oxidized to benzoic acid.

It is unfortunate that Boedtke and Halse have included so few details of their investigation. The published results are so striking that they suggest the necessity of further work on this interesting reaction. Perhaps the mills have been throwing away material of far greater value than they supposed.

A REGRETTABLE DECISION OF THE DIRECTORS

At the Annual Meeting of the Directors on December 8th a report was presented by the Press and Publicity Committee of the Society urging an appropriation of $5,500 for the continuance of the work of that Committee during the year 1918. In the light of all of the estimates of expense presented to the Directors, the recommendation of the Committee was not approved; instead, a renewal of the present appropriation of $500 for this work was ordered, this amount to be used in sending to the press each month advanced copies of editorials in THIS JOURNAL which might be of public interest.

The press and publicity work during the past year has been carried on largely by a fund contributed by the New York Section from an available balance left from the contributions to the expenses of the General Meeting in New York City in 1916. This contribution was supplemented by $500 appropriated by the Society and by clerical help contributed by some members of the Committee without charge. The limited appropriation for the next year means therefore that the educational work carried on by the Committee through the newspapers of the country must be practically abandoned, the valuable connections of this service must be discontinued, and a well developed business representing a real asset of the Society must be discarded.

It is sincerely to be regretted that this important educational work of the Society must be discontinued. We sympathize fully with the critical and grave situation which the Directors faced in the preparation of the budget for 1918. The necessity of larger issues of the three Journals to supply the hoped-for increase in members made heavy inroads upon the estimated income; on the other hand, the uncertainties due to the war situation led to grave apprehensions as to what the actual income of the Society will be. This situation, nevertheless, should become clear by April 1st. If, then, the fears of decreased income have proved groundless and the hoped-for increase has materialized, we trust that the Directors will again take up this matter, having before them the full information as to the work of the Committee which can easily be placed at their disposal.

We live in a democracy, and under such conditions sure foundations can be laid only in broad educational work from the bottom upward. Our people through their newspapers should have opportunity to learn more of chemistry treated in a popular way, and should be brought into a more sympathetic relationship with American chemists through the record of their achievements. Such work is preëminently the function of the American Chemical Society, an organization which has no propaganda to promote other than the welfare of this country through increased appreciation of chemistry. It was largely for this reason that the newspapers of the country responded so sympathetically to the suggestions of the Committee that more and more of such material be carried in their columns. The great mass of clippings collected by the Committee furnishes ample proof of how wide-spread this response has been. The arbitrary reduction of the mailing list at one time to sixty papers was immediately followed by more than two hundred requests for continuance of the service. During the past year the work has been largely enhanced by the creation of similar committees in many local sections, whose work, in turn, has been coördinated with that of the general committee. This is too valuable a piece of machinery to be thrown away. The best means to ensure its continuance is a largely increased membership during 1918. In securing this increase each and every member of the Society can take part.

It is time to get busy!

THE MISSING FIVE THOUSAND

The great increase in the number of members of the American Chemical Society during the past year has been a source of deep satisfaction to all—not because of the natural American love of bigness, but from the conviction that when American chemists speak through the medium of this organization it is the voice of practically all chemists of the country.

Recently this feeling of satisfaction has had a rude jolt. Secretary Parsons' records show that on December 1, 1917, the membership of the Society reached the high total of 10,603. In the light of the figures that marked the very gradual growth during the years preceding the past decade the present number of members seems enormous, and it is so when compared with the membership of similar organizations in European countries.

The magnitude of the figures, however, is considerably dwarfed in the revelation made by the census of American chemists recently compiled by the Society and the U. S. Bureau of Mines in coöperation for purposes of possible war service. To the questionnaire sent out for that census a little more than 15,500 replies were received. This means that there are practically 5000 who stand ready to serve our country directly and individually in this period of war, yet have not felt disposed to serve it indirectly and collectively through the medium of the national organization of chemists. Why is this?

Can we be satisfied with reading the journals in the library of the university or the plant, conscious of the fact that these journals exist only as a result of the joint effort of fellow chemists? Is it because we take no interest in attending meetings of the Society? These meetings are of great help to all who attend, and spread the gospel of chemistry in every section where they are held. Moreover, the men who to-day are serving the country so loyally in the solution of immediate war questions are the very men who are most frequently seen at the meetings. Indeed, Washington to-day looks like an adjourned meeting of the American Chemical Society. Do we feel that we cannot afford the expense of the ten dollars a year dues? If so, let us watch carefully our expenditures along the lines of purely self-interest and see if the required sacrifice is indeed too great. Are we waiting to be asked to join? That is not necessary, for the doors are wide open to all reputable chemists. Has it simply not occurred to us to join?

To call attention to the opportunity before us is one of the purposes of this editorial. Whatever the explanation, the New Year is just upon us. Good resolutions can quickly be turned into deeds. Coöperation is in the air everywhere. The closer union of the Allies so recently and so gladly acclaimed as the forerunner of more efficient action against a common enemy [illegible] as an example of that desirable union of [illegible] which must prevail if we are to win the fight for the welfare of our country through the science which we represent.

ORIGINAL PAPERS

RECOVERY OF POTASH FROM GREENSAND[1]

By H. W. Charlton

In the original process as developed the material adopted was feldspar, but it was later found that glauconite, commonly called greensand, in many respects possesses marked advantages, although carrying a smaller percentage of potash. It exists in almost unlimited quantities in the Eastern states, particularly in New Jersey, and, unlike feldspar, requires neither blasting nor crushing.

It is an accepted fact that any commercially successful process of liberating potash in rocks, etc., must include a method of profitably employing the residue. In this case a building material is produced and has the advantages of an unlimited market, as well as being a superior product capable of being manufactured at a remarkably reasonable figure.

The method consists in digesting under pressure finely ground greensand with lime and water, thereby obtaining caustic potash of remarkable purity and at the same time converting the residue into a material of value.

The reaction is carried out in large digesters or autoclaves, heated by introducing into the charge high-pressure steam in sufficient quantity to maintain the desired pressure of about 225 lbs. for a period of from 2 to 4 hrs. To conserve the heat, at the completion of each digestion the steam is allowed to escape and be condensed in the greensand-lime-water mixture next to be treated, and the contents of the autoclave, which should have a cream-like appearance, is filtered to separate the dissolved caustic potash from the insoluble residue.

With sufficient lagging the unavoidable heat losses are very moderate, especially as the chemical action requires but little, if any, beyond the heat necessary to raise the temperature of the mass to the reaction point. For this reason the efficiency is largely dependent upon the thoroughness of the heat insulation.

On filtering, the potash appears in the filtrate as potassium hydrate associated with so few impurities that on concentration it may be sold as a high-grade product without further treatment.

Following is an analysis:

	Per cent
K_2O	77.2
SO_3	0.90
Cl_2	0.35
SiO_2	0.70
Al_2O_3	Free

From the origin of glauconite it would naturally be supposed that the percentage of impurities would be higher and the variety greater than is found to be the case. According to standard works on mineralogy, it is a hydrous potassium iron silicate, but this conclusion was probably based on the simple analytical figures, and there are very strong recent data to show that this is not its true composition. As greensand is at the present time being carefully investigated, it will very probably be shown to be a potassium iron compound enveloping free silica, but not a silicate. That it is of marine origin is undoubted, and its rich green color is probably due largely, if not entirely, to organic matter with which it is chemically combined.

The solid remaining on the filter, which is the insoluble portion resulting from the digestion, is employed in the manufacture of steam-hardened brick, tile, artificial stone, etc. It acts as a binding or cementing material and is incorporated with high silica sand, as is customary in the manufacture of steam-hardened products, but differs fundamentally in that, whereas lime has always previously been employed as a binding agent, in this case a pre-formed self-cementing hydrous silicate performs this function.

In the past, steam-hardened brick, commonly known as Sand Lime Brick, have not been the success predicted. They are not able to stand the weather without more or less crumbling, and the edges and corners are seldom perfect even in the freshly made brick. This is due primarily to the fact that all the binding power depends on the interaction of lime and sand during steaming, with the resulting formation of a surface coating of calcium silicate which binds the sand particles. If any one of the many factors governing this reaction are overlooked, the brick is faulty. Imperfect slaking of the lime, improper mixing, imperfect steaming, a deficiency or excess of moisture, or dull cornered sand, would each be sufficient in themselves to ruin the product. In fact, every detail has to be rigidly observed and little leeway is permissible.

It is also found that the adhesion between the sand and lime in the pressed but unsteamed brick is slight in every case and that these "green brick" crumble unless handled with the greatest care.

When employing the digestion solids as cementing material these troubles are largely overcome. The pre-formed cementing properties insure an unfailing bond in addition to any chemical action that may take place between the hydrous silicate and the sand during steaming. Any type, such as bank, sea or loamy sand is permissible. Ordinary ground rock will serve the purpose. One of the most convincing proofs of the self-cementing properties of the digestion material is its ability to bond ground limestone, with which there could not be any chemical action.

Sand and the cementing material may be mixed in widely varying proportions ranging from 98 and 2 to 40 and 60. In fact, it is almost true that the process is "fool-proof."

The chemical composition of the autoclave residue depends, of course, on the material treated. With feldspar it is probably a complex calcium aluminum silicate, and with greensand a calcium iron silicate. In both cases it possesses remarkable properties, being to a degree self-cementing but capable of acting,

[1] Presented at the 55th Meeting of the American Chemical Society, Boston, Mass., September 13, 1917.

when subjected to steam pressure, as a powerful binding agent, cementing sand so firmly that small enclosed quartz pebbles fracture before the bond gives way.

The cementing material resulting from the digestion of feldspar is superior to that from greensand, although the latter possesses sufficient cementing power to meet the most rigid requirements and produces a brick of a pleasing light green shade at a greatly reduced cost.

The feldspar brick are of a marble-like creamy whiteness, entirely devoid of a lifeless milky tint, and have surfaces so smooth that at a distance of a hundred feet they cannot be distinguished from marble.

If colored brick are desired, inorganic pigments may be mixed with the binding material, and if an ochre color is to be produced the coloring matter may be obtained as a by-product in the general process. It is necessary to calcine only a portion of the greensand-lime digestion product, under which treatment it becomes a rich ochre, and add it to either the feldspar or greensand cementing material.

The properties of these brick are best illustrated by tests on samples chosen from the general run by an inspector from the Building Department of New York City. The actual tests were carried out at Columbia University and Pittsburgh Testing Laboratory.

	Feldspar Brick	Required Standard
Crushing Strength, lbs. per sq. in.	9267	2000
Modulus of Rupture, lbs. per sq. in.	1060	450
Average Absorption	4.44 per cent	Under 15 per cent

The low absorption may be explained partially at least by the voluminous, easily compressible, water-repellent nature of the bonding material. On being mixed with sand and subjected to the usual high pressure in brick presses it oozes in and completely fills all the interstices between the grains of sand.

Another feature, and in some respects perhaps the most important, is the plastic nature of the binding material which adds a toughness to the brick after compressing and before steaming. This makes possible the handling of the "green brick" without breaking off the corners.

While brick is referred to particularly, it is not intended to convey the impression that this is the only marketable product. The particular advantage of brick is the immense market.

In investigating the various factors governing the yield of potash it was found that a high pressure and a large excess of water were absolutely essential. In treating feldspar it is necessary to use eight times its weight of water, and ten is a fair amount. This necessitated a great deal of evaporation, materially reducing the capacity of the plant and requiring a large outlay for initial heating.

After a series of experiments it was determined by a process of elimination that the alumina was the cause of the trouble, and this naturally could not be removed in the case of feldspar, $K_2O.Al_2O_3.6SiO_2$, as it is an essential element in its composition. The only remedy consisted in the adoption of an alumina-free material, or one in which this element was partially or wholly replaced by a non-injurious one.

Greensand appeared very suitable and was tried. Although its true composition is in doubt, the results in this case were surprisingly satisfactory. It was found that the concentration could be doubled or in fact the water could be reduced to a point where it was just possible to agitate the mixture.

A difficulty that has been met in every process of recovering potash from feldspar is the invariable liberation of soda at the same time. This is always difficult and expensive to separate, and especially so where both alkalies are liberated as hydrates. Theoretically potash feldspar is soda-free, but in practice it invariably contains from 2 to 3 per cent.

Greensand is almost soda-free, which is all the more remarkable from the fact that it is of marine origin, being formed on the ocean bed by the selective absorption of potash from sea water by precipitated colloidal silica and ferric hydroxide.

Another difficulty encountered in applying this process to feldspar is the invariable presence of alumina in the digestion liquors. Efforts to entirely overcome this by adding more lime while reducing the amount do not in any case remove it entirely. In the greensand-lime digestions there is not a trace. This is surprising from the fact that the analysis of greensand always shows a little alumina present probably in adhering clayey matter. It must be present in some combination that this process does not break up. This is extremely fortunate.

Another important feature in the process is the employment of a high temperature and pressure in the digestion. The reactions are not only speeded up, as might be surmised, but are different. This is partially due at least to the production of a chemically active sub-hydrate of lime approximating the formula $CaO.CaO.H_2O$, which is formed at pressures of 200 lbs. and over.

That $CaO.H_2O$ should be partially dehydrated during digestion in a large excess of water, such as an amount equal to ten times the weight of the lime, appears to be paradoxical, but such is the case; and it supplies a plausible explanation of the increased activity of the lime in decomposing the feldspar at pressures above 200 lbs. and corresponding temperatures. It is found that the digestion of feldspar with lime at 150 lbs. pressure for any reasonable length of time scarcely liberates any potash, but above 200 lbs. pressure the reaction is rapid.

Greensand, on the other hand, is less refractory and may be liberated at lower pressures, but it is not advisable to employ them, as the yield is uncertain and the insoluble residue unsatisfactory.

Considered from an economic standpoint, it is believed that it is quite feasible to adapt this process to either greensand or feldspar and, in conjunction with the production of a marketable by-product, to

operate at a profit when selling the potash at pre-war prices. With feldspar, owing to the invariable presence of soda, the mixed hydrate required to be carbonated to effect a separation. The potash is then sold as hydrated carbonate. Carbonating is not necessary in the case of greensand as high-grade caustic potash is obtained in one operation. If potassium chloride is desired it is necessary only to modify the digestion by adding calcium chloride to the original mixture.

It is found in the case of feldspar that the percentage potash content does not give reliable data as to the possible yield, this being dependent on unknown factors pertaining to each individual deposit. Often feldspars that are valueless in pottery manufacture, being weathered and mixed with mica, give the highest yield, in some cases up to 90 per cent, while some very high-grade samples yield as low as 30 per cent.

Greensand contains usually from 6 to 7 per cent K_2O and it may be almost completely recovered, but it is found that 70 to 80 per cent of the total potash is a satisfactory yield after considering such factors as dilution, time of digestion, etc. This means the production of about 100 lbs. of K_2O, and binder material for from twenty to thirty thousand brick from each ton of greensand.

If artificial stone, building blocks, roof, floor or drain tile are manufactured, the resulting amount will vary with the composition and weight of the products. If desired, the digestion material without admixture with sand may be molded in its plastic condition, dried and employed as insulating fire-proof blocks. On the other hand, it is believed that brick have the most extensive market. The fact that the greensand beds are usually overlaid with a high silica sand lessens the cost of manufacture. The overburden, which has to be removed in any case, supplies the necessary sand.

The initial experiments and the commercial development of the process have been made possible by the scientific interest exhibited in the undertaking by Mr. Richmond Levering, who has, himself, borne the great expense entailed in its development.

KALOLIN PRODUCTS CORPORATION
120 BROADWAY, NEW YORK

TOLUOL BY CRACKING SOLVENT NAPHTHA IN THE PRESENCE OF BLUE GAS

BY GUSTAV EGLOFF

RECEIVED NOVEMBER 20, 1917

All past estimates of the gallonage of toluol which would be required in this war have been far too low. May not the present estimate of Brigadier-General Crozier of 22,000,000 gallons of toluol required by September, 1918, also be far too low for our war needs?

The cry is toluol, more toluol and more toluol!

One of the fruitful fields for increasing our toluol yield is by stripping carbureted water gas,[1] coal gas and oil gas, by means of suitable scrubbing towers for their toluol content. But, to pass the sorely needed legislation, to change from a candle power to a heat standard will take time, unless the War Department, as a military necessity, commandeers or orders the erection of gas scrubbers in every commercial sized gas plant in this country. But it will take time to build scrubbers for the various gas plants. To quickly add 2,000,000 gallons of toluol to our supply, it is proposed in this communication to suggest the use of water-gas machines to crack solvent naphtha and produce toluol in the presence of blue gas.

It is calculated that there will be produced in the year 1917, 15,000,000 gallons of solvent naphtha from which, in round numbers, 2,000,000 gallons of toluol can be made by cracking solvent naphtha in carbureted water-gas machines. A more than sufficient number of carbureted water-gas machines are already installed throughout the country to more than take care of the cracking of 15,000,000 gallons of solvent naphtha from which 2,000,000 gallons of toluol can be quickly made.

SOLVENT NAPHTHA USED

The solvent naphtha used in the following experiment was derived from the thermal decomposition of coal and analyzed, using a standard Engler flask for distillation and the Westphal balance for specific gravity.

DISTILLATION ANALYSIS

Specific Gravity 0.867/15.5° C.

Temp. ° C.	Per cent by Vol.
135.5	1st drop
140.0	49.1
150.0	87.0
160.0	91.5
170.0	96.3
180.0	98.5
185.5	Dry point

CRACKING TEST

The following test of cracking solvent naphtha was conducted upon a Lowe 6′ carbureted water-gas set, over a period of 48 hrs. The operation of the plant in cracking solvent naphtha in the presence of blue gas for toluol is practically the same as when cracking gas oil in ordinary carbureted water-gas making, with the exception that the gallonage per hour of solvent naphtha into the cracking zone is higher. The data upon a 24-hr. basis averaged as follows for a carbureted water-gas set:

Make per 6-ft. set per day of gas formed	[illegible] cu. ft.
Candle power of the gas	[illegible] at 21° C.
Candle power of gas per gallon of oil	1.75 at 21° C.
Solvent naphtha cracked per 1,000 cu. ft. of gas formed	12.[illegible] gal.
Gas per gallon of solvent naphtha cracked	85 [illegible] ft.
Coke used per 1,000 cu. ft. gas	[illegible] lbs.
Steam used per 1,000 cu. ft. gas	[illegible] lbs.
Temperature of superheater [illegible]	[illegible]° C.
Temperature of condenser outlet	[illegible]° C.
Length of run	4 days
Length of blow	3 min.
Rate per hour solvent naphtha	250 gal.
Rate actual flow of solvent naphtha into system	[illegible] gal.
Total allowance of solvent naphtha passing through set in 24 hr. day	6,000 gal.
Light oil collected in drips and seals	[illegible] per cent
Per means loader	15 per cent

ANALYSIS OF LIGHT OIL

The light oil was distilled in a one-barrel still with steam to a temperature of 175° C. This cut was

[1] This Journal, 9 (1917), 1067.

[2] *Met. and Chem. Eng.*, 16 (1917), 12; Moore and Egloff, 17 (1917), 297.

analyzed by a method[1] already devised for the benzene, toluol and solvent naphtha content.

The analysis showed on the basis of light oil recovered from the cracking of solvent naphtha the following percentages of aromatic hydrocarbons:

	Per cent
Refined Benzol	14.5
Refined Toluol	23.7
Refined Solvent Naphtha	19.8
Crude Heavy Naphtha	9.7
Dead Oil	14.0

On the basis of 100 gallons of solvent naphtha cracked the following percentage of aromatics can be recovered:

	Per cent
Refined Benzol	8.3
Refined Toluol	13.6
Refined Solvent Naphtha	11.2
Crude Heavy Naphtha	5.5
Dead Oil	8.0

In these critical times, with a high scarcity of toluol, no quicker method lends itself to adding to our toluol supply than the cracking of solvent naphtha in carbureted water-gas machines. This being due to the fact that there is more than a sufficient number of carbureted water-gas machines already in operation, which could be used at once without any change for the adding of 2,000,000 gallons of toluol to our much needed supply.

THE ESTIMATION OF PHENOL IN THE PRESENCE OF THE THREE CRESOLS[2]

By G. W. Knight, C. T. Lincoln, G. Formanek and H. L. Follett

Received July 30, 1917

Of the many methods proposed for the estimation of phenol in the presence of the three cresols, only those based on the determination of physical constants of mixtures of these substances would have much practical value in the analysis of coal-tar distillates, for the reason that small amounts of xylenols and other impurities that are apt to be present in the final distillate would seriously affect the accuracy of any of the chemical methods.

Many methods of proximate analysis have been based on the determination of physical constants such as the specific gravity, index of refraction, solidifying point, optical rotation, etc., of the substance to be analyzed or a part of it that has been purified as much as possible. In the case of the determination of phenol in the presence of the cresols, advantage can be taken of variations in the solidifying points and specific gravities of the various constituents to determine the phenol.

Part of the problem of working out along these lines a really accurate method for the determination of phenol in the presence of the cresols was accomplished by Lowe,[3] and also by Weiss.[4] Very recently, Masse and Leroux[5] and Weiss and Downs[6] have investigated the problem further and have published methods in which they make use of the specific gravities and solidifying points or solidifying points alone obtained by them for certain mixtures of phenol and cresols.

The principal difficulty in working out a reliable and satisfactory method for the determination of phenol in the presence of cresols in coal-tar products lies in the fact that in coal-tar distillates there is no constant relation between the amounts present of any of the cresols, *i. e.*, any of the three cresols may be present in any amount varying over a very large range, and this is more particularly true now since *m*-cresol is being removed in some cases for making trinitrocresol. Attention has been called to this fact in the literature by Lunge,[1] Ihle,[2] Tiemann and Schotten,[3] Wegen,[4] Schulze[5] and even Weiss and Downs.[6] Nevertheless, the methods of Weiss and Downs and Masse and Leroux have been partly based on the arbitrary assumption that *m*-cresol and *p*-cresol occur in certain fixed proportions to each other in coal-tar distillates or crude tar acids. Weiss and Downs assumed this proportion to be 50 per cent of *m*- to 50 per cent of *p*-, and Masse and Leroux 60 per cent of *m*- to 40 per cent of *p*-cresol. Consequently, when the interproportion of *m*- to *p*-cresol present in the final distillate upon which the constants are determined is different from that upon which their methods are based, a condition very frequently met with in actual practice, the results obtained by the use of either of these methods are apt to be unreliable.

The following investigation was carried on in the hope of developing a method along similar lines that would eliminate this and other weaknesses in these methods, be capable of wider application, give more concordant results and be as short and concise as accuracy would permit.

EXPERIMENTAL

In order to accomplish this end it was necessary to obtain phenol, *o*-cresol, *p*-cresol and *m*-cresol in as pure a condition as possible and to work with as many samples from different sources as possible in order to study the effect produced by slight amounts of impurities on the constants of the different mixtures.

Various samples of the purest phenol obtainable were procured from different commercial sources. A large number of samples of the purest *o*-cresol made commercially was obtained from American sources and also from England. Most of the samples of phenol were synthetic, while the *o*-cresol was all obtained directly from coal tar. Some of the *m*-cresol used in the investigation was synthesized in this laboratory by the method of Staedel and Kolb,[7] while some was of coal-tar origin obtained from commercial sources. Likewise some of the *p*-cresol used was

[1] Egloff, *Met. & Chem. Eng.*, **16** (1917), 259.

[2] Contributed with the permission of the Secretary of the Treasury and the U. S. Appraiser, Port of New York.

[3] Lunge, "Coal Tar and Ammonia," 5th Ed., **1916**, 784.

[4] *J. Franklin Inst.*, **1912**, 683.

[5] *Compt. rend.*, **165** (1916), 361–3.

[6] This Journal, **9** (1917), 569.

[1] "Coal Tar and Ammonia," 5th Ed., **1916**, 784.

[2] *J. prakt. Chem.*, [2], **14** (1876), 442.

[3] *Ber.*, **11** (1878), 767.

[4] *Z. angew. Chem.*, **1909**, p. 391.

[5] *Ber.*, **20** (1887), 409.

[6] *Loc. cit.*

[7] *Ann.*, **259** (1890), 209.

synthesized in the laboratory by the method of Erdmann,[1] while the rest was bought from commercial houses, as having been obtained directly from coal tar. The specific gravities and solidifying points of these substances were determined by the methods and apparatus described later on. The various samples of phenol had solidifying points of from 40.4 to 40.7° C. and specific gravities of from 1.0640 to 1.0647 at 45° C./45° C. Those of *o*-cresol varied in solidifying point from 28.8 to 30.2° C. and in specific gravity (25° C./25° C.) from 1.0439 to 1.0451. The *p*-cresols varied in solidifying point from 31.9 to 34.4° C. and in specific gravity (25° C./25° C.) from 1.0334 to 1.0335, while the *m*-cresols varied from —3.3 to +3.0° C. in solidifying point and from 1.0248 to 1.0333 in specific gravity (25° C./25° C.). Of the various samples the following were selected as being either the purest or else freest from slight impurities that might introduce serious errors:

	Specific Gravity	Solidifying Point
Phenol	1.0647 at 45° C./45° C.	40.6° C.
o-Cresol	1.0439 at 25° C./25° C.	29.0° C.
p-Cresol	1.0335 at 25° C./25° C.	34.4° C.
m-Cresol	1.0333 at 25° C./25° C.	3.0° C.

These samples were selected after a considerable amount of preliminary work with mixtures of the various substances to determine the impurity present, if any, in each one. They represent as a rule those having the highest solidifying points, although this is not the case with the *o*-cresol. Another *o*-cresol sample had a solidifying point of 30.2° C. but was not selected because it appeared to contain 2 or 3 per cent of phenol.

The constants obtained by using these samples in making up the necessary mixtures were used in the final plotting of lines and calculation of formulae, while those obtained by the use of the other less pure samples were used for comparison and to study the effect of varying amounts of the different impurities.

The following mixtures of the pure substances mentioned above were made up and the constants of the mixtures determined and plotted on cross-section paper. Most of the constants obtained were checked by two or more chemists working independently in order to eliminate errors due to personal equation.

Mixtures of the *o*-cresol and the *p*-cresol were made containing varying quantities of *o*-cresol from 95 to 70 per cent by weight and *p*-cresol from 5 to 30 per cent by weight and the solidifying points and the specific gravities at 25° C./25° C. of these mixtures were obtained, using all precautions to have the data as accurate as possible. The values obtained were plotted using the specific gravities as abscissae and the solidifying points as ordinates. Other mixtures were made using varying proportions of *o*-cresol from 90 to 70 per cent by weight, *p*-cresol from 5 to 25 per cent by weight and phenol 5 per cent by weight in each mixture. Similar mixtures containing decreasingly proportionate amounts of *o*-cresol and *p*-cresol and increasing proportions of phenol in terms of increments of 5 per cent were made up, the constants determined and the values plotted as before. The results are shown in Fig. I.

[1] *Ann. Chem. Pharm.*, 272, 133; *J. Chem. Soc. Abs.*, 1892, 1294; *Ber. d. chem. Ges.*, 25, 2194; *J. Chem. Soc. Abs.*, 1892, 1294; *Anleitung z. Darst. Org. Präp.*, 1894.

This process was repeated using the *m*-cresol in place of the *p*-cresol. The line representing mixtures of the *o*-cresol and the *m*-cresol and no phenol is shown in Fig. I, the lines representing those mixtures containing the increments of phenol being omitted to avoid confusion. Similar mixtures were made up using the other less pure samples of the different cresols and the constants determined and plotted. These results, being used only for comparison, were not plotted.

It was found that the tangent of the angle formed by the line representing mixtures of the purest *o*-cresol and the purest *p*-cresol and no phenol and a line drawn through the point representing 100 per cent *o*-cresol parallel to the axis (X = 0) is numerically equal to 0.13. It was also found that the tangent of the angle formed by the *o*-cresol + *m*-cresol line in Fig. I and a line drawn through the point representing 100 per cent *o*-cresol parallel to the axis (X = 0) is equal to 0.22. These angles are represented in Fig. I as "α *o.p.*" and "α *o.m.*," respectively. Calculated from this data the tangent of the angle formed by a line representing mixtures of *o*-cresol and a distillate composed of 50 per cent *m*- and 50 per cent *p*-cresol would be 0.175. The similar tangent calculated from the data obtained by Weiss and Downs for mixtures containing the same percentages of *o*-cresol and a coal-tar distillate containing 50 per cent *p*- and 50 per cent *m*-cresol using a line drawn through the maximum number of nearest points obtained by them was found to be 0.181, a very close agreement with the above, notwithstanding the fact that the constants themselves were very different.

With the other less pure samples various lines were obtained depending on the purity of the *o*-cresol, *p*-cresol or *m*-cresol used—the position of the line indicating the impurity present.

As may be seen by referring to Fig. I, lines drawn through the points represented by mixtures containing no phenol, 5 per cent phenol, 10 per cent phenol, etc., up to 30 per cent phenol, within the limits of the plot, are parallel in the case of *p*-cresol. This is also true of *m*-cresol and mixtures of *m*- and *p*-cresol in varying proportions. The general equation for the pure *o*-cresol + *p*-cresol lines, with or without phenol, as may be seen by inspection, is

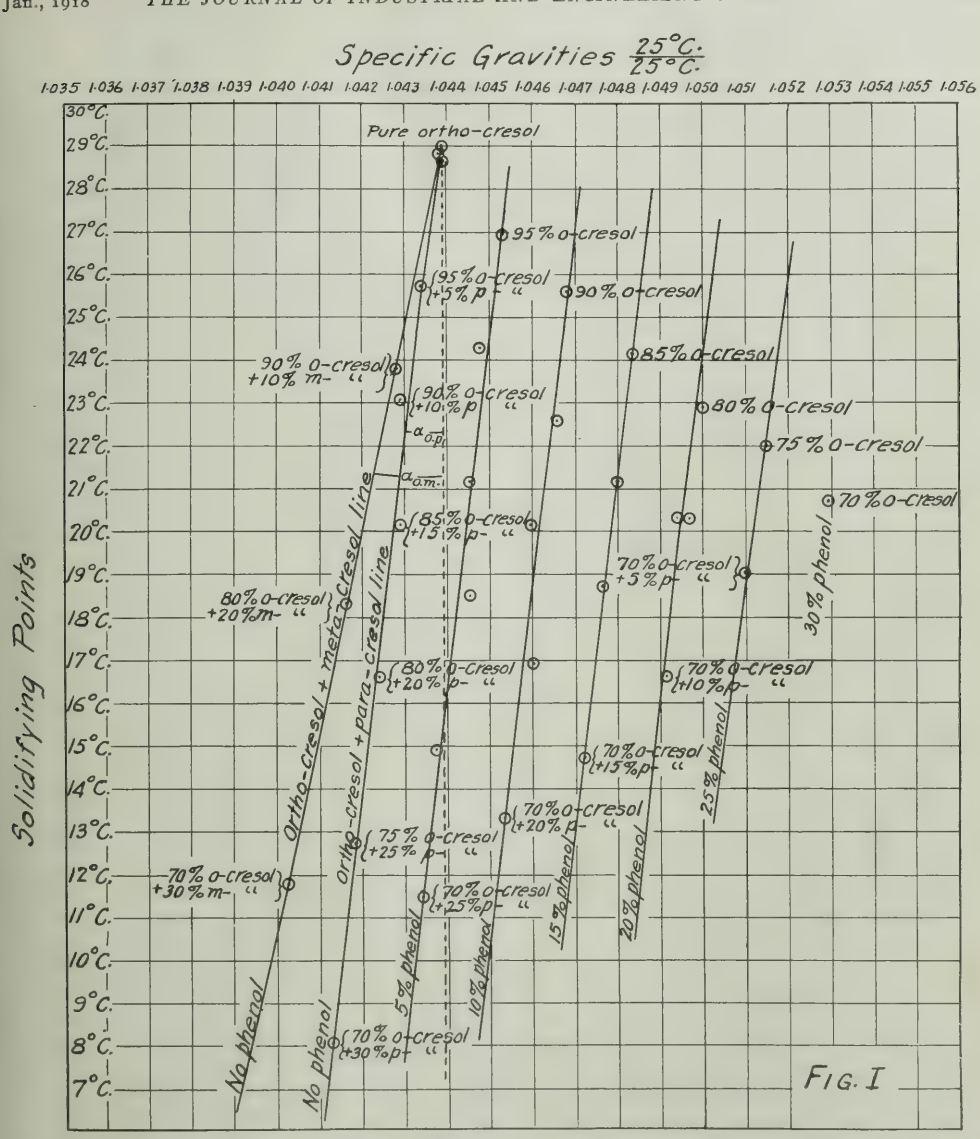
$$1000\,(G_o - G_p) - 0.130\,(T_o - T_p) = 0.$$

That for the pure *o*-cresol + *m*-cresol lines, with or without phenol, is

$$1000\,(G_o - G_m) - 0.218\,(T_o - T_m) = 0,$$

where G_o = sp. gr. 25° C./25° C. of the *o*-cresol,
G_p = sp. gr. 25° C./25° C. of the *p*-cresol,
G_m = sp. gr. 25° C./25° C. of the *m*-cresol,
T_o = solidifying point of the *o*-cresol,
T_p = solidifying point of the *p*-cresol,
and T_m = solidifying point of the *m*-cresol.

These lines, in addition to being parallel, are also equi-distant for equal increments of phenol, both in the case of *p*-cresol mixtures and *m*-cresol mixtures, although for the same increments the distances between the lines are greater in the case of *m*-cresol than in the



case of *p*-cresol. In other words, with mixtures of *o*-cresol, *p*-cresol and phenol containing more than 70 per cent of *o*-cresol and less than 30 per cent phenol, and of the same solidifying point, the per cent of phenol varies directly with the specific gravity. The same rule holds true with mixtures of *o*-cresol, *m*-cresol and phenol and mixtures of *o*-cresol, phenol and varying proportions of *m*-cresol and *p*-cresol within the same limits. In the case of mixtures of *p*-cresol, *o*-cresol and phenol, the solidifying point remaining the same, it was found that each per cent of phenol increased the specific gravity 0.0003367; in that of mixtures of *m*-cresol, *o*-cresol and phenol, 0.0003600. in that of mixtures of *p*-cresol, *m*-cresol, *o*-cresol and phenol proportionately intermediate values depending on the ratio of *p*-cresol to *m*-cresol.

Similarly it was found that, the specific gravity remaining constant, each per cent of phenol depressed the solidifying point 2.75° C. in case of the *p*-cresol mixtures, and 1.71° C. in that of the *m*-cresol mixtures.

These facts enable us to formulate an equation which will give the percentage of phenol without

having recourse to a plot in cases where (1) *o*-cresol, *p*-cresol and phenol, or (2) *o*-cresol, *m*-cresol and phenol are present in the mixtures, and 30 per cent of the mixture has been mixed with 70 per cent of pure *o*-cresol.

$$\text{Per cent phenol} = \frac{1.00}{2.78}(T_o - T_{30}) - \frac{1.00}{0.0003367}(G_o - G_{30}) \quad \text{(I)}$$

or,

$$\text{Per cent phenol} = 0.366\,(T_o - T_{30})$$

$$\text{Per cent phenol} = 0.585(T_o - T_{30}) - \frac{1}{2780}(G_o - G_{30}) \quad \text{(II)}$$

where T_o = solidifying point of the pure *o*-cresol used,

T_{30} = solidifying point of mixture of 70 per cent of *o*-cresol + 30 per cent of substance,

G_{30} = specific gravity 25° C./25° C. of mixture of 70 per cent of *o*-cresol + 30 per cent of substance,

G_o = specific gravity 25° C./25° C. of the pure *o*-cresol used.

Since in the analysis of commercial products, as has been said before, the proportion of *m*- to *p*-cresol may vary over very wide limits, it is necessary to have some means of obtaining a measure of the amount of *m*- or *p*-cresol present in the portion of distillate used for determining the constants.

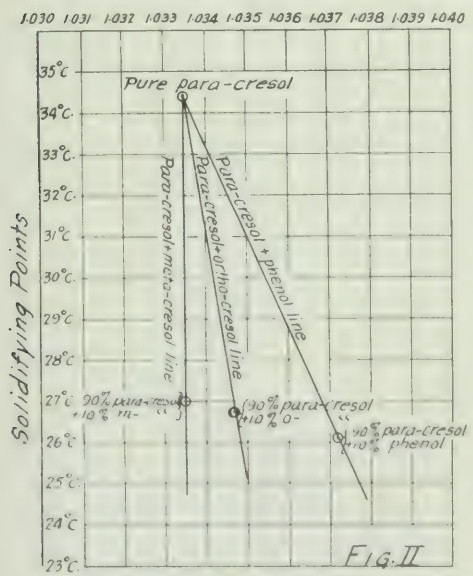


FIG. II

In the hope of finding such a means, mixtures of 90 per cent of pure *p*-cresol with 10 per cent of phenol and also with 10 per cent of *o*-cresol, and 70 per cent of *m*-cresol, were made up separately, and the constants determined and plotted. The results are shown in Fig. II. As a study of the plot failed to throw any light on the problem, this particular line of investigation was abandoned.

The effect of varying amounts of the different cresols on the constants of pure phenol was studied by making mixtures containing 90 to 70 per cent of the purest phenol and 10 to 30 per cent of the purest *o*-cresol and similar mixtures containing the same percentages of the purest *p*-cresol and the purest *m*-cresol separately in place of the *o*-cresol, determining the constants for each mixture and plotting the points representing them. The terminal points and the three lines drawn through the nearest points representing the three classes of mixtures are shown graphically in Fig. III as "Phenol + *m*-cresol line," "Phenol + *o*-cresol line" and "Phenol + *p*-cresol line."

The effect of using the slightly impure cresols was also studied to determine the effect of the small amounts of impurities present on the constants of the different mixtures. The results clearly indicated the impurities present in the same way as was the case with the mixtures of the different slightly impure substances with 70 per cent or more of the different *o*-cresols.

A study of the results obtained with the pure samples revealed the following facts:

The effect of the addition of each of the cresols on the solidifying point of phenol is widely different as may be seen by referring to Fig. III. Each per cent of *o*-cresol added, within the limits of the plot, depresses the solidifying point of the phenol about 0.65° C., each per cent of *m*-cresol depresses it about 0.55° C., and each per cent of *p*-cresol about 0.83° C. Obviously, under such circumstances it would be folly to attempt to determine the per cent of phenol in a mixture of the cresols by determining either the solidifying point alone or the solidifying point and specific gravity of a mixture of phenol and cresols containing 70 per cent or more of phenol unless the relative proportions of each cresol present in the mixture were known at least approximately. Meta-cresol can be determined by the Raschig method.[1] A number of distillates were analyzed by this method after first being purified and fractionally distilled. As the percentage of *m*-cresol found by this method varied over very wide limits and there seemed to be no connection between the distillation point and the amount of *m*-cresol found and as no way was devised for determining the relative proportions of *o*- and *p*-cresol present it was decided that this line of attack would be unproductive of results.

Further study of the results obtained on the mixtures of phenol and the separate cresols containing more than 70 per cent of phenol showed that the effect of the addition of the different cresols on the specific gravity of the phenol is also different in each case as may be seen by referring to Fig. III. Each per cent of *o*-cresol added, within the limits of the plot, lowers the specific gravity (45° C./45° C.) of the phenol 0.00031, each per cent of *p*-cresol lowers it 0.00040, and each per cent of *m*-cresol, 0.00044.

[1] Z. angew. Chem., 1900, 759.

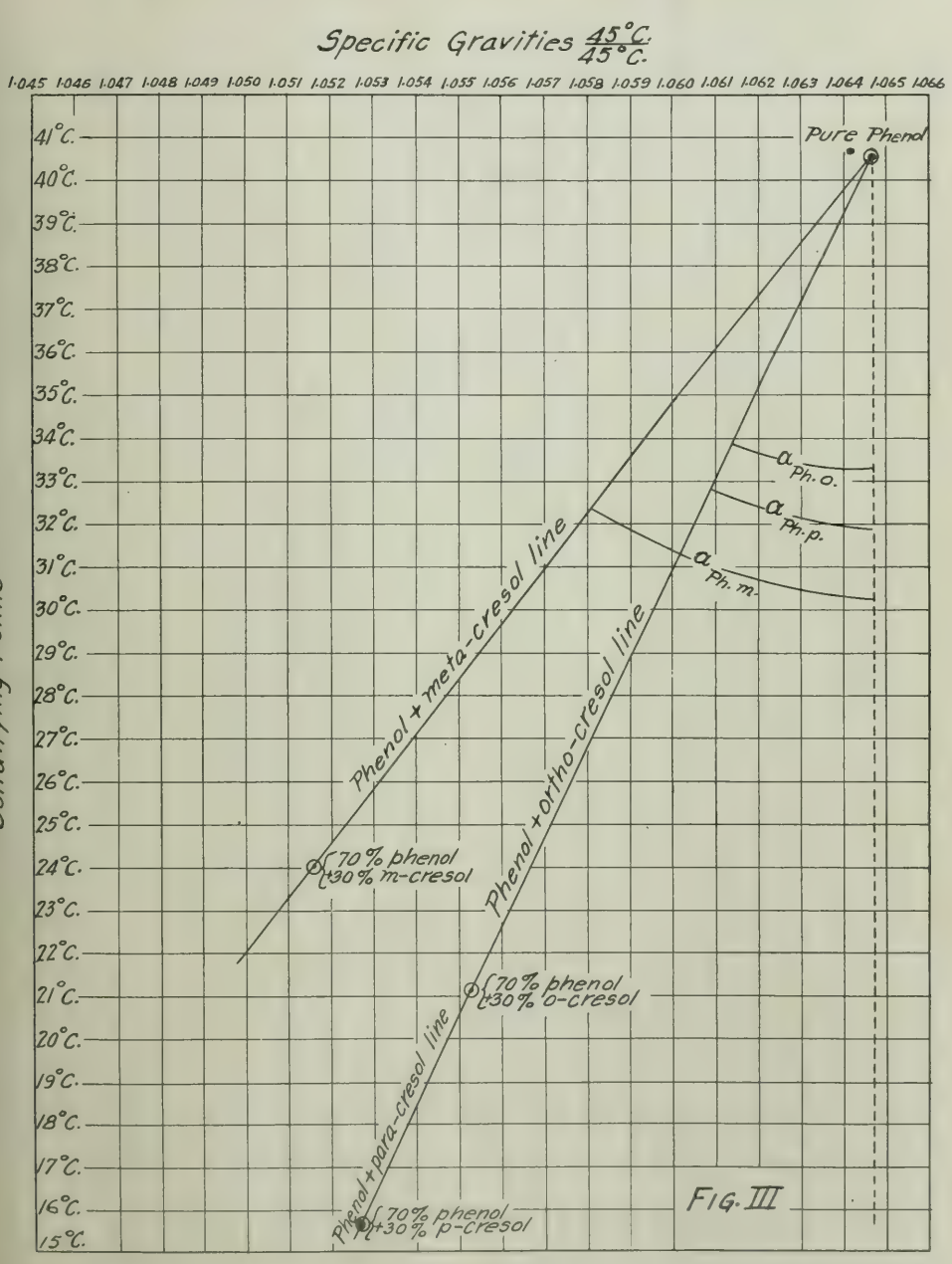

Specific Gravities 45°C./45°C.
1.045 1.046 1.047 1.048 1.049 1.050 1.051 1.052 1.053 1.054 1.055 1.056 1.057 1.058 1.059 1.060 1.061 1.062 1.063 1.064 1.065 1.066
Solidifying Points
41°C. 40°C. 39°C. 38°C. 37°C. 36°C. 35°C. 34°C. 33°C. 32°C. 31°C. 30°C. 29°C. 28°C. 27°C. 26°C. 25°C. 24°C. 23°C. 22°C. 21°C. 20°C. 19°C. 18°C. 17°C. 16°C. 15°C.
Pure Phenol
α Ph. o.
α Ph. p.
α Ph. m.
Phenol + meta-cresol line
70% phenol
30% m-cresol
Phenol + ortho-cresol line
70% phenol
30% o-cresol
Phenol + para-cresol line
70% phenol
30% p-cresol

FIG. III

The combined effect of each cresol on the solidifying point and specific gravity of phenol is represented by the three lines shown in Fig. III and is measured in each case by the tangent of the angle formed by each line and a line drawn through the point representing the constants for pure phenol parallel to the axis (X = 0). These angles are represented in the plot as "$\alpha_{Ph.o.}$" and "$\alpha_{Ph.m.}$" and "$\alpha_{Ph.p.}$" Inspection of Fig. III will show that "$\alpha_{Ph.o}$" = "$\alpha_{Ph.p.}$," consequently tan. $\alpha_{Ph.o.}$ = tan. $\alpha_{Ph.p.}$

The value of this tangent was found to be numerically equal to 0.482 by the formula

$$\text{tan. } \alpha_{Ph.s.} = \frac{1000\,(G_p - G_{sp})}{T_p - T_{sp}} \qquad \text{(III)}$$

where G_p = specific gravity 45° C./45° C. of phenol used,
G_{sp} = specific gravity 45° C./45° C. of phenol + cresol used,
T_{sp} = solidifying point of phenol + cresol used,
T_p = solidifying point of phenol used.

The same value was obtained by calculation from the data obtained by Weiss and Downs for their sample of pure phenol and their mixture of 70 per cent phenol and 30 per cent of *o*-cresol in spite of the fact that the constants obtained by them were very different from those obtained by the writers.

The tangent of the angle formed by the "phenol + *m*-cresol" line (tan. $\alpha_{Ph.m.}$) was found to be equal to 0.794, while that of a "phenol + (50 *m* + 50 *p*)-cresol" line was equal to 0.65. The tangent corresponding to the latter case calculated from the data obtained by Weiss and Downs for their phenol and their mixture of 70 per cent of phenol plus 30 per cent of a coal-tar distillate containing 50 per cent of *m*-cresol and 50 per cent of *p*-cresol was found to be about 0.64.

Those results obtained by the writers for the tangents of the angles that are comparable with those calculated from the data obtained by Weiss and Downs, are in remarkable agreement, both in the case of the phenol mixtures and the *o*-cresol mixtures, although the constants themselves are widely different for the same mixtures.

By a series of experiments it was shown that if 30 per cent of a pure cresol or a mixture of cresols containing varying amounts of phenol were mixed with 70 per cent of pure phenol and the constants obtained on this mixture, the value of the tan. $\alpha_{Ph.s.}$ calculated from the constants of the phenol and the mixture by Equation III would be the same, within the limit of error of the analytical work, regardless of the amount of phenol present, provided the same cresol or mixture of cresols were present and only the per cent of phenol varied. Consequently by calculating the tan. $\alpha_{Ph.s.}$ for a given mixture of cresols containing any amount of phenol over 70 per cent the influence of any phenol originally present before the 70 per cent was added is eliminated and since tan. $\alpha_{Ph.s.}$ for *o*-cresol and also for *p*-cresol is equal to 0.482, any increase in the value of tan. $\alpha_{Ph.s.}$ over 0.482 gives a measure of the amount of *m*-cresol present.

Now the "phenol + *o*-cresol line" in Fig. III is coincident with the "phenol + *p*-cresol line" and no matter how much phenol is present in the original mixture of cresol and phenol the point representing the constants after mixing with 70 per cent of phenol will lie somewhere on the line if *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present. Likewise if *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present, the point representing the constants of a mixture of 30 per cent of the original mixture and 70 per cent of *o*-cresol will lie somewhere on the "*o*-cresol-*p*-cresol line" shown in Fig. I, or a line parallel to it if phenol also is present. In this case tan. $\alpha_{Ph.s.}$ will be equal to 0.482, showing that *o*- or *p*-cresol alone or mixtures of *o*- and *p*-cresol in any proportion are present only and the per cent of phenol in the original mixture may be calculated by Equation I. If the tan. $\alpha_{Ph.s.}$ is equal to 0.794, only *m*-cresol in addition to phenol is present; the point representing the constants of a mixture of 30 per cent of the original mixture and 70 per cent of *o*-cresol will lie somewhere on the "*o*-cresol-*m*-cresol line" in Fig. I, if phenol is absent in the original mixture, or, on a line parallel to this line if phenol is present, and the per cent phenol present, if any, is obtained by the use of Equation II. Now if in addition to *o*- or *p*-cresol alone or *o*- and *p*-cresol in any proportion, *m*-cresol is also present, tan. $\alpha_{Ph.s.}$ will be intermediate between 0.482 and 0.794; and the difference between the value found and 0.482 will give a measure of the *m*-cresol present in proportion to the other cresols present, which, if multiplied by the ratio of the difference between the tan. $\alpha_{Ph.m}$ and $\alpha_{Ph.o.}$ (Fig. III) to the difference between the tan. $\alpha_{o.m.}$ and $\alpha_{o.p.}$ (Fig. I) will give the necessary factor for correcting Equation I for varying amounts of *m*-cresol present. The resulting equation is derived algebraically as follows:

The difference between tan. $\alpha_{Ph.m.}$ and tan. $\alpha_{Ph.o.}$, or tan. $\alpha_{Ph.p.}$, = 0.794 — 0.482, or 0.312. The difference between tan. $\alpha_{o.p.}$ and tan. $\alpha_{o.m.}$ is equivalent to the difference between Equations I and II.

0.366 $(T_o - T_{so})$ — 2970 $(G_o - G_{so})$ = % phenol
0.585 $(T_o - T_{so})$ — 2780 $(G_o - G_{so})$ = % phenol
or,
0.219 $(T_o - T_{so})$ + 190 $(G_o - G_{so})$ = 0, for equal percentages of phenol.

Dividing this equation by 0.312 gives

$$\frac{0.219}{0.312}(T_o - T_{so}) + \frac{190}{0.312}(G_o - G_{so}) = 0$$

or, 0.702 $(T_o - T_{so})$ + 609 $(G_o - G_{so})$ = 0.

Multiplying by (tan. $\alpha_{Ph.s.}$ — tan. $\alpha_{Ph.o.}$) or (tan. $\alpha_{Ph.s.}$ — 0.482) which can be represented by the symbol L_s, meaning the tangential lowering of the constant of phenol caused by the substance compared with that caused by *o*- or *p*-cresol, gives

0.702 L_s $(T_o - T_{so})$ + 609 L_s $(G_o - G_{so})$ = 0.

Adding this equation to Equation I gives

$(0.366 + 0.702\ L_s)(T_o - T_{so}) - (2970 - 609\ L_s)$
$(G_o - G_{so})$ = per cent phenol
or, $(0.366 + 0.702\ L_s)(T_o - T_{so}) + (2970 - 609\ L_s)$
$(G_{so} - G_o)$ = per cent phenol, (IV)

where $L_s = \frac{1000\,(G_p - G_{sp})}{T_p - T_{sp}} - 0.482$

in which G_p = sp. gr. 45° C./45° C. of the phenol used,

G_{sp} = sp. gr. 45° C./45° C. of the 70 per cent phenol + 30 per cent cresol mixture,

T_{sp} = solidifying point of the 70 per cent phenol + 30 per cent cresol mixture

and T_p = solidifying point of the 70 per cent, phenol used,

and where G_o = sp. gr. 25° C./25° C. of the *o*-cresol used,

G_{so} = sp. gr. 25° C./25° C. of the 70 per cent *o*-cresol + 30 per cent cresol mixture,

T_{so} = solidifying point of the 70 per cent *o*-cresol + 30 per cent cresol mixture,

and T_o = solidifying point of the *o*-cresol used.

When the distillate analyzed is composed of *o*-cresol or *p*-cresol alone or a mixture of these two cresols in any proportion L_s becomes equal to 0.0 and Equation IV is transformed into Equation I. As the proportion of *m*-cresol to the other cresols present increases, L_s increases in value until 100 per cent of *m*-cresol is present, when L_s becomes equal to 0.312 and Equation IV is transformed into Equation II.

Although Equation IV does not give absolutely accurate results with all possible mixtures of the three isomeric cresols it does give them with any of the three cresols alone, with all possible mixtures of *o*- and *p*-cresol and all possible mixtures of *m*- and *p*-cresol. Where *o*-cresol and *m*-cresol are present in varying proportions and *p*-cresol is absent or present in very small quantities, results obtained are too low, the error increasing as *o*-cresol increases and *p*-cresol simultaneously decreases until the greatest is introduced where *p*-cresol is absent and less than 50 per cent of *m*-cresol and more than 50 per cent of *o*-cresol is present. Even in this case the error is compensated for, as the relative proportion of *o*- to *m*-cresol increases, by the factor $(T_o - T_{so})$ simultaneously decreasing proportionately, so the ultimate error is never very large in any case. Moreover, it is hard to conceive of a case in actual commercial practice where *o*- and *m*-cresol would occur together in the absence of, or in the presence of a small amount of *p*-cresol, since no evidence has ever been found that *p*-cresol was removed from a crude cresylic acid, as is the case with *m*-cresol, and, owing to the fact that *p*-cresol distils at a temperature between the boiling point of *o*-cresol and that of *m*-cresol, in the ordinary processes of distillation there is more likely to be a dearth of *o*- or *m*-cresol in a mixture of the three cresols in commercial products than of *p*-cresol. This fact is confirmed by Ihle[1] and by Tiemann and Schotten[1] who found "mostly *o*- and *p*-cresol with a little *m*-cresol" present, while Schulze[2] found "about 40 per cent *m*-, 35 per cent *o*- and 25 per cent *p*-cresol" in tar oils. In the latter case, as well as in practically all those cases ordinarily met with in commercial practice, where all three cresols are present in varying amounts, the probable error would amount to only a few tenths of a per cent in the final result, which is about the same as the probable error inherent to the determination of the constants of the different mixtures.

In the application of Equation IV to the determination of phenol in commercial products, such as crude cresylic acid, it is necessary to remove completely even small quantities of hydrocarbons, and to remove effectively xylenols, higher homologues and bases, inasmuch as it was found on practical application that the presence of even very small amounts of hydrocarbons would seriously affect the accuracy of the results while the presence of bases, xylenols and other higher homologues, though not affecting the ultimate result to so great a degree as the hydrocarbons, nevertheless introduced serious errors when present in very great amounts.

THE HYDROCARBONS were found to be more effectively removed by diluting the original sample with 2 volumes of benzol before extracting with caustic soda solution. In addition, this process in most cases renders unnecessary the preliminary distillation in the case of dark colored products.

THE BASES are effectively removed by the regular process of separating the tar acids, being left behind in the acid liquor on acidifying the carbolate solution.

The problem of separating effectively the XYLENOLS and HIGHER HOMOLOGUES from phenol and the cresols was investigated by comparing results obtained in actual analysis, using most of the still-heads enumerated and illustrated by Rittman and Dean[1] in their article on the analytical distillation of petroleum.

The results were far from satisfactory. Those still-heads that effectively removed the xylenols choked up and caused considerable annoyance and delay in the process of distillation, while those that distilled without choking up failed to remove the xylenols. To remedy these defects a special still-head was designed of the proper dimensions for this work. This still-head is described later on. It has been used for a long time now and has proved satisfactory.

Other details in the manipulation, the necessity for which will be obvious, were worked out and owing to the impracticability of obtaining thermometers and still-heads of exactly standard dimensions the distillation temperatures are given corrected for emergent steam, thus eliminating the necessity of having still-heads and thermometers of certain dimensions.

DESCRIPTION AND METHOD OF USE OF THE KNIGHT STILL-HEAD

This still-head is especially designed for use in separating xylenols and higher homologues from phenol and the cresols. It consists of three 2-in. bulbs joined by 2 glass tubes $^3/_{16}$ in. long and having a $^9/_{32}$-in. aperture. The upper bulb is connected with a glass tube open at the top ($^5/_8$ in. inside diam. and 3 in. long) and having a side tube ($^7/_{32}$ in. inside diam.)

[1] *Loc. cit.*

[1] THIS JOURNAL, 7 (1915), 755.

which is joined on about 1 1/4 in. above the upper bulb and is bent downward at any suitable angle and for any desired length. The lower bulb has a glass syphon tube (1/8 in. inside diam.) joined to the side of the bottom of the bulb and bent upward to slightly less than half way up the side of the lower bulb and then bent downward, following roughly the contour of the bulb, and passing through and down the center of another tube, 4 1/2 in. long and 3/8 in. inside diam., along 3 1/2 in. of the lower part and 7/32 in. inside diam.

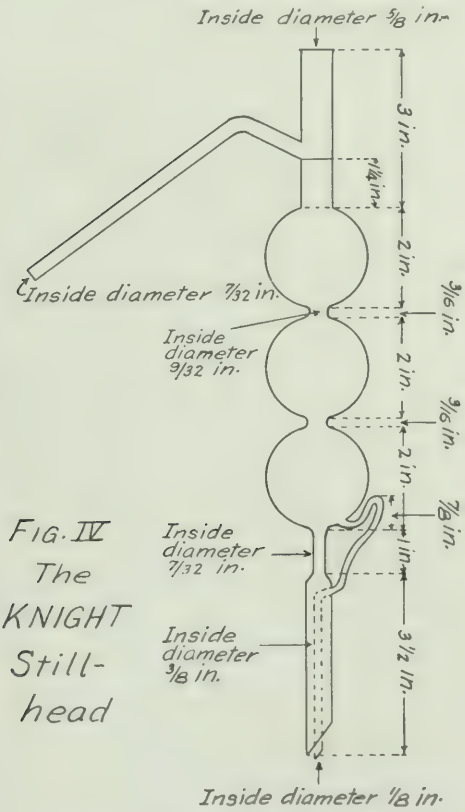


FIG. IV
The KNIGHT Still-head

Scale 1/2 in. = 1 in.

along 1 in. of the upper part where it is joined to the lowest bulb of the still-head. The syphon tube enters the 3/8 in. diameter part of the lower tube about 1 1/2 in. from the bottom of the lower bulb and passes through the center of the tube to the bottom as shown in the accompanying diagram.

The dimension of the constriction in the lower tube is so calculated to the condensing area of the bulb of the still-head that when the distillation is carried on at the specified rate more vapor will condense than can run back into the distilling flask through the constriction; thus a layer of liquid collects in the bottom of the lowest bulb and acts as a liquid condenser for all vapors passing through it having a higher boiling point than the temperature of the liquid layer. In this way the xylenols and higher homologues which tend to pass over with the phenol and cresols are retained in the liquid layer, and the temperature of the liquid layer is kept hot enough by the vapors to prevent phenol from being condensed. When the height of this layer reaches above the level of the top of the outside portion of the syphon tube, the syphon automatically empties the bulb of the liquid layer and delivers the condensed liquid back into the distilling flask again, provided the rate of distillation is not too fast. A Tirrell burner should be used as a source of heat on account of the ease with which the rate of distillation may be controlled by its use.

Towards the end of the redistillation of the 190–202° fraction, when all the phenol has been removed, occasionally such a small amount of liquid remains in the distilling flask that scorching is liable to occur. In this case, and in other cases where it seems necessary to carry a small amount of liquid layer in the lower bulb, this may be accomplished by tipping the top of the still-head away from the condenser so that the still-head instead of being vertical is inclined at an angle from top to bottom toward the condenser. By regulation of this angle the syphon may be made to empty as frequently as the operator desires.

METHOD

Weigh out 100 g. of the sample (W) in a tared beaker to centigrams. Pour the oil into a separatory funnel (500 cc. capacity); rinse the flask with 200 cc. of benzol, adding the rinsings to the sample contained in the separatory funnel. Mix the contents of the separatory funnel, add 100 cc. of a 20 per cent NaOH solution, shake thoroughly for two minutes, allow to settle, and draw off the lower layer[1] into another separatory funnel of 600–700 cc. capacity.

Repeat the extraction of the benzol layer with successive 100-cc. portions of 20 per cent NaOH solution, drawing off the lower layer as before until no more tar acids are extracted, as shown by acidifying the last portion (3 or 4 shake-outs are usually sufficient). Shake the combined NaOH extracts out with 30-cc. portions of benzol until any hydrocarbons that may have been carried through into the NaOH extracts by benzol and tar acids have been removed as shown by heating the NaOH solution in a beaker to a gentle boil until the odor of benzol disappears and the characteristic odor of coal-tar hydrocarbons can no longer be detected. Wash the combined benzol extracts a couple of times with 15 cc. of 20 per cent NaOH solution and add the washings to the NaOH solution.

[1] Occasionally a black tarry [illegible] with which it will be difficult to distinguish the [illegible] layers. In this case it will be necessary first to dilute the sample to be sure that all of the phenol has been [illegible] the distillate into the separatory funnel, add the [illegible] ceed as above.

Acidify the combined caustic soda extracts with dilute sulfuric acid (50 cc. of concentrated acid mixed with 150 cc. of water). The solution is conveniently held in a 1-liter Jena Erlenmeyer flask. The acid must be added in small portions at a time, and the solution cooled by immersing the flask in water or holding it under a tap of running water so that the temperature does not rise above 40° C. as measured by a thermometer placed in the flask.

As it approaches neutrality the solution becomes light in color, and should be tested occasionally with litmus paper. When neutral, add 4 to 5 cc. more of the dilute sulfuric acid, transfer to a 700-cc. separatory funnel rinsing flask and allow to stand till the two layers separate well (from 1 to 4 hours are necessary according to the character of the sample).

Draw off the lower layer into another separatory funnel. Shake the acid-water layer with 30 cc. of benzol; allow the two layers to separate well, draw off the lower layer into another separatory funnel and repeat the extraction with 20-cc. portions of benzol until no more tar acids are extracted, as shown by evaporating a test portion just to dryness on the water bath (usually 4 extractions are enough). Reject the exhausted water layer, add the second benzol shake-out to the first; add the third benzol shake-out to the separatory funnel which had contained the second benzol shake-out and then add it to the first two benzol shake-outs. Repeat this process with the fourth benzol extract, etc., rinsing out each successive funnel with the last benzol extract, and combine all the shake-outs with the first. Wash the combined benzol extracts with 10 cc. of saturated salt solution and draw off and reject the salt solution. Draw off the tar acids into a 300-cc. round bottom, short neck, distilling flask, made of Jena or other heat-resisting glass; rinse out the separatory funnel with the combined benzol shake-outs of the acid-water layer, and add to the tar acids in the distilling flask. Distil off the benzol and water into a separatory funnel, using a medium size Wurtz still-head having an inlet tube below the first bulb $^{9}/_{32}$ in. inside diameter (both will come off practically completely below 170° C., and there will be an abrupt rise beginning at about 100–120° C.). The distilling flask should rest on a $^{1}/_{4}$ in. asbestos board 6 in. square with an opening in the center $3^{1}/_{2}$ in. in diameter and be enclosed entirely in an asbestos shield; the thermometer should be a standard thermometer, calibrated by the Bureau of Standards and accurate to $^{1}/_{5}$° C., over the range 170 to 210° C.; the condenser should be long enough, and cooled with sufficient cold water, to prevent loss by lack of proper condensation; the top of the bulb of the thermometer should be on a level with the bottom of the outlet tube of the still-head, and the upper part of this still-head and the one used later should be protected with thick asbestos cloth held in place with copper wire hoops and extending from the top of the upper bulb to the top of the still-head. When water and benzol are out of the condenser, stop the distillation (it does not matter if some oil distils over with the water).

Allow the still to cool; rinse out the Wurtz still-head with a small amount of benzol and add the rinsing to the benzol and water distillate. Saturate the water layer with salt, shake, separate, reject the salt water layer, and extract the benzol layer with 5-cc. portions of 20 per cent NaOH solutions until any tar acids in the benzol layer are removed (as shown by acidifying a test portion of the last shake-out with dilute sulfuric acid.) (Usually 3 or 4 extractions are enough.) Acidify the combined NaOH extracts with dilute sulfuric acid as before, allow to stand, separate any tar acids that collect, and add to the tar acids in the distilling flask. Continue the distillation, using a Knight still-head in place of the Wurtz still-head, and collect the distillate, first in a 10-cc. burette, until the oil passes over clear, then change to a tared 100-cc. cylinder, weighed to centigrams, and collect up to 193° C. (corr.).[1] Meanwhile saturate with salt any water layer that may be mixed with the tar acids in the 10-cc. burette and allow to stand. At 193° C. (corr.) change the receiver, stop the distillation, allow the still to cool, separate the tar acids from the saturated salt water, if any, contained in the 10-cc. burette, rejecting the salt water and drawing off the tar acids into the distilling flask; continue the distillation and collect the distillate up to 206° C. (corr.), distilling, as nearly as possible, at the rate of 0.5 to 1.0 cc. per minute.

Transfer the distillate collected from 193 (corr.) to 206° C. (corr.) to another flask and redistil at the same rate as before, collecting the distillate up to 201° C. (corr.) in the same tared cylinder used for collecting up to 193° C. (corr.) in the initial distillation. Weigh the cylinder containing the distillate to centigrams and calculate the weight of the distillate (D). Pour the distillate into a suitable size Erlenmeyer flask and mix thoroughly by pouring back and forth, and then stopper the flask.

Weigh out as accurately as possible 4. 5 g. of this distillate and 10.5 g. of *o*-cresol (solidifying point above 28° C.). Mix these two portions thoroughly; if necessary, heat cautiously in warm water to dissolve any crystals of *o*-cresol that may be undissolved, and keep in a stoppered flask.

Determine the SPECIFIC GRAVITY (G_{50}) of this mixture, at 25° C./25° C., in a carefully calibrated and tared 10-cc. Geissler pycnometer, having a thermometer carefully calibrated to within 0.1° C. at 25° C., being careful to make consecutive weighings and to wipe off the pycnometer thoroughly between weighings, until the weight is constant to a few tenths of a milligram.

Determine the solidifying point of the same mixture, using the apparatus and method described below.

The SOLIDIFYING POINT determination should be

[1] This temperature and all subsequent distillation temperatures are given corrected for stem exposure, using the formula: stem correction = 0.00016 N ($T° - t°$), where N = number of degrees exposed, $T°$ = temperature of the thermometer bulb, and $t°$ = average temperature of the exposed stem. This correction will make a difference of 3 to 40° C. at these temperatures, but the corrected temperatures will be consistent regardless of the thermometer used, provided it is a standard thermometer. A corrected temperature of 193° C. will usually give an observed reading of 190° C. although this will vary slightly with different thermometers.

made in an apparatus composed of a cylindrical glass vessel 6 in. in diameter by $7^1/_2$ in. high filled with water or iced water at a temperature about 5° C. below the expected solidifying point and containing a cylindrical salt-mouthed bottle of about $3^1/_2$ in. diameter and about $6^1/_4$ in. high, clamped in position so that the bottle is almost completely immersed. The bottle is closed with a cork stopper through which passes a short test tube 4 in. long by $^7/_8$ in. diameter, fitted snugly into the stopper so that none of the tube extends above the top of the stopper. The test-tube is closed with a rubber stopper through which pass the standard thermometer and a looped platinum stirrer. The thermometer used should be a standard thermometer reading to tenths and calibrated by the Bureau of Standards to hundredths of a degree over the range between 6 and 41° C. The determination should be conducted as follows:

Pour enough of the mixture into the test-tube to give a layer more than sufficient to cover the bulb of the thermometer. Insert the thermometer and the platinum stirrer passing through the rubber stopper into the mixture; press the stopper tightly into the test-tube and stir the mixture continuously with the platinum stirrer till the temperature is near the expected solidifying point. Then introduce a few fine crystals of *o*-cresol into the mixture and continue the stirring until the mass crystallizes, and the temperature rises to a maximum point and remains constant. This temperature is the solidifying point (T_{so}).

Repeat the determination of the specific gravity and solidifying point (T_{sp}) of the distillate, using phenol of 40° C. or higher solidifying point, instead of *o*-cresol, and determining the specific gravity at 45° C./45° C. (G_{sp}), instead of 25° C./25° C.

The following procedure should be followed in determining the specific gravities:

In the case of phenol and phenol mixtures, where the specific gravity is determined at 45° C., the pycnometer with the cap and thermometer removed is filled with the phenol or phenol mixture which has previously been heated very cautiously in warm water at a temperature of about 50° C. until the phenol crystals have dissolved and the phenol reached a temperature of about 45° C. The thermometer is then placed in the pycnometer and the pycnometer immersed in water at a temperature slightly higher than 45° C. The water in the bath is then repeatedly adjusted until it is at 45° C. at the same time that the pycnometer thermometer registers 45° C. (The pycnometer is immersed in the warm water almost up to the point where the thermometer enters the pycnometer.) The pycnometer is then removed from the water, the cap put on, the whole pycnometer carefully wiped dry, weighed to tenths of a milligram, removed from the scale pan, wiped again and weighed again until two successive weighings check to within a few tenths of a milligram.

In the case where the specific gravity is determined at 25° C. and the room temperature is above 25° C., the mixture to be tested, after first being heated, if necessary, in water at about 30–35° C. to melt any *o*-cresol crystals, should be first cooled in cold water to a few degrees below 25° C. and then the pycnometer filled, immersed up to the neck in water slightly above 25° C., etc., the same procedure being followed as described above. The cap in this case should have a slight perforation at the top to relieve any pressure that might raise the cap and cause loss.

The per cent of phenol in the original substance is calculated in the following manner:

First calculate the relative tangential lowering of the specific gravity of the phenol-distillate mixture (L_s) by the equation

$$L_s = \frac{1000\ (G_p - G_{sp})}{T_p - T_{sp}} - 0.482.$$

Then calculate the per cent phenol in the sample by the following equation:

$$\text{Per cent phenol} = 100\ D\ [(T_s - T_{so})\ (0.366 + 0.702\ L_s) + (G_{so} - G_o)\ (2070 - 606\ L_s)]\ 30W,$$

where G_p = sp. gr. 45°/45° C. of the phenol used,
G_{sp} = sp. gr. 45°/45° C. phenol + distillate mixture,
T_p = solidifying point of the phenol used,
T_{sp} = solidifying point of the phenol + distillate mixture,
D = weight of total distillate below 197° C.,
G_o = sp. gr. 25°/25° C. of the *o*-cresol used,
G_{so} = sp. gr. 25°/25° C. of the *o*-cresol + distillate mixture,
T_o = solidifying point of the *o*-cresol used,
T_{so} = solidifying point of the *o*-cresol + distillate mixture,
and W = weight of the sample used,

SUMMARY

For the determination of phenol in the presence of the three cresols, a feasible method is developed which not only obviates the necessity of referring to a plot in calculating results, but gives concordant and reliable results with all the different combinations and percentages of the different cresols and phenol likely to be met with in commercial practice; in addition, the method is not dependent for its accuracy on the purity of the particular *o*-cresol used by the investigators for the derivation of their formula for calculating the per cent of phenol. In applying the principle involved to the practical determination of phenol in crude commercial tar acids, suitable provision is made for the complete separation of the small amounts of hydrocarbons that are usually present in crude cresylic acids, especially those made from blast furnace tar, which would otherwise introduce serious error. A new still-head, especially designed for this kind of work, is used for the more complete and satisfactory removal of the xylenols and higher homologues.

641 WASHINGTON STREET
NEW YORK CITY

THE DETERMINATION OF MANGANESE IN STEEL IN THE PRESENCE OF CHROMIUM AND VANADIUM BY ELECTROMETRIC TITRATION

By G. L. Kelley, M. G. Spencer, C. B. Illingworth and T. Gray

Received July 14, 1917

The determination of manganese in steel in the presence of chromium and vanadium has long offered difficulties to the analyst in steel works laboratories. Numerous methods have been developed with the object of alleviating or overcoming these difficulties. Cain[1] and Watters[2] recommend devices for the separation of the manganese. Cornelius[3] and Dedericks,[4] although not particularly concerned with the analysis of steel, have recommended procedures available for the quantitative separation of manganese from chromium and vanadium. Talminger[5] has proposed a method of the latter type, using von Knorre's procedure, *viz.*, the precipitation of manganese by ammonium persulfate. Koester[6] has investigated Engel's method for the electrodeposition of manganese in the presence of chromium, and finds chromium occluded. Cain[7] finds that the Ford-Williams method gives high results due to the occlusion of chromium. Even in the Volhard-Wolff[8] method chromium and vanadium interfere.

The two methods most in use for the determination of manganese in steel are known as the persulfate and bismuthate methods. In the first of these the manganese in a nitric acid solution of the steel is oxidized with ammonium persulfate and silver nitrate, after which it is titrated with sodium arsenite. Wdowiszewski[9] reports good results with this method, even in the presence of 1 per cent chromium. In this laboratory, however, it has been noted that the method rapidly becomes less useful as the percentage of chromium rises, owing to the obscurity of the end-point. In the bismuthate method the manganese in a solution of the sample is oxidized with sodium bismuthate, the excess filtered out and an added excess of ferrous sulfate titrated with permanganate. Here even a trace of chromium may cause trouble and this difficulty rapidly increases with the larger percentage of chromium often met in commercial steels. By cooling the solution thoroughly with ice before oxidizing the manganese the tendency of the chromium to oxidize is depressed, and if this procedure is followed by rapid filtration fairly satisfactory determinations of manganese may be made even in the presence of 5 per cent of chromium in the sample. The consistently successful analysis of such material by this method, however, requires a high degree of skill. Demorest[10] suggests titrating the solution with sodium arsenite until the color of the permanganate disappears. He has tested this method by titrating solutions of steel to which chromium corresponding to 3 per cent of the weight of the sample has been added as chromate immediately before titrating. Under the usual conditions of analysis most of the chromium is present as chromic salt and such amounts of chromium in this state make the end-point obscure. In the presence of 5 per cent or more of chromium all of these methods, except those which involve the separation of manganese, are extremely uncertain.

In this paper we describe a method which has sufficient accuracy for all technical purposes and which, without the separation of chromium and vanadium, is not interfered with by these elements under the conditions of analysis. The oxidation of the manganese in this method may be accomplished either by the bismuthate or persulfate procedures, and titration is made electrometrically, using mercurous nitrate as the reducing agent. In the course of the examination of a long list of reducing agents this was the only reagent found which would reduce permanganate quantitatively and rapidly at ordinary temperatures without reducing chromates or vanadates.

THE STANDARDIZATION OF THE MERCUROUS NITRATE SOLUTION

10.5 g. of mercurous nitrate are dissolved in 150 cc. of water to which 2 cc. of nitric acid have been added. Any undissolved salt is removed by decantation and the solution made up to a volume of one liter. This is compared electrometrically on the apparatus made for this laboratory by the Leeds & Northrup Company,[1] with a solution of potassium permanganate which has been standardized against sodium oxalate. The permanganate solution contains 0.5 g. of Mn per liter, each cc. being equivalent to 0.05 per cent of Mn in a 1-g. sample of steel. The medium in which the titration is made is a solution containing 50 cc. of sulfuric acid (sp. gr. 1.58) and 200 cc. of water. The temperature should not be above 40°. For purposes of this titration, permanganate is added to the solution in any convenient amount and titrated with mercurous nitrate. The details of the titration will be given at a later point in this article.

THE REACTION

When titration is complete, the solutions have a brown color suggesting dissolved manganese dioxide. The solutions, however, appeared to be quite stable. When solutions containing 10 cc. of permanganate had been titrated and were allowed to stand in a stoppered Erlenmeyer flask at room temperature, no precipitates appeared after some weeks. Filtration removed only a small amount of the solids. With solutions containing as much as 40 cc. permanganate solution, a faint turbidity appeared after 24 hrs. On warming, even to 40°, manganese dioxide was precipitated.

After titrating 40 cc. of the $KMnO_4$ solution with mercurous nitrate, the titration was continued with ferrous sulfate of equivalent concentration on the same apparatus. This was found to require 12 cc.

[1] This Journal, **3** (1911), 630.
[2] *Met. & Chem. Eng.*, **9** (1911), 244.
[3] *Pharm. Ztg.*, **58**, 427.
[4] *Ibid.*, p. 446.
[5] *Chem.-Ztg.*, **34** (1910), 1877.
[6] *Z. Elektrochem.*, **17** (1911), 57.
[7] *Loc. cit.*
[8] *Stahl u. Eisen*, **33** (1913), 633.
[9] *Ibid.*, **28** (1908), 1067.
[10] This Journal, **4** (1912), 19.

[1] This Journal, **9** (1917), 780.

of ferrous sulfate. It is believed that the latter reaction was the reduction of quadrivalent manganese to the bivalent state. Our efforts to prove this point were not entirely successful. When the solutions after titration were warmed, both in the original volume of 250 cc., and diluted to larger volumes up to one liter, the amount of MnO_2 precipitated varied in an uncertain manner. Changing the temperature from 40° to boiling did not serve to indicate a procedure which would give consistent results. The MnO_2 so precipitated was collected on asbestos and, after washing, mixed with dilute sulfuric acid. An excess of ferrous sulfate was then added and the solution titrated with permanganate electrometrically. From 8 to 10 cc. of ferrous sulfate were required for titration, an amount always less than that required for a similar titration before precipitation. One possible explanation of this is that the manganese dioxide as formed is in a hydrated condition and while in this condition it may be that it very readily undergoes decomposition in part into manganous sulfate and oxygen. That there is a diminution in oxidizing power by precipitation is shown by the fact that the oxidizing power of the precipitate and filtrate combined is insufficient to oxidize 12 cc. of ferrous sulfate as is done when the titration with ferrous sulfate is made without precipitation.

In the foregoing discussion 40 cc. of the solution were taken as a unit in the study of the quantitative precipitation of manganese dioxide. In the discussion which follows we shall adhere to this volume.

To determine the amount of mercurous salt present in the mercurous nitrate solution 40 cc. were diluted to 200 cc., and 200 cc. of a solution containing 5 g. of sodium chloride gradually added with stirring. This was followed by the addition of 10 g. of sodium acetate in the form of a filtered solution. The precipitate was washed with water containing a little sodium chloride and finally with water alone. It was dried at 150°. Two determinations gave 0.3005 g. and 0.2999 g., respectively. The $Hg_2(NO_3)_2$ present in 40 cc. of this solution was found from the average of these determinations to be 0.3340 g.

From the data supplied by the known concentrations of the permanganate and mercurous nitrate solutions, and from the oxidizing power of the solution towards ferrous sulfate after titration with permanganate, we can construct the following equation:

$$4\ Mn^{VII} + 14\ Hg^{I} = 3\ Mn^{IV} + 1\ Mn^{II} + 14\ Hg^{II}$$

Basing our calculation on the known strength of the permanganate solution, theory requires that the mercurous nitrate in 40 cc. should be 0.3340 g., which corresponds closely with 0.3340 g. found. Correspondence is also found in that 12 cc. of an equivalent solution of ferrous sulfate would be required for the reduction of three atoms of quadrivalent manganese.

While the reaction given above quite certainly indicates with accuracy the oxidizing power of the solution as left after titration, it has seemed to us necessary to make an effort to secure additional information in its support. We give below a brief outline of some of our observations with their implications as understood by us, omitting, however, experimental details because of the inconclusive character of the work.

When manganous sulfate is added to the solution of permanganic acid before titration with mercurous nitrate, it has the effect of diminishing the amount of mercurous nitrate necessary. The effect, however, is not a regular one, for the addition of small amounts of manganous salt produces a proportionately larger effect upon the titration than large additions. Such additions noticeably alter the color of the solution, changing it from brownish yellow to brownish red, suggesting the formation of manganic salts. Barnebey[1] reviews the explanations which have been offered to account for the effect of manganous salts upon the titration of ferrous iron with permanganate in the presence of hydrochloric acid. He quotes Volhard as suggesting that the action of manganous salts on the permanganate results in the formation of quadrivalent manganese, while Birch suggests the formation of trivalent manganese. When the solution after titration with mercurous nitrate is treated with manganous salt, the same reddish color appears as when the manganous salt is added before titration. If we are correct in our belief that the product of the reaction is manganic sulfate in both instances, this would constitute additional evidence of the presence of quadrivalent manganese in the titrated solution.

From the fact that we are unable to remove MnO_2 from the solution by filtration after titration, this substance, if present, must be evident either as a sulfate or in the colloidal condition. Witzemann,[2] discussing the conditions under which colloidal solutions of manganese dioxide are stable, points out that small amounts of either salts or acids cause immediate precipitation. Evidence for the existence of sulfates of quadrivalent manganese is meagre. Fremy[3] states that $MnO(SO_4)$ is formed by acting on hydrated MnO_2 with concentrated sulfuric acid in air. The fact that a moderately high concentration of sulfuric acid is necessary to prevent the precipitation of manganese dioxide in this titration may be construed as indicating the formation of a sulfate of quadrivalent manganese.

From the reaction as given above it appears that after titration one-fourth of the manganese is present as manganous salt. We precipitated the quadrivalent manganese by boiling a diluted solution and determined the manganese in the filtrate. The filtrate from the titration of 40 cc. of permanganate should have contained the equivalent of 0.0833 g. Mn in solution. We always found it to be larger than this, about 15 cc., as might have been expected from the fact that the manganese dioxide precipitated was always too small in amount to correspond to the theory. Blum[4] states that precipitated manganese dioxide is not

[1] J. Am. Chem. Soc. 36 (1914), 1411.
[2] Ibid. 37 (1915), 1039.
[3] Compt. rend. 82 (1876), 1501.
[4] J. Am. Chem. Soc. 34 (1912), 1411.

oxidized by sodium bismuthate in nitric acid. We added 30 cc. of nitric acid (sp. gr. 1.13) to a solution in which 40 cc. of permanganate solution had been titrated and which therefore probably contained quadrivalent manganese. The solution was then oxidized with sodium bismuthate, filtered through asbestos and titrated. The average of four determinations indicated a manganese content corresponding to 31.5 cc. of the permanganate solution. To test the completeness of oxidation of manganous salts under these conditions, we oxidized a solution of manganous sulfate in a similar mixture of acids and found the oxidation to be complete. Our failure to secure an amount or permanganic acid corresponding to 40 cc. of the original solution of permanganate may have been caused by the failure of the quadrivalent manganese to oxidize completely, owing to the nature of the solution. A colloidal solution of manganese dioxide, if it were possible for it to exist, might be expected to react as in this case.

From the foregoing and other considerations, our quandary as to the course of the reaction may be set forth as follows: (1) The relation of permanganate and mercurous salt seems to be definitely established. (2) The presence of manganese corresponding in oxidizing capacity to 3 MnO_2 for 4 $KMnO_4$ reduced, appears equally certain. (3) The presence of so large an amount of MnO_2 apparently in solution or suspension seems improbable. (4) The solution upon filtration through paper or asbestos after titrating leaves too much on the filter to correspond to complete solution. (5) If we accept the statement that undissolved manganese dioxide is not oxidized by sodium bismuthate in nitric acid solution, less than one-fourth of the manganese can be present in that form instead of three-fourths as shown in the reaction. (6) The ease with which warming the solution precipitates MnO_2 from these solutions after titration might correspond to the precipitation of suspended manganese dioxide or to the decomposition of trivalent or quadrivalent manganese sulfates. It is not impossible that the reaction might lead to $2\ Mn(SO_4)_2 + Mn_2(SO_4)_3$, but the color of the solution after titration does not indicate the presence of manganic salt. (7) The red color produced by the addition of manganous salts to the titrated solution is probably due to the formation of manganic salts and therefore furnishes evidence of the probable presence of compounds of quadrivalent manganese. The fact that a red color is not produced by interaction between the Mn^{IV} and Mn^{II} shown in the reaction we explain as due to the low concentration of Mn^{II}, for the effect described appears only when relatively large additions of manganous salt are made. (8) Since the final equilibrium corresponds to the disappearance of septivalent manganese and the formation of compounds of quadrivalent and bivalent manganese, we are at a loss to understand why the reaction should not have been either $2\ Mn^{VII} + 6Hg^{I} = 2\ Mn^{IV} + 6\ Hg^{II}$ or $2\ Mn^{VII} + 8\ Hg^{I} = Mn^{IV} + Mn^{II} + 8\ Hg^{II}$ instead of the more complex one first shown, which is the sum of these.

THE TITRATION OF PERMANGANIC ACID IN THE PRESENCE OF CHROMATES AND VANADATES

This titration is best carried out in the presence of a moderately high concentration of sulfuric acid. We have used 50 cc. of acid of sp. gr. 1.58, and 200 cc. of water. With a lower concentration of acid, manganese dioxide separates from solution and irregular results are obtained in titration. Nitric acid does not interfere, but it must be free from nitrous acid, which is best accomplished by treating it with a small amount of sodium bismuthate and filtering to remove the excess. To titrate permanganic acid, the resistance of the electrometric titration apparatus is adjusted to bring the beam of light on the scale. During the addition of the mercurous salt the beam remains stationary or shows a slight anomalous rise of potential until the end of the titration is approached. At this time the addition of more mercurous nitrate causes the beam to move in the opposite direction from which it returns more or less slowly after each addition until the end-point is reached, when it usually remains off the scale. The addition of a few drops of $KMnO_4$ serves to cause it to return. The titration having been carried out rapidly to this point, may be completed by adding the mercurous nitrate solution drop by drop. The end-point is sharp, and it is not affected by the presence of chromates or vanadates, but it is subject to the influence of temperature.

TABLE I—THE TITRATION OF POTASSIUM PERMANGANATE WITH MERCUROUS NITRATE IN THE PRESENCE OF CHROMATES AND VANADATES

Titrations made in 50 cc. H_2SO_4 (sp. gr 1.58) and 200 cc. H_2O

$KMnO_4$ Cc.	$Hg_2(NO_3)_2$ Cc.	G. Cr as Chromate	G. V as Vanadate
5.0	5.0	None	None
5.0	5.0	0.020	0.020
10.0	9.95	None	None
10.0	9.95	0.020	0.020
20.0	19.85	None	None
20.0	19.90	0.020	0.020
40.0	39.85	None	None
40.0	39.80	0.020	0.020

TABLE II—THE INFLUENCE OF TEMPERATURE

Volume and Concentrations as in Table I

Temperature	$KMnO_4$ Cc.	$Hg_2(NO_3)_2$ Cc.
20°	20.00	19.90
20°	20.00	19.90
40°	20.00	19.95
40°	20.00	19.90
60°	20.00	19.90
60°	20.00	19.95
80°	20.00	21.1
80°	20.00	21.4

The titrations shown in Tables I and II were made with a solution of permanganate containing 0.0005 g. of Mn per cc. This corresponds to 0.05 per cent Mn in a 1-g. sample of steel.

THE DETERMINATION OF MANGANESE IN STEEL AFTER OXIDATION WITH SODIUM BISMUTHATE

This method of oxidation is carried out exactly as described by Blair.[1] After filtering, a small piece of ice is added, followed by 50 cc. of sulfuric acid (sp. gr. 1.58). The volume should be 250 cc. and the temperature not above 40° at the time of titration. The procedure in titration is then as described above (Table I).

In Table III analyses of samples of steel issued by the Bureau of Standards are given. To certain of

[1] "The Chemical Analysis of Iron," 7th Ed., p. 122.

these, 0.02 g. Cr as chromate was added immediately before titration.

TABLE III—ANALYSES OF STEELS WITH AND WITHOUT CHROMIUM ADDED AS CHROMATE AFTER OXIDATION WITH SODIUM BISMUTHATE

SAMPLE	Mn FOUND — No Cr Added	Mn FOUND — 0.020 g. Cr Added	Mn PRESENT†
9a	0.895	0.910	0.915
9a	0.910	0.905	
19a	0.850	0.850	0.850
19a	0.860	0.850	
30*	0.560	0.560	0.563
30	0.565	0.560	
31*	0.155	0.155	0.156
31	0.160	0.155	
32*	0.215	0.216	0.216
32	0.220	0.215	
35	0.305	0.305	0.300
35	0.310	0.305	

* Sample 30 contains 1.35 percent Cr and 0.21 per cent V. Sample 31 contains 3.51 per cent Cr and 19.55 per cent W; Sample 32 contains 0.89 per cent Cr.

† Except on Samples 30 and 31 the official values given throughout this paper are those obtained by bismuthate oxidation.

In oxidizing manganese with sodium bismuthate in steel containing chromium, it is customary to add large amounts of ice and to filter quickly, for in cold solutions in which the bismuthate is allowed only a short time to act the oxidation of chromium is reduced to a minimum. Success in this method, however, depends largely upon compensating errors, for some chromium is always oxidized and the oxidation of manganese tends to be slow or incomplete at these very low temperatures. In this new method we had much better success by oxidizing between 20 and 35°. The only danger here is that after the removal of the bismuthate the permanganate may oxidize some of the chromic salt, being itself reduced. When the titration is made with ferrous sulfate and permanganate in the ordinary way this causes no error. That it does not cause error in this method can be due only to the fact that at temperatures below 40° the oxidation of chromium by permanganate proceeds slowly. It is at once evident, however, that with high percentages of either chromium or manganese the danger of error from this source will be diminished (1) by oxidizing in the neighborhood of 20°, (2) by adding ice after oxidation is complete and before filtering, and (3) by titrating immediately after filtration.

TABLE IV—DETERMINATION OF MANGANESE IN STEELS CONTAINING 17 PER CENT OF CHROMIUM

SAMPLES	Mn Found after Separation	Mn by Electrometric Titration
A 1201	0.385	0.395
A 1204	0.260	0.258

In Table IV manganese is shown as determined in steels containing 17 per cent of chromium. Since these steels are not readily soluble in nitric acid, the samples were dissolved in hydrochloric acid and repeatedly evaporated to a small volume with nitric acid. The solutions were then oxidized with sodium bismuthate as usual. Manganese was also determined in these samples after precipitation with ammonium persulfate.

In Table V the influence of time is shown where the percentages of chromium and manganese are both high. Bureau of Standards' Sample 0a was treated with 1 g. of potassium dichromate before solution and 1 g. afterwards. This gave rise to a very large amount of chromic salt as well as much chromate. These solutions were then titrated after different intervals.

Where such large amounts of chromium are present (over 30 per cent) it would be safer to oxidize both the chromium and the manganese.

TABLE V—THE EFFECT OF TIME UPON THE [illegible] FOUND WHEN THE PERCENTAGES OF BOTH M[illegible] ARE HIGH

Time of Standing after Filtration, Minutes	Percentage Found	Percentage Present
1	0.895	0.915
1	0.910	...
10	0.875	...
10	0.815	...
20	0.830	...
20	0.885	...

To test the suitability of the method for determining the higher percentages of manganese, we dissolved the Bureau of Standards sample of manganese ore, No. 25, in hydrochloric acid and evaporated with sulfuric acid until fumes appeared. It was then diluted to a liter. To portions of this representing 0.04 g. of the sample, nitric acid and sodium bismuthate were added. Fourteen titrations gave results ranging from 56.17 to 56.44. The average was 56.27. Blum[1] says that the most probable value for the manganese in this sample lies between 56.20 and 56.30. While these results are good the method is not recommended for determinations where such a high percentage of accuracy is needed as is the case in ores and ferro-manganese. In steels an error of one- or two-hundredths of a per cent is almost unavoidable under all methods and is rarely important. It is in this field that the usefulness of the method lies.

THE DETERMINATION OF MANGANESE IN STEEL AFTER OXIDATION WITH AMMONIUM PERSULFATE

One of the advantages of the ammonium persulfate method for determining manganese is that the filtration of the solution is not necessary. Where many routine determinations are made this is a valuable quality in a method because of the time saved. We accordingly attempted to develop this method for use on the electrometric apparatus. In titrating permanganate in sulfuric acid with mercurous nitrate in the presence of ammonium persulfate the relation of one solution to the other is slightly different from that which obtains when the persulfate is absent, but the relation is definite. This titration has the disadvantage of being more sensitive to temperature differences than is the titration in sulfuric acid alone. However, it gives results generally accurate enough for most technical purposes.

TABLE VI—THE TITRATION OF POTASSIUM PERMANGANATE IN THE PRESENCE OF AMMONIUM PERSULFATE

Solutions contained 50 cc H_2SO_4, sp. gr. 1.84, [illegible] ammonium persulfate and 200 cc. of water. Temperature, 20°

Cc. $KMnO_4$	Cc. $Hg_2(NO_3)_2$	Factor[1]
10.0	9.9	1.010
10.0	9.8	1.020
20.0	19.5	1.026
20.0	19.5	1.026
30.0	29.0	...
30.0	29.1	...
40.0	38.8	1.031
40.0	38.8	1.031

[1] The subtraction of a blank of 0.1 cc. from the mercurous nitrate makes the factor more nearly constant.

In Table VI titrations of potassium permanganate at 20° are shown. The effect of temperature is demonstrated in Table VII.

[1] *Loc. cit.* p. 1326.

TABLE VII—THE INFLUENCE OF TEMPERATURE UPON THE TITRATION OF POTASSIUM PERMANGANATE IN THE PRESENCE OF AMMONIUM PERSULFATE

The solution was identical with that used in Table VI

Temp. °C.	Cc. $KMnO_4$	Cc. $Hg_2(NO_3)_2$	Factor
10	20	19.6	1.020
10	20	19.7	1.015
15	20	19.5	1.026
20	20	19.5	1.026
20	20	19.5	1.026
25	20	19.6	1.020
30	20	19.8	1.010
35	20	19.8	1.010
35	20	20.5	0.97
35	20	20.0	1.00
40	20	19.8	1.01
40	20	21.0	0.95
60	20	21.6	0.93
60	20	21.8	0.92
80	20	21.6	0.93
80	20	22.0	0.91

It will be evident from the results shown in Table VII that the temperature of the solution should be kept close to 20° C. The increase in the amount of mercurous nitrate used in titrating at the higher temperature is undoubtedly due to the partial reoxidation of the manganese. At low temperatures this proceeds so slowly as to cause no trouble. Additional difficulties arise in trying to work at temperatures above 40° C. in that the behavior of the galvanometer is irregular.

When the steel is dissolved in nitric acid it is not generally possible to use more than 0.2 g. of the sample. We have found a preferable procedure to be the use of a 0.5 g. sample in sulfuric acid. However, where the manganese is below 0.5 per cent 1 g. samples may be used. Our method is to dissolve 0.5 g. of the steel in 65 cc. of sulfuric acid of sp. gr. 1.20 and when solution is complete to oxidize with nitric acid added dropwise. After boiling a minute or two the solution is diluted with hot water to a volume of 200 cc., heated to boiling and 10 cc. of silver nitrate solution (2.5 g. in a liter) and 20 cc. of ammonium persulfate solution (100 g. in a liter) added. Boiling is allowed to continue about one minute when the solution is allowed to cool slowly, or rapidly with the aid of ice, according to convenience. When the solution is nearly cool enough, a little more sulfuric acid is added and the solution adjusted to about 20°. Titration is then made.

At the time titration is made in this method all of the chromium and vanadium present in the steel is in the oxidized condition, while in the method previously described these elements are oxidized only in part by the sodium bismuthate. In Table VIII analyses of Bureau of Standards sample steels are shown, some of which already contain chromium and vanadium, but an additional amount of chromium as chromate has been added in alternate determinations to illustrate the independence of the presence of chromic acid shown by this method. Samples weighing 0.5 g. were used and titration was made with permanganate and mercurous nitrate of such strength that 1 cc. was equivalent to 0.05 per cent in a half-gram sample.

In this method it is not important to make the titrations at once, as in the case after the filtration following oxidation with sodium bismuthate. Eight portions of Sample 35 were oxidized at the same time

TABLE VIII—THE DETERMINATION OF MANGANESE IN STEELS AFTER OXIDATION WITH AMMONIUM PERSULFATE

Temperature, 10 to 25° C. Volume, 250 cc. Sample, 0.5 g.

	Mn Found		
Sample	0.02 g. Cr Added as Chromate	No Cr Added	Mn Present
9a	0.896	0.896	0.915
9a	0.900	0.902	
19a	0.844	0.844	0.850
19a	0.830	0.850	
30	0.545	0.556	0.563
30	0.556	0.558	
31	0.158	0.154	0.156
31	0.165	0.144	
32	0.205	0.220	0.216
35	0.299	0.301	0.300
35	0.298	0.309	

and titrated at intervals during the succeeding 24 hrs. The lowest result was 0.298 and the highest 0.314 less than 0.02 per cent difference.

The two methods have been in use in this laboratory during some months. Young men without previous chemical training and with only a few weeks' experience in laboratory work after a few minutes' instruction have been able to make analyses of steels containing chromium, vanadium, molybdenum and tungsten, which could have been made by other methods only by men of large experience and a high degree of skill. Approximately a thousand determinations have been made by these methods and compared with other standard methods.

SUMMARY

I—A method has been shown for the determination of manganese in the presence of chromium or vanadium.

II—A method in two modifications has been shown for the electrometric determination of manganese.

III—A study of the reaction between permanganic acid and mercurous nitrate has been made.

IV—The method does not require special skill for its application.

RESEARCH DEPARTMENT
MIDVALE STEEL COMPANY
PHILADELPHIA

REAGENTS FOR USE IN GAS ANALYSIS
VI—THE ABSORPTION OF HYDROGEN BY SODIUM OLEATE

By R. P. ANDERSON AND M. H. KATZ

Received August 16, 1917

Bosshard and Fischli[1] have suggested the use of a solution of sodium oleate containing nickel in suspension, for the gas-analytical absorption of hydrogen. Inasmuch as they did not determine definitely the optimum conditions for the use of the reagent or its specific absorption,[2] experiments were undertaken to obtain data on these points. At the very outset the authors met with the difficulty of not being able to duplicate the results of Bosshard and Fischli in getting complete absorption of hydrogen. After various attempts, the method was abandoned, and this note has been prepared for publication in order that this experience with the reagent may be placed on record.

The procedure that is recommended by Bosshard

[1] *Z. angew. Chem.*, **28**, I (1915), 365.

[2] Anderson, THIS JOURNAL, **7** (1915), 587.

and Fischli for preparing the catalyst and carrying out the absorption, the one which the authors first tried to duplicate, is as follows:

Metallic nickel is prepared by the reduction of nickel oxide[1] by hydrogen at 340° C. The nickel oxide is placed in a glass tube provided with constrictions dividing it into compartments of such size as to hold easily about 4.3 g. nickel oxide each, and hydrogen is passed slowly through this tube. After reduction of the nickel oxide, the nickel is cooled in a current of hydrogen and the constrictions sealed off, thus separating the nickel into portions of about 3 g. in air-free containers. The reagent, which consists of a concentrated solution of sodium oleate in water to which about 3 per cent nickel has been added, is placed over mercury in a Hempel pipette, preferably modified by substituting for the long capillary connection a short glass tube of somewhat larger bore. To effect the absorption of hydrogen from a sample of gas, the sample is shaken with the reagent in the pipette for three minutes, allowed to stand under diminished pressure for three minutes as an aid in breaking up some of the troublesome foam which forms, and is then passed into a second pipette along with the remaining foam. Here the sample is shaken with the reagent for three minutes, and then to it is added about 1 cc. of alcohol to destroy the foam and enable the remaining gas to be drawn back into the burette for the reading of the decrease in volume.

Bosshard and Fischli used a lead bath for heating the tube. The authors found it preferable to employ a gas-heated combustion furnace of the usual form, taking proper precautions to avoid local overheating.

After first employing the bulbed tube as suggested by Bosshard and Fischli, and sealing off at the constrictions to preserve the nickel in an atmosphere of hydrogen, the authors substituted for it a straight tube about 3 cm. in diameter with a stopcock at each end, one of them having a bore of about 5 mm. After cooling the nickel in this tube in an atmosphere of hydrogen, the stopcocks were closed, thus preserving the entire product in one container. When a portion of the catalyst was desired, the tube was placed in a vertical position, with the stopcock of large bore at the lower end, and the proper amount of nickel allowed to pass out through the lower stopcock, pressure being furnished by the admission of hydrogen through the upper stopcock. This procedure simplified materially the preparation of the catalyst.

No figures are given by Bosshard and Fischli as to the actual concentration of sodium oleate in the solution which they employed. The authors used a 10 per cent solution of sodium oleate for the greater part of the experiments. Such a solution must be prepared shortly before using since it jellies rather rapidly on standing. Stronger solutions solidify too rapidly to be of use.

In the absence of any description of the method of introducing the nickel into the solution of sodium oleate without access of air, the following procedure was adopted: To the tip of the modified Hempel pipette for use with mercury was attached a short-stemmed funnel by means of a piece of rubber tubing. The air was forced out of the pipette by filling the bulb with mercury. With hydrogen flowing into the funnel through a glass tube inserted almost to the bottom, the desired amount of nickel was allowed to drop into the funnel from the tube in which the product was kept, the solution of sodium oleate being added immediately and the mixture drawn into the pipette by lowering the leveling bulb.

With the reagent finally in the pipette, samples of hydrogen were placed in contact with it, but with practically no absorption. Many attempts were made to obtain an active reagent, using metallic nickel prepared from nickel oxide of various degrees of fineness down to 200 mesh, but with no success. A temperature of 80° C. was maintained in the reagent in one case, but to no advantage. It was noticed, however, that the solutions of sodium oleate to which nickel had been added hardened much more quickly than those of the same concentration that contained no nickel. It was assumed that this was due to the "hardening" of the solution by the hydrogen adsorbed by the nickel. Accordingly, the preparation of nickel was modified by substituting a current of nitrogen for the hydrogen at the point when the reduction of the nickel oxide had been completed, continuing the heating of the material for a short time to drive off occluded hydrogen. The nickel was finally cooled in nitrogen and stored in an atmosphere of this gas. When this material was employed as a catalyst, the sodium oleate showed no tendency to harden sooner than it would have done in the absence of nickel, entirely in accordance with the suggested explanation, but the reagent thus obtained did not absorb hydrogen from gas mixtures placed in contact with it.

At this juncture, the attempt to ascertain the conditions under which complete absorption of hydrogen by sodium oleate in solution might be obtained was abandoned, because of certain objections inherent in the method which would make it of little value even when standardized and found capable of giving satisfactory results. Among these objections might be mentioned the following:

I—The time and effort required for the preparation of the catalyst is considerable, and the necessity of keeping it out of contact with air adds to the difficulty of its use.

II—The reagent foams badly and this renders the absorption process itself a lengthy and tedious operation.

III—The rapidity with which even moderately dilute solutions of sodium oleate solidify renders it necessary to prepare fresh solutions frequently. Also, old solutions must be discarded before they solidify in the pipette, otherwise they can be removed only with difficulty.

[1] Bosshard and Fischli used nickelic oxide, the authors used nickelous oxide.

CORNELL UNIVERSITY
ITHACA, NEW YORK

REAGENTS FOR USE IN GAS ANALYSIS
VII—THE DETERMINATION OF BENZENE VAPOR

By R. P. Anderson

Received August 16, 1917

In connection with the development of a new method for the determination of benzene vapor in gas, a brief history of the determination of this substance has been prepared, and is here presented. Following this historical summary, there is a brief statement of the principle of this new method, upon which considerable preliminary work has been done. The various methods that have been employed are taken up in chronological order.

FUMING NITRIC ACID METHOD

Berthelot[1] appears to have been the first to suggest a procedure for the determination of benzene vapor in illuminating gases. A sample of gas whose benzene content was desired was placed in contact with fuming nitric acid and the approximate amount of benzene determined either by weighing the dinitrobenzene formed or by determining the decrease in volume of the sample. Olefines were removed by bromine water previous to the treatment with fuming nitric acid. Treadwell and Stokes[2] found that the volumetric method gave unreliable results because treatment with bromine water for the removal of olefines results in the absorption of some of the benzene, and because fuming nitric acid, the reagent for benzene, also oxidizes carbon monoxide. Drehschmidt[3] found the method unsatisfactory for the same reasons, and it does not appear to have been used to any great extent.

DINITROBENZENE METHOD

The gravimetric method suggested by Berthelot was developed by Harbeck and Lunge[4] into one with which accurate results can be obtained. The gas to be examined is passed through a mixture of equal parts of fuming nitric acid and concentrated sulfuric acid, thereby quantitatively converting the benzene vapor into dinitrobenzene. The separation of the greater part of the dinitrobenzene from the acid is effected by diluting with water and neutralizing with sodium hydroxide. The crystals of dinitrobenzene which separate from the liquid on standing are separated by filtration, dried, and weighed. The dinitrobenzene remaining in solution is recovered by extraction with ether. The procedure recommended by Pfeiffer[5] differs from that just described in that the nitration is carried out on a sample of gas enclosed in a special container and in that the dinitrobenzene that is formed is not weighed, but is titrated with stannous chloride according to the method of Limpricht.[6]

COMBUSTION METHOD

Bunsen,[7] by making combustions on samples of illuminating gas before and after the absorption of benzene vapor and olefines by fuming sulfuric acid, obtained data from which he computed the amounts of benzene, ethylene, and propylene. The accuracy of this method depends upon the amount of other hydrocarbons, absorbable by fuming sulfuric acid, which may be present in the gas.

ALCOHOL METHOD

Bunsen[1] also determined the amount of benzene vapor and other hydrocarbon vapors present in illuminating gases by absorption in absolute alcohol. The hydrocarbons thus removed from the gas, consisting chiefly of benzene, are separated from the alcohol by pouring it into a large volume of a concentrated solution of sodium chloride, whereupon the hydrocarbons are obtained as an oily liquid upon the surface of the salt solution. Their amount is determined by weighing. By the method of Hempel and Dennis,[2] alcohol may be employed for the gas-volumetric determination of benzene vapor by employing 1 cc. of absolute alcohol in a pipette over mercury, and measuring the decrease in volume that results from contact of gas with the alcohol. Later Dennis and O'Neill[3] showed that, while concordant results may be obtained by the alcohol method, absorption of benzene by this reagent is by no means complete.

PHOTOMETRIC METHOD

Knublauch[4] has devised a method for the determination of benzene and ethylene in illuminating gases based upon the determination of the illuminating power of the gas and the total amount of benzene and ethylene present. From these data and a knowledge of the illuminating powers of benzene and ethylene in the pure state, the amounts of each can be determined. Graul[5] has utilized the photometric method by comparing the illuminating values of the gas before and after the removal of benzene. In the method employed by Reineke,[6] the amount of benzene is determined from the candle power of the flame, possible variations in the luminosity due to other constituents of the gas being disregarded.

CONDENSATION METHOD

Deville[7] has developed a method for determining the benzene vapor in gas mixtures by cooling to —22° C. and weighing the solid benzene which separates. Correction must be made for the vapor pressure of benzene at the temperature employed. Application of the principle of this method has been made by Neubeck.[8] According to the procedure followed by Burrell and Robertson,[9] the benzene vapor is condensed from a sample of gas by using a mixture of solid carbon dioxide and ether or acetone as a refrigerant. The gas which remains is pumped out and then the benzene is allowed

[1] *Compt. rend.*, **82** (1876), 871, 927; **83** (1876), 1255; *Ann. chim. phys.*, [5] **10** (1877), 171; **12** (1877), 289; *Bull. soc. chim.*, **50** (1888), 660.
[2] *Ber.*, **21** (1888), 3131.
[3] Post, "Chem.-techn. Analyse," 2nd Ed., Vol. I, pp. 108, 179.
[4] *Z. anorg. Chem.*, **16** (1898), 41.
[5] *J. Gasbel.*, **42** (1899), 698; *Chem.-Ztg.*, **28** (1904), 884.
[6] *Ber.*, **11** (1878), 35.
[7] "Gasometrische Methoden," **1877**, 2nd Ed., p. 142.

[1] "Gasometrische Methoden," **1877**, 2nd Ed., p. 144.
[2] *Ber.*, **24** (1891), 1162; *J. Gasbel.*, **34** (1891), 414.
[3] *J. Am. Chem. Soc.*, **25** (1903), 503.
[4] *J. Gasbel.*, **22** (1879), 652; **23** (1880), 253, 274.
[5] U. S. Patent No. 1,163,654, December, 1915.
[6] German Patent No. 285,920, June, 1914.
[7] *J. Gasbel.*, **32** (1889), 652.
[8] *Ibid.*, **58** (1915), 616. See also anonymous article in *Gas World*, **64** (1916), 224.
[9] This Journal, **7** (1915), 669

to vaporize, the pressure exerted by the vapor being determined from a manometer attached to the apparatus. Knowing the atmospheric pressure, the per cent by volume of benzene vapor is computed. A modification of the apparatus employed by Burrell and Robertson has been suggested by Whiton[1] as being more desirable for use in determining the efficiency of the benzol scrubbers used on coke-oven gas.

FUMING SULFURIC ACID METHOD

The determination of the combined benzene and ethylene content of an illuminating gas by fuming sulfuric acid may be utilized for the indirect determination of benzene when the amount of ethylene is determined by some other method. Haber and Oechelhäuser[2] have employed this procedure, determining the ethylene content of the gas mixture by treatment with standardized bromine water, and subsequent determination of the excess of bromine. Since benzene is also absorbed by bromine water, the combined benzene and ethylene content can be determined approximately by bromine water, as well as by fuming sulfuric acid. Haber and Lunge[3] have described a method for determining ethylene in the presence of benzene by causing the ethylene to combine with hydrogen in the presence of platinum black. The amount of benzene is then arrived at indirectly by taking the difference between the combined benzene and olefine content, as determined by fuming sulfuric acid, and the ethylene content.

PARAFFIN OIL METHOD

Müller[4] has proposed that benzene vapor in illuminating gas be determined by passing the gas through cooled paraffin oil. The greater part of the benzene vapor can be absorbed by this method. Nowicki[5] had described a special absorbing device for carrying out this determination. The method has been elaborated by Krieger.[6] Neubeck[7] has modified the procedure by distilling off the benzene taken up by the oil, but does not recommend the method on account of the difficulty in maintaining air-tight joints during the distillation. Copp[8] has described the procedure adopted by him in obtaining more efficient absorption of the benzene vapor.

SPECIFIC GRAVITY METHOD

In Lunge's "Chemisch-technische Untersuchungsmethoden," Vol. 2 (1900), p. 586, there is described a method for determining the benzene content of an illuminating gas from the specific gravity of the gas and the amount of olefines in it. This method is open to the objection that possible variations in the amounts of the other constituents of the gas are not considered.

AMMONIACAL NICKEL CYANIDE METHOD

Dennis and O'Neill[9] developed a gas-volumetric method for the determination of benzene, employing as a reagent an ammoniacal solution of nickel nitrate. Later Dennis and McCarthy[1] suggested the use of an ammoniacal solution of nickel cyanide instead of nickel nitrate, having found that more uniformly reliable results could be obtained with the former reagent.

SULFURIC ACID METHOD

Morton[2] has suggested the use of concentrated sulfuric acid for the absorption of benzene vapor in the presence of ethylene. Dennis and McCarthy[3] found that this reagent does not give satisfactory results both on account of the fact that some ethylene is absorbed by it, and also because the absorption of benzene is not complete.

SATURATION METHOD

The Société Roubaisienne d' Eclairage par le Gaz and RR. L. H. Forrieres[4] have developed a method for benzene based upon the determination of the amount of benzene that is required to saturate a known volume of gas. After computing the amount that would be required, under the conditions of the experiment, for gas containing no benzene vapor, the benzene content of the gas is gotten by difference.

THE NEW METHOD

During the summer of 1915, in attempting to develop a method for determining benzene vapor in gas simply, quickly, and accurately, the author did considerable preliminary work upon a method which appears more nearly to satisfy these requirements than any of the methods that have been mentioned. In the proposed method, a measured quantity of gas containing an unknown amount of benzene vapor is placed in contact with benzene in a special apparatus and the increase in volume read. By determining what the increase in volume would have been, had the gas contained no benzene vapor, the amount of benzene vapor actually present is easily computed. That this idea is not entirely new was learned when a search of the literature was made and reference to the German Patent described under the previous heading was found. The procedure that has been employed is, however, much simpler and quicker than that described in the patent.

Owing to the failure of attempts to obtain, under present conditions, apparatus considered essential for the proper standardization of the method, its further development has been temporarily postponed.

CORNELL UNIVERSITY
ITHACA, NEW YORK

[1] THIS JOURNAL, **8** (1916), 733.
[2] *Ber.*, **29** (1896), 2700; *J. Gasbel.*, **39** (1896), 804.
[3] *Z. anorg. Chem.*, **16** (1898), 26.
[4] *J. Gasbel.*, **41** (1898), 433.
[5] *Ibid.*, **48** (1905), 292.
[6] *Ibid.*, **58** (1915), 61.
[7] *Ibid.*, **58** (1915), 815.
[8] *Gas World*, **66** (1917), 222.
[9] *J. Am. Chem. Soc.*, **25** (1903), 593.

RESEARCH ON THE DETECTION OF ADDED WATER IN MILK

By HALSEY DURAND AND RUSTON STEVENSON

Received September 13, 1917

At the annual meeting of the American Chemical Society, held in New York City, September 27, 1916, one of the authors read a paper on "The Detection of Added Water in Milk,"[5] in which the importance of devising a rapid and accurate method was brought

[1] *J. Am. Chem. Soc.*, **30** (1908), 253.
[2] *Ibid.*, **28** (1906), 1732.
[3] *Ibid.*, **30** (1908), 233.
[4] German Patent No. 267,491, May, 1913.
[5] THIS JOURNAL, **9** (1917), 44.

out and a review of the existing methods was presented.

The *first* was the determination of the refractive index of the milk serum, which, while having the advantage of speed, proved unreliable for the detection of less than 10 per cent of added water, vastly too great a margin. The *second* was the determination of the freezing point,[1] the elevation above that of normal milk indicating the percentage of added water; this is an excellent method, but one requiring too much time for a routine laboratory. A *third* method, the determination of the specific gravity of the whole milk and of the serum, was also mentioned as having been in use for many years, but never having given satisfactory results.

A brief outline was given, in which methods for further research were proposed and the results obtained are the subject of this contribution.

I—The first of these methods to be investigated was based on the theory that added water would increase the solubility of inorganic salts in the serum. A series of determinations was made using a weighed amount of anhydrous lead subacetate. The reagent was that used in Horne's methods for sugar analysis. Experiment showed that 3 g. were required for the coagulation of 100 cc. of milk. After the addition of the subacetate, the contents of the flask were vigorously shaken to coagulate the milk thoroughly. The contents of the flask were poured on a dry folded filter and 50 cc. of the serum collected for the determination. The lead was precipitated with 25 per cent of sulfuric acid, and alcohol added to facilitate the precipitation. The lead sulfate was collected in an alundum crucible, washed with water and finally with alcohol, ignited and weighed. Several determinations were made by the above method.

The results proved unreliable, in that a variable amount of the subacetate in solution is adsorbed by the coagulum, and that, owing to the slowness of the filtration, it proved impractical to wash out all of the organic matter not coagulated, this latter causing a reduction of a portion of the lead sulfate when ignited.

[1] *Chem. News*, **110**, No. 2870, p. 259; No. 2871, p. 275; No. 2872, p. 283.

II—A second series of determinations was made, in which weighed amounts of finely divided silver nitrate was used for the coagulation. The procedure was the same as described under I. The silver in 50 cc. of the serum was determined by titration with $N/10$ ammonium sulfocyanate, after addition of nitric acid and using ferric ammonium sulfate as indicator. This method is much more accurate and rapid than Method I, but the results show that the differences in the number of cc. used, in milks of known purity, are sometimes greater than those between whole milk and samples watered in the laboratory. The method was, therefore, abandoned as useless.

III—The third method, the determination of the electrical conductivity by method of Kohlrausch of the whole milk, and of the serum after coagulation with electrolytes and non-electrolytes, has been tried out in an exhaustive manner during the past year by the authors.

Through the courtesy of Dr. Charles Baskerville, director of the Department of Chemistry, of the College of the City of New York, permission was obtained to carry on these experiments in the laboratories of that institution.

The first series of experiments (Table I) was performed in a cell used for conductivity experiments in the laboratory, in which the electrodes were kept at a uniform distance, but were placed in the cell after filling without regard to their proximity to the sides. This cell was designated as No. 1. A constant temperature was maintained during all of the following determinations, by warming the water by a coil of resistance wire, and stirring by bubbling compressed air, the current in the coil being regulated by a rheostat. It will be observed from these results that there is a decided similarity in the results on whole milk, and also following the theory, the milks to which water has been added give a lower conductivity.

In the second series of experiments, Table I, Cell 2, a cell similar in construction to Cell 1 but of greater capacity and with larger electrodes than the above, was used.

Here as with Cell 1, the samples of known purity gave excellent results. The results on the samples

TABLE I—PRELIMINARY EXPERIMENTS

Cell No.	Sample	No.	Temp. °C.	Conductivity
1	Whole Milk *a*	1	25.2	0.00527
	b	2	25.17	0.00520
	c	3	25.15	0.00520
	b + 10% Distilled Water	4	25.10	0.00479
	a + 10% Croton Water	5	25.17	0.00478
	c + 10% Distilled Water	6	25.07	0.00466
	Whole Milk *a*	7	24.95	0.00513
2	Milk from Individual Cow	1	25.0	0.00522
		2	25.0	0.00523
		3	25.0	0.00522
	Suspicious Sample	4	25.0	0.00549
		5	25.0	0.00517
	Sealect, Grade A	6	25.0	0.00503
	After Standing in Ice-box for 2 days	7	25.0	0.00585
		8	25.0	0.00530
		9	25.0	0.00521
		10	25.0	0.00571
		11	25.0	0.00624
		12	25.0	0.00755
		13	25.0	0.00560
		14	25.0	0.00515
		15	25.0	0.00569

TABLE II—TESTS USING TEST-TUBES AS CELLS

Temperature, 25° C.

Sample	No.	Conductivity
Authentic Sample	1	0.00543
Authentic Sample	2	0.00504
Same as 2	3	0.00504
Same as 1	4	0.00518
Same as 2	5	0.00475
Authentic Sample	6	0.00504
Authentic Sample	7	0.00495
Authentic Sample	8	0.00460
Authentic Sample	9	0.00563
Same as 1	10	0.00559
Same as 2	11	0.00605
Same as 3	12	0.00712
Same as 4	13	0.00727

TABLE III—TESTS USING CELL NO. 2, ACCURATELY FILLED TO MARK

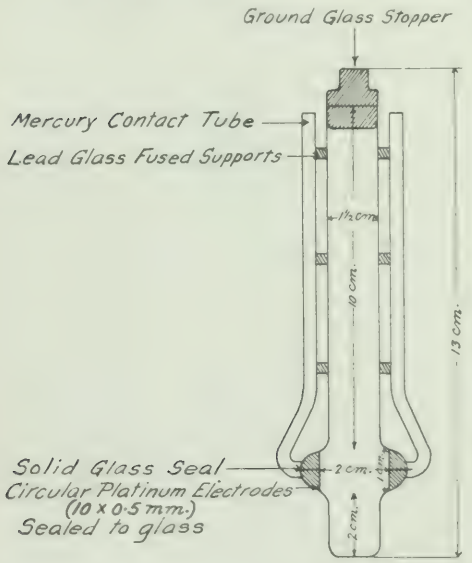
Temperature, 25° C.

Sample	No.	Conductivity
Borden's Grade B, pasteurized	1	0.00519
Borden's Grade B, pasteurized	2	0.00519
Locust Farm Grade B, pasteurized	3	0.00516
Milk from Individual Holstein Cow (Morning Milking, unpasteurized)	4	0.00519
	5	0.00516
	6	0.00519
	7	0.00513
	8	0.00519
No. 4 + 10% Distilled Water	9	0.00478
+ 10% Distilled Water	10	0.00478
+ 20% Distilled Water	11	0.00430
+ 50% Distilled Water	12	0.00307
+ 1.3% Distilled Water	13	0.00513
+ 3% Distilled Water	14	0.00503
+ 5% Distilled Water	15	0.00491
+ 7% Distilled Water	16	0.00482
+ 10% Distilled Water	17	0.00477
Grade A Milk from 1/2 bottle (2 days old)	18	0.00503
Cream from No. 8	19	0.00439
Milk from 1 after Removal of Cream	20	0.00532

marked, "in ice-box 2 days," are not to be relied on, as change in composition has probably taken place.

In Table II, [illegible] of the same commercial size, were used to facilitate the work, as a number of tubes could be placed in the bath at the same time, to bring them to the required temperature. The same methods were used as in Table I. In this series a wide deviation was observed on different tube containing the same milk, amounting at most to 37.0 per cent in the conductance. This was found to be due to the difference in size of the tubes and to the amount of sample contained. To avoid a continuance of these errors a file mark was made on Cell 2 and in the subsequent determinations the cell was carefully filled to this mark.

The results in Table III for the whole milk are much more uniform than in the previous determinations, but a variation still persists. The samples to which



water has been added show a regular decrease in conductivity as the amount of water added increases. A search of the literature on electrical conductivity, while discussing the size and distance of the electrodes and the form of the cell, fails to make mention of the error introduced by using varying amounts of solution. This phenomenon is being made the subject of a separate investigation.

As a final effort to determine the cause of the above variations in the whole milk a special cell was constructed as shown in the accompanying drawing. This cell has the advantage that the electrodes are sealed in a permanent position, a constant distance apart, and with the same amount of liquid above and below them.

The results in Table IV are [illegible]

TABLE IV—TESTS USING [illegible] No. 3

Temperature, 28° C.

SAMPLE OF MILK	No.	Conductivity
[illegible] days after pasteurization	1	0.00546
Raw Herd Milk from Fresh cow	2	0.00540
[illegible]	3	0.00541
Grade B pasteurized (Borden's	4	0.00563
Same, another sample	5	0.00559
Same, another sample	6	0.00559
[illegible]	7	0.00544
Grade B pasteurized (Clover Farm)	8	0.00569
Same, another [illegible]	9	0.00566
Grade B pasteurized Mixed Melrose	10	0.00563
No. 4 + 2 per cent distilled water	11	0.00546
No. 4 + 5 per cent distilled water	12	0.00537
No. 4 +10 per cent distilled water	13	0.00512
No. 4 + [illegible] per cent distilled water	14	0.00536
No. 4 + [illegible] per cent distilled water	15	0.00523
No. 8 + 5 per cent distilled water	16	0.00541
Grade B collected from shop	17	0.00539
	18	0.00541
	19	0.00550
	20	0.00560
	21	0.00561
	22	0.00555
No. 22 repeated after 5 minutes	23	0.00554
Grade B collected from shop	24	0.00558
	25	0.00577
	26	0.00579
	27	0.00535
	28	0.00558
No. 27 repeated	29	0.00536
Grade B collected from shop	30	0.00560
	31	0.00575
	32	0.00554
	33	0.00567
	34	0.00566
	35	0.00563
	36	0.00564
	37	0.00563
	38	0.00577
	39	0.00554
	40	0.00537
	41	0.00546
Grade A collected from shop	42	0.00555
	43	0.00552
	44	0.00532
	45	0.00534
	46	0.00535
	47	0.00530
	48	0.00548
Grade A, mixed samples, 1st bottle	49	0.00652
2nd bottle	50	0.00633
Authentic sample	51	0.00678
No. 51 second reading	52	0.00682
Authentic sample	53	0.00450
	54	0.00643
Same as above after 30 minutes	55	0.00843
No. 53 + 7 per cent water	56	0.00435
AUTHENTIC SAMPLE, unpasteurized	57	0.00555
Milk from 3 or 4 mixed breed cows	58	0.00552
Same as above after 30 minutes	59	0.00565
No. 59 after 40 minutes	60	0.00569
Same as No. 57	61	0.00575
	62	0.00551
No. 62 second reading	63	0.00545

in that a wide discrepancy in conductivity exists even in authentic samples. It was then decided to separate the milk and cream and to determine the conductivity of the skimmed milk. Through the courtesy of Messrs. Paul and Terhune of the DeLaval Separator Company, a cream separator was obtained and the samples separated. Determinations were made on whole milk, skimmed milk and cream.

The determinations in Table V were made under ideal conditions. The cell was accurately filled to the mark, the temperature kept at 28.0° C. ±0.05 and correction made for each [illegible]. A large number of the samples were collected under the personal supervision of department inspectors so that there could be no doubt as to their authenticity. The method of measurement was sufficiently sensitive to detect 0.5 per cent of added water, and the fact that the cell constant did not vary was confirmed by frequent determinations, using $N/50$ potassium chloride solution. To preclude the possibility of error through improper running of the separator, a representative of the

TABLE V—DETERMINATION ON WHOLE AND SKIMMED MILK AND CREAM

Authentic Samples. From 5 Cows. Milk from 4 Cows in Each Can. Morning Milkings (1-13)

Temperature, 28° C.

SAMPLE	No.	Conductivity
Whole Milk, Can No. 1	1	0.00561
No. 1 after separation	2	0.00590
Whole Milk, Can No. 2	3	0.00592
No. 2 after separation	4	0.00629
Whole Milk, Can No. 3	5	0.00567
No. 3 after separation	6	0.00605
Whole Milk, Can No. 4	7	0.00595
No. 4 after separation	8	0.00621
Whole Milk, Can No. 5	9	0.00555
No. 5 after separation	10	0.00594
No. 5 after separation and filtering to remove air bubbles	11	0.00595
No. 4 after separation, coagulated with rennin and filtered	12	0.00672
No. 3 after separation, coagulated with pancreatin and filtered	13	0.00643
One Holstein cow producing 16 qts. per day	14	0.00539
One Jersey cow producing 14 qts. per day	15	0.00601
Mixed Jersey and Holstein herd	16	0.00555
	17	0.00547
Holstein herd	18	0.00554
No. 14 after separation	19	0.00576
No. 15 after separation	20	0.00627
No. 16 after separation	21	0.00596
No. 17 after separation	22	0.00581
No. 18 after separation	23	0.00586
No. 18 after separation and filtration	24	0.00586
Grade B, pasteurized (Borden's)	25	0.00565
Grade B, pasteurized (Sheffield)	26	0.00543
Grade B, pasteurized (Clover Farms)	27	0.00580
Grade A, pasteurized (Locust Farms)	28	0.00573
Grade A, pasteurized (Sealect Sheffield)	29	0.00560
No. 25 after separation	30	0.00596
No. 26 after separation	31	0.00581
No. 27 after separation	32	0.00605
No. 28 after separation	33	0.00599
No. 29 after separation	34	0.00586
No. 29 coagulated with rennin and filtered	35	0.00611
No. 28 coagulated with rennin and filtered	36	0.00645
One Holstein cow	37	0.00590
One Durham cow	38	0.00538
Mixed Holstein and Durham herd	39	0.00560
	40	0.00559
	41	0.00560
No. 37 after separation	42	0.00607
No. 38 after separation	43	0.00574
No. 39 after separation	44	0.00587
No. 40 after separation	45	0.00599
No. 41 after separation	46	0.00599
1 qt. morning milk 4 or 5 cows	47	0.00538
	48	0.00562
Mixed common herd unpasteurized	49	0.00561
	50	0.00561
	51	0.00603
No. 47 after separation	52	0.00574
No. 48 after separation	53	0.00589
No. 49 after separation	54	0.00616
No. 50 after separation	55	0.00593
No. 51 after separation	56	0.00632
Separated cream from all samples mixed	57	0.00395
Separated milk from all samples mixed	58	0.00601
Separator run by representative of DeLaval Co. Milk from single Holstein unpasteurized	59	0.00576
	60	0.00555
	61	0.00536
	62	0.00606
	63	0.00569
No. 59 after separation	64	0.00606
No. 60 after separation	65	0.00586
No. 61 after separation	66	0.00569
No. 62 after separation	67	0.00614
No. 63 after separation	68	0.00610
Mixed separated milk + 5 per cent separated cream	69	0.00593
+ 10 per cent separated cream	70	0.00589
Mixed separated milk, all samples	71	0.00602
Mixed separated cream, all samples	72	0.00445
Grade A, certified unpasteurized (Sheffield)	73	0.00554
Grade A, pasteurized (Locust Farms)	74	0.00581
Grade A, pasteurized (Sheffield, Sealect,)	75	0.00573
Grade A, pasteurized (Sheffield, Sealect)	76	0.00552
Grade A, pasteurized (Mutual-McDermott)	77	0.00547
No. 73 after separation	78	0.00591
No. 74 after separation	79	0.00619
No. 75 after separation	80	0.00595
No. 76 after separation	81	0.00575
No. 77 after separation	82	0.00570
Separated cream from No. 73	83	0.00448
Separated cream from No. 74	84	0.00431
Separated cream from No. 75	85	0.00435
Separated cream from No. 76	86	0.00414
Separated cream from No. 77	87	0.00417
Grade B raw taken from cans	88	0.00585
	89	0.00592
Nos. 88 and 89 mixed	90	0.00589
Grade B raw taken from cans	91	0.00545
	92	0.00537
Nos. 91 and 92 mixed	93	0.00540
Nos. 88, 89, 91, 92 mixed	94	0.00563
No. 89 second reading	95	0.00555
Nos. 88, 89, 91, 92 mixed, after separation	96	0.00589
	97	0.00596
	98	0.00592
	99	0.00594
No. 95 after separation	100	0.00597
No. 88 after separation and standing 24 hours	101	0.00590

DeLaval Company, separated the samples in Determinations 59 to 72.

As the milk after separation contains air bubbles, the milk was filtered to remove them. It was found that the readings before and after filtration did not vary (Nos. 10 and 11).

As the samples were run through the separator one after another, it was deemed advisable to determine if the samples were affected by the ones preceding. Four samples were mixed thoroughly, then divided again into 4 samples and run through the separator successively (Nos. 96 to 99). Three of these results were fairly uniform.

It will also be observed that the average of the readings on individual milks corresponds very closely with the reading after mixing Nos. 88 to 94.

With all known sources of error eliminated the readings on authentic samples still showed so wide a difference as to render the method useless.

In the freezing-point determination the fat and protein of the milk play no part and the constant depends entirely on the concentration of the substances in solution.

In the conductivity measurements, however, the fat and protein of the milk decrease the specific conductance by decreasing the number of ions between the electrodes in just the same manner as would glass beads placed in the cell between the electrodes.

A final series of determinations (Table VI) was made on samples of milk coagulated with basic lead acetate

TABLE VI—TESTS USING MILK SERA

Temperature, 28° C.

SAMPLE	CHEMICAL ANALYSIS Total Solids	Fat	No.	Conductivity
AA–223	11.82	3.3	1	0.00653
AA–226	12.01	3.4	2	0.00645
AA–227	13.18	3.6	3	0.00647
AA–228	11.94	3.4	4	0.00647
AA–230	12.06	3.5	5	0.00649
AA–232	11.90	3.6	6	0.00645
AA–233	11.78	3.5	7	0.00645
AA–234	11.94	3.4	8	0.00649
AA–235	12.13	3.5	9	0.00643
B–456	11.94	3.4	10	0.00651
B–457	12.13	3.5	11	0.00649
B–460	11.70	3.2	12	0.00649
B–461	12.38	4.0	13	0.00653
B–463	12.28	3.8	14	0.00647
2A–501	12.36	3.4	15	0.00647
2B–505	11.87	3.4	16	0.00643
2A–505				
Serum + 5 per cent water			17	0.00653
Serum from authentic milk Grade A raw			18	0.00682
			19	0.00659
			20	0.00667
			21	0.00682
			22	0.00657
			23	0.00667
As above + 5 per cent water			24	0.00659
+ 5 per cent water			25	0.00663
+ 10 per cent water			26	0.00678
+ 10 per cent water			27	0.00616
+ 20 per cent water			28	0.00573
+ 20 per cent water			29	0.00591

(Horne's). One hundred cubic centimeters of the milk were taken and 3 g. of the acetate accurately weighed and added, thoroughly shaken and filtered to 50 cc. Readings were then made on the clear sera.

The determinations made on laboratory samples 1 to 16 show a fair degree of uniformity. It will be observed from a comparison of the conductivity and the chemical analysis, that the differences in fat and total solids content bear no relation to the differences in conductivity. The sera from authentic samples 18 to 23 show a far greater variation than has been observed in any of the foregoing determinations and the results are entirely unreliable.

In the authentic samples adulterated in the laboratory (24 to 29) the water was first added to the samples and 100 cc. of the adulterated milk were then taken and coagulated as described above.

These results show great differences, even at the same adulteration and these differences are greater than those between the authentic and adulterated samples. This is probably due to an irregular adsorption of the lead salt by the coagulum, which would account for the lack of uniformity in the results, as was the case in experiments mentioned under Method I at the beginning of this paper.

Having tried out the method and investigated all of the modifications at hand in a most exhaustive manner and being unable to obtain any uniformity in results it was decided to abandon the method as impractical.

It is to be regretted that this method proved ineffective, as a rapid and accurate method of this sort would be of great value to the food analyst.

One of the authors, Durand, proposes at an early date to continue this research, making use of the osmotic pressure of milk, in a cell specially constructed to measure the differential osmotic pressure between milks and a standard saline solution.

CHEMICAL LABORATORY, DEPARTMENT OF HEALTH
AND
COLLEGE OF THE CITY OF NEW YORK
NEW YORK CITY

THE LOGANBERRY AND THE ACID CONTENT OF ITS JUICE

BY MILO REASON DAUGHTERS

RECEIVED SEPTEMBER 24, 1917

Attention has been called to the composition of loganberry pulp and juice and to the drying properties of loganberry oil.[1] This paper gives the composition of the fresh, ripe, whole berry and some data on the juice, with special reference to its acid content.

TABLE I—COMPOSITION OF THE LOGANBERRY[2]

	Per cent
Total Solids	20.74
Moisture	79.26
Citric Acid (anhydrous)	1.52
Invert Sugar	7.15
Sucrose	Absent
Proteins (N × 6.25)	4.85
Fat (ether extract)	0.613
Crude Fiber	1.38
Ash	0.571

[1] THIS JOURNAL, 9 (1917), 1043.

[2] Colby reported the analysis of a sample of California loganberries. California Experiment Station Report, 1895, 177.

The sample (Table I) was taken from 14 lbs. of berries gathered at the close of a uniformly dry season. Total moisture was obtained by heating *in vacuo* at 70° C. to constant weight. An electric muffle furnace heated to dull redness was used for the ash determinations. Citric acid was estimated by the method given in the *Journal of the Association of Official Agricultural Chemists*, Vol. 2 (1916), 183.

TABLE II—COMPOSITION OF THE [illegible]

SAMPLE NO.	I	II	III	IV
Date of Collection (1917)	July 18	July [illegible]	July 25	August 7
Specific Gravity 15° C.	[illegible]	[illegible]	[illegible]	1.0599
Acidity as anhydrous citric	[illegible]	[illegible]	[illegible]	1.54
Citric Acid (anhydrous)	1.82	1.521	1.511	1.54
Volatile Acids (acetic)	[illegible]	[illegible]	[illegible]	[illegible]
Total Solids	[illegible]	[illegible]	[illegible]	14.74
Invert Sugar	8.35	[illegible]	[illegible]	8.74
Protein (N × 6.25)	[illegible]	[illegible]	[illegible]	0.87
Ash	....	0.499	0.45	0.39

The first three samples of juice were pressed from 4 to 5 lbs. of berries purchased in the open market. The berries were ground in a food chopper and then pressed in a small fruit press lined with doubled bird's-eye cotton cloth. Sample IV was obtained in a similar manner in a larger press from 14 lbs. of berries after removing the sample for the analysis given in Table I. The specific gravity readings were made by the pycnometer method on the juice which was kept in a constant temperature bath at 25° C.

Dunbar and Lepper[1] have made a study of the Kunz[2] modification of Stahre's method[3] for the quantitative estimation of citric acid and have announced its applicability to fruit products. This method was applied directly to the juice without preliminary precipitation of the citric acid as the barium salt in the last three samples. Twenty-five grams of juice were placed in a volumetric flask of 100 cc. capacity, and 2 cc. of dilute sulfuric acid and 5 cc. of freshly prepared bromine water added, and then made up to the mark with distilled water. Aliquots of 25 cc. each were used in the analysis. Approximately 40 cc. of 5 per cent potassium permanganate were required to complete the oxidation of the citric acid, pectins, sugars, etc. Pentabromacetone separated in a very satisfactory manner as a white semicrystalline solid, leaving a clear supernatant liquid after the addition of ferrous sulfate.

Samples II and III were examined for volatile acids, which were found to be present in traces. Tartaric acid was found in traces by Jorgensen's method.[4] Dunbar and Bacon's[5] uranyl acetate method for malic acid was tried on Sample I, but with negative results.

In conclusion, it may be stated that citric is the chief acid of the loganberry. Traces of tartaric and volatile acids are also present. Malic acid is absent.

DEPARTMENT OF CHEMISTRY
OREGON STATE AGRICULTURAL COLLEGE
CORVALLIS

[1] *Jr. A. O. A. C.* **3** (1916), 182, No. 4 [illegible]

[2] *Arch. Chem. Mikros.*, **7** (1914), 285; *Chem. Abs.*, **9** (1915), 687.

[3] *Nordisk Tidsskrift*, **2** (1895), 141; *Z. anal. Chem.*, **36** (1897), 195.

[4] *Z. N[illegible]* **17** (1909), 897. [illegible] Handbuch Biochem Arbeitsmeth." **2** (1910), 38 [illegible] **3** [illegible] 81.

[5] U. S. Dept. of Agr. Bureau of Chemistry [illegible] 76 *Jr. A. O. A. C.*, **2** (1917), 179; THIS JOURNAL, **3** (1911), 826.

REACTION OF HAWAIIAN SOILS WITH CALCIUM BICARBONATE SOLUTIONS, ITS RELATION TO THE DETERMINATION OF LIME REQUIREMENTS OF SOILS, AND A RAPID APPROXIMATE METHOD FOR THE DETERMINATION OF LIME REQUIREMENTS OF SOILS[1]

By Maxwell O. Johnson

Received October 1, 1917

The importance of liming for the maintenance of soil fertility is so well recognized that a number of methods for determining the lime requirements of soils have been proposed. Most of these methods are based on reactions which do not parallel those occurring in the field. Whether lime is applied as oxide, hydroxide or carbonate the main reaction of the limed soil would appear to be with calcium bicarbonate in solution.

Hutchinson and MacLennan[2] and MacIntire[3] have proposed methods for determining the lime requirements of soils using calcium bicarbonate solutions. In the Hutchinson-MacLennan method, 10-20 g. of soil are shaken for 3 hours with 200 to 300 cc. of an approximately 0.02 *N* bicarbonate solution. After filtering, a portion of the filtrate is titrated with 0.1 *N* acid, using methyl orange as an indicator to determine the calcium carbonate absorbed by the soil. In the MacIntire method 150 cc. of bicarbonate solution are evaporated with 10 g. of soil to a thin paste and the excess calcium carbonate estimated by the CO_2 liberated with acid.

An investigation has been made of the reaction of typical Hawaiian soils with calcium bicarbonate solutions under various conditions. As a preliminary announcement of results, it may be stated that the extent of the reaction has been found to depend on the usual factors influencing absorption, *i. e.*, the nature of the soil, the concentration of solution, the period of contact and the ratio of soil to solution. This would account for the variations in results obtained by the Hutchinson-MacLennan and by the MacIntire methods when slight variations are made in the methods of procedure.[4]

The absorption by the soils from calcium bicarbonate solutions increased with the period of contact and approached an equilibrium. As the concentration of the bicarbonate solution was decreased, the absorption decreased in amount but an increasing percentage of the total calcium carbonate in the bicarbonate solution was absorbed. This would show that by using solutions of decreasing concentrations or by using increasing weights of soil a point would be reached where absorption would be practically complete under prolonged contact sufficient to insure equilibrium of the soil with the solution. The total amount of calcium carbonate (calculated as per cent of the weight of the soil) in the solution at and below whose concentration absorption by a given soil is complete, would appear to express a definite absorptive capacity for that soil. This definite absorptive capacity has been designated the "minimum absorption." An amount of calcium carbonate slightly in excess of the minimum absorption would appear to be the correct application to make in the field as being sufficient to insure a slight alkaline reaction. In theory, the lime requirements of a soil by the Veitch method[1] should lie very slightly above the minimum absorption, since the Veitch method depends, in principle, upon the satisfying of the minimum absorption of a soil and the presence in the solution, which is allowed to stand in contact with the soil over night, of sufficient calcium bicarbonate to give an alkaline reaction to phenolphthalein when 50 cc. are boiled down to 5 cc. Under the practical conditions of the method, however, some of the factors introduced may cause the results to differ from the minimum absorption. The lime requirements of soils by the Hutchinson-MacLennan method,[2] by the MacIntire method,[3] by the Tacke method,[4] by Süchting's modification[5] of the Tacke method, and by the Vacuum method of Gaither[6] would be much greater than the minimum absorption and depend on the conditions selected, since the results are determined from the absorption when the soil is in equilibrium with a large excess of calcium bicarbonate in solution.

The minimum absorption of a soil may be determined as defined above by subjecting to prolonged contact a constant weight of soil with decreasing concentrations of bicarbonate solution or increasing weights of soil with a constant concentration of bicarbonate solution and determining the point where complete absorption occurs.

For the routine examination of soils, where great accuracy is not required, a rapid approximate method of determining lime requirements has been worked out and appears to give good results. It was found that when "acid" Hawaiian soils were shaken with solutions of sufficient concentration to insure a fairly rapid contact of solute with soil particles, an extemely rapid absorption reaction takes place, approaching in velocity that of an ionic reaction with a soluble acid, which reaction is followed by a much slower increase in the absorption with the time. This is illustrated by the following experiment:

200 cc. portions of 0.01 *N* calcium bicarbonate solution were measured out in 500 cc. Erlenmeyer flasks. The soils used were three typical acid Hawaiian soils and an alkaline station soil containing 1.63 per cent CaO. 10 g. of soils were added to each flask and the flasks immediately stopped and shaken vigorously by hand for 1, 2, 3, 4, 5, 7 and 10-minute periods. At the conclusion of the period of shaking, the flasks were opened, and the contents filtered through a 24 cm. folded filter paper, discarding the first 40 or 50 cc. of filtrate. 100 cc. of the filtrate were titrated with 0.1 *N* HCl, using methyl orange as an indicator. The absorption was measured by the difference in titration between

[1] Published by permission of the Secretary of Agriculture.

[2] *J. Agr. Sci.*, [1] **7** (1915), 75–105.

[3] This Journal, **7** (1915), 864–867.

[4] See *Jour. Assoc. Off. Agr. Chem.*, **3** (1917), 133–149.

[1] *Jour. Amer. Chem. Soc.*, **24** (1902), 1120–1128; **26** (1904), 637–662.

[2] *Loc. cit.*

[3] *Ibid.*

[4] *Chem.-Ztg.*, **21** (1897), 174–175.

[5] *Z. angew. Chem.*, **21** (1908), 151–153.

[6] This Journal, **8** (1916), 243–246.

100 cc. of the original bicarbonate solution and of the filtrate, 0.1 cc. of 0.1 *N* acid difference in titration being equivalent to an absorption of 0.01 per cent calcium carbonate by the 10 g. of soil. The results are given in Table I and in graphical form in Fig. 1.

TABLE I—ABSORPTION FROM CALCIUM BICARBONATE SOLUTIONS BY HAWAIIAN SOILS UNDER VARIOUS PERIODS OF CONTACT

Absorption expressed as calcium carbonate in per cent of the weight of the soil

Time of Shaking Minutes	Haiku Soil	Kaiwiki Soil	Waipio Soil	Alkaline Station Soil
1	0.17	0.34	0.24	0.03
2	0.20	0.39	0.29	0.04
3	0.23	0.41	0.35	0.05
4	0.25	0.43	0.36	0.05
5	0.26	0.45	0.37	0.05
20	0.28	0.48	0.39	0.06
10	0.30	0.50	0.41	0.06

An examination of Table I and Fig. I shows, with the Haiku and Kaiwiki soils, the very rapid reaction taking place during the first minute of shaking and the much slower absorption which follows. With the Waipio soil, the rapid reaction apparently requires 3 minutes' shaking for completion. The alkaline station soil shows a slight, slowly increasing absorption. It should be noted that the absorption during the first rapid

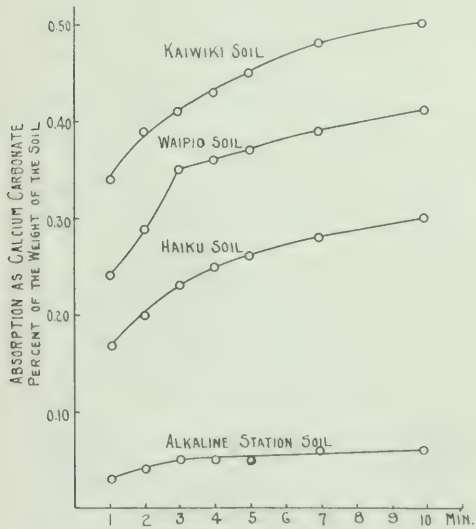


FIG. 1—CURVES SHOWING THE EFFECT OF THE TIME OF SHAKING UPON THE ABSORPTION BY HAWAIIAN SOILS FROM CALCIUM BICARBONATE SOLUTION

reaction corresponds closely with the lime requirements by the Veitch method[1] which are 0.17, 0.31, and 0.32 per cent calcium carbonate for the Haiku, Kaiwiki and Waipio soils, respectively.

The method of examination used in the above experiment has been applied to over 80 Hawaiian soils, and the absorption during the first rapid reaction appears to offer quite an accurate measure of the lime requirements of these soils. Determining the lime requirements of a soil by the absorption during a single shaking of one minute appears sufficiently accurate for routine soil examinations.

Due to the known peculiar nature of Hawaiian soils, 48 soil samples were secured for camparison from 8 different mainland states and the method used in the above experiment applied to these samples. It was found that the time of shaking could be shortened to 10 seconds for these mainland soils. The absorption during this 10 seconds' shaking corresponded closely with the lime requirements for these soils by the Veitch method and with the amounts of lime which general experience has found best in field trials, running from 1 to 3 tons of calcium carbonate per 2,000,000 lbs. of soil for ordinary acid soils and about 6 to 8 tons for acid peats. The method appeared to distinguish easily alkaline from acid soils as the alkaline soils had but a small absorption (less than 0.06 per cent calcium carbonate). For mainland soils, the following procedure is therefore recommended as a rapid, approximate method of determining lime requirements:

Measure out 200 cc. of 0.01 *N* calcium bicarbonate solution into a 500 cc. Erlenmeyer flask. Add 10 g. of the soil to be examined to the flask, stopper and shake vigorously by hand for 10 seconds. Filter through a large folded filter paper, discarding the first 40 or 50 cc. of filtrate. Titrate 100 cc. of filtrate with 0.1 *N* acid, using methyl orange as an indicator. The 0.1 difference in titration between 100 cc. of the filtrate and of the original solution is equivalent to 0.01 per cent calcium carbonate required. Multiplying by 10 the percentage calcium carbonate required gives directly the tons of calcium carbonate per 2,000,000 lbs. of soil, which is the weight of soil per acre commonly assumed as being in reaction with applied forms of lime. As filtration is very rapid, it appears that the absorption by this method is sufficient to induce flocculation. A clear filtrate, easily titrated, is always secured, even with peat soils.

For preparing calcium bicarbonate solutions, MacIntire[1] gives in detail a method of preparation by passing carbon dioxide through a suspension of calcium carbonate. The method of preparation made use of by Hutchinson and MacLennan[1] is more convenient. A refillable soda water syphon is used, which is charged by means of small bulbs of compressed carbon dioxide. In this laboratory, about 10 g. of C. P. calcium carbonate are placed in the carbonic syphon which is filled to the mark with distilled water and charged. Solution is sufficiently complete in about 15 min. if the syphon is gently shaken. The syphon is then opened and the contents poured into a 2.5-liter bottle and diluted to about 1500 cc. After the solid calcium carbonate has settled, the liquid is decanted, in portions, into a 600-cc. beaker, from which, after settling, it is decanted into a large filter paper. A glass stirring rod placed in the funnel along the sloping side underneath the filter paper aids the rapidity of filtration. Decanting and filtering in this manner makes the filtration a very rapid process. The filtrate is shaken to insure uniformity and

[1] *Loc. cit.*

[1] *Loc. cit.*

50 cc. are titrated with 0.1 *N* acid, using methyl orange. The filtrate is then diluted to the desired concentration, which can be done with sufficient accuracy by measuring the filtrate and the diluting water into a 4-liter bottle with a 500-cc. graduated cylinder. The accuracy of the dilution is confirmed by titrating 100 cc. of the diluted solution. A 0.01 *N* solution is used as this concentration is fairly stable provided the containing bottles are kept stoppered. It was not found necessary to displace the air in the flasks with carbon dioxide during determinations when this concentration was used. The calcium carbonate which settled when the liquid was decanted is returned to the syphon which is recharged and set aside until a fresh solution of bicarbonate is required. While the 0.01 *N* solution is fairly stable and may be kept under pressure, it is better, however, to prepare the bicarbonate solution fresh each day. Any solution remaining unused from the previous day may be added to the fresh solution before filtration.

HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, T. H.

REVERTED PHOSPHATE

By CARLTON C. JAMES

Received August 28, 1917

As there has been so much published recently concerning the reversion of acid phosphate, its value after reversion, and its effect upon plant growth, it seems advisable to set forth some of the work done by the writer along these lines during the last eight years.

This work was inaugurated and continued in order to control better the complete fertilizer mixtures, and to provide a more effective phosphate for soil conditions in Hawaii. Moreover, the contradictory results and opinions of investigators and control chemists elsewhere has made it necessary to verify or disprove them when applied to conditions in Hawaii. It has been generally held that iron and aluminum phosphates are of little value as a source of phosphorus. Now comes a recent publication by McGeorge[1] showing that in sand cultures with millet, ferric and aluminum phosphate produced more vigorous plants than acid phosphate, sodium phosphate, phosphate rock or Thomas slag. Similarly, it has been held that reverted phosphate is of less value than acid phosphate. Considering the results obtained here by an acid phosphate which has been reverted, we are inclined to believe that under certain conditions prevailing in Hawaii, reverted phosphate gives the better results.

EXPERIMENTAL

In a previous article[2] the writer showed that some reversion may be expected from the action of lime, carbonate of lime, and a mixture of carbonate and phosphate of lime in mixed fertilizers. In this article methods, means and materials used to revert the acid phosphate completely, are considered.

In the first experiment four laboratory samples

[1] Hawaii Agric. Exp. Station, *Bull.* **41**.
[2] THIS JOURNAL, **9** (1917), 682.

TABLE I—PER CENT WATER-SOLUBLE PHOSPHORIC ACID IN MIXTURES ALLOWED TO STAND.

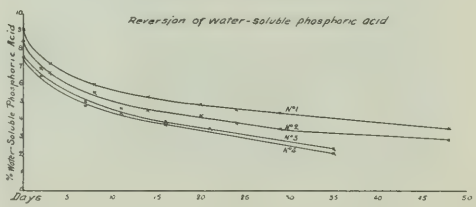
A—ACID PHOSPHATE & GUANO

Period of Standing	Mixture No. 1	Mixture No. 2	Mixture No. 3	Mixture No. 4
On mixing	9.1	8.6	7.6	7.5
2 days	....	....	7.0	6.63
3	7.25	6.72	....	....
7	....	....	5.08	5.39
8	6.08	5.67	....	....
11	....	....	4.47	4.72
14	5.37	4.6	....	....
16	....	....	3.98	3.82
20	4.8	4.3	....	....
24	4.59	3.8	....	....
29	4.47	3.54	....	....
35	....	....	2.44	2.23
48	3.55	2.97	....	....

B—LIME SUPERPHOSPHATE & LIME MIXTURE CONTAINING

Period of Standing	15% Lime	30% Lime
On mixing	15.81	13.02
2 days	10.17	6.93
6	9.05	6.23
10	8.34	5.52
14	7.87	5.05
18	7.23	4.70
21	7.23	3.82
25	6.99	3.98
28	6.76	4.58
35	6.64	4.19
40	6.46	4.11
54	6.51	5.67
68	6.46	5.62
458	0.93	4.60
1580	0.48	2.90

were prepared, the constants of which were acid phosphate and brown guano, the name given to a low-grade Laysan Island phosphate containing coral sand. The variable was lime, CaO. Each sample contained 200 g. acid phosphate and 200 g. brown guano: in addition, No. 1 contained 7.4 g. of lime, the theoretical amount to revert all water-soluble lime phosphate, disregarding whatever effect the calcium carbonate in the brown guano might have. No. 2 contained twice as much lime, 14.8 g. To Nos. 3 and 4 were added 2 g. and 4 g. of lime, respectively. The samples



became appreciably warm, and one hour after mixing, the temperatures in Nos. 1 and 2 were 35 and 36° C., respectively, a rise of 9 and 10° C. over room temperature.

At intervals, analyses were made by the uranium volumetric method for water-soluble phosphoric acid, the results of which are shown in Table I*A*.

This table shows a reversion of from 5.16 to 5.63 per cent of water-soluble phosphoric acid, and also that the greater reversion is caused by the greater amount of lime.

These points have been laid out diagrammatically on quadrille paper and a smooth line drawn through the points plotted to show the rapidity with which the action takes place at first and how it is gradually retarded. It will be seen that if the lines were extended, considerable time would elapse before all the phosphoric acid would become reverted. While these results were satisfactory, it was deemed advisable to remove the brown guano as the supply was becoming limited, and to try larger samples over a longer period of time.

Some time later, with this in mind, another laboratory experiment was carried on with lime superphosphate, the analyses being made at close intervals

for about two months, the next analyses after 458 days, and the final complete analyses after 1580 days or approximately 4 years and 5 months. To 1000 g. of acid phosphate in each of two bottles were added 150 and 300 g. lime, CaO. The analyses of water-soluble phosphoric acid are shown in Table I*B*. On mixing, the sample with 15 per cent lime contained 15.81 per cent water-soluble P_2O_5 and 17.18 per cent total P_2O_5; after standing 1580 days, 0.48 per cent water-soluble, 13.89 available, and 20.02 total P_2O_5. The sample to which 30 per cent lime was added contained on mixing 13.02 per cent water-soluble P_2O_5 and 14.15 per cent total P_2O_5; after 1580 days, 2.9 per cent water-soluble, 13.69 per cent available and 16.62 per cent total P_2O_5.

The sample containing 15 per cent lime shows a

TABLE II—FACTORY EXPERIMENT OF MIXING ACID PHOSPHATE AND LIME

	Mixture			Composition of Mixture	
	Acid		Total	Available and	Water Soluble
Per Cent Mixture	Lime	Phosphate	P_2O_5	Available P_2O_5	P_2O_5
No. 1	10	90	19.26	[illegible]	1.15
2	15	85	18.57	13.46	1.92
3	20	80	17.86	13.11	1.50
4	25	75	17.20	13.01	1.88

Samples for analyses of the first series of experiments with lime and acid phosphate were taken 18 hrs. after mixing. Reaction started from 10 to 20 mins. after mixing, and the material lost water rapidly. At the same time it took on a lighter color and a more friable powdery condition. One-half hour after mixing, the temperature in Nos. 1, 2 and 3 was approximately 110° C., while in No. 4 it rose to 190° C. The results of this series of experiments are given in Table II.



UNFERTILIZED IN FRONT OF STAKE: 90 LBS. PER ACRE REVERTED PHOSPHATE AT RIGHT



UNFERTILIZED AT LEFT: 90 LBS. PER ACRE REVERTED PHOSPHATE AT RIGHT

continued reversion over the whole period as was expected, but what was responsible for the irregularity in the sample with 30 per cent has not been explained. It will be noticed that some reversion to tri-calcium phosphate has taken place, but the greater part remains as di-calcium phosphate.

Since these laboratory experiments indicated in a general way the trend and rate of reaction it was considered advisable to continue experimenting on a larger scale under factory conditions. Consequently, the following series of experiments were conducted with lots of one ton or more.

In Experiment 1, lime and acid phosphate were mixed in a ball mill in proportions of 10 parts lime to 90 parts acid phosphate. The material after grinding through a coarse screen was caught in bags and set out on the floor in order that the reaction could go on to completion and the temperature drop to that of the atmosphere. Experiments 2, 3 and 4 were conducted in the same manner as No. 1, the only difference being that the proportion of lime to acid phosphate was increased in each succeeding experiment.

The method of handling was not satisfactory, as the heat and dust soon drove the men away from the mill.

The reaction goes on more rapidly as the percentage of lime is increased. The water content of the acid phosphate and also the length of time it ages in the bin before mixing affect the rapidity of reaction and intensity of heat generated.

Having studied the reverting action of lime, our attention was next turned to carbonate of lime and combinations of carbonate of lime with lime and acid phosphate, the object being to obtain a fertilizer which would contain a considerable part of the phosphoric acid in the reverted form and also to effect a less dusty mechanical condition. The dusty nature of the reverted mixture makes a very difficult and disagreeable product to handle on a large scale.

The results of experiments with calcium carbonate (coral sand) and acid phosphate are given in Table III. It will be noticed that reversion takes place quite rapidly at first but as the time increases, the rate of reversion diminishes. As with lime, the

TABLE III—PERCENTAGES WATER SOLUBLE P_2O_5 IN MIXTURES OF ACID PHOSPHATE AND CORAL SAND

Mixture	Acid Phosphate	[illegible]	80%
	Coral Sand	[illegible]	20
On mixing	[illegible]	[illegible]	14.48
After	18 hours	[illegible]	10.98
	48 hours	[illegible]	9.58
	120 hours	14.41	8.86
	11 days	13.52	8.2

reversion increases with increasing proportions of carbonate of lime. With the carbonate of lime, however, there is very little rise in temperature. It is unfortunate that only the water-soluble phosphoric acid determinations were made on this series of experiments, as a comparison of the soluble and available would have been valuable and interesting.

In an endeavor to get more satisfactory results with lime and acid phosphate on a factory scale, mixtures of 90 per cent acid phosphate and 10 per cent lime, and also 85 per cent acid phosphate with 15 per cent lime were again ground together in a ball mill. These mixtures were allowed to cool and after 24 hrs. samples were taken for analyses. The mixtures were sampled again after one week.

TABLE IV—MIXTURES OF ACID PHOSPHATE AND LIME

	90% Acid Phosphate & 10% Lime			85% Acid Phosphate & 15% Lime		
Per cent P_2O_5 {	Water-Soluble	Soluble and Available	Total	Water-Soluble	Soluble and Available	Total
After standing						
24 hours...	3.03	18.50	19.42	None	17.56	19.1
1 week.....	1.66	17.97	19.28	None	16.55	18.64

The reversion here was quite complete and little if any of the acid phosphate was changed to the tricalcium form. The appearance of the material was quite similar to precipitated phosphate. It was found impractical to work this material through a ball mill, however, on account of the gradual accumulation of the mixture in the mill and also the heat generated by the reaction.

A similar experiment was then undertaken with mixtures of acid phosphate, lime and coral sand with the object of obtaining the same result: *i. e.*, a reverted phosphate, but with the idea of retarding and tempering the violence of the reaction. The limited capacity of the ball mill and its tendency to choke and to accumulate heat led us to run the remaining tests through a cage disintegrator. The reversion which took place in this material is shown in Table V.

TABLE V—EXPERIMENT WITH ACID PHOSPHATE, LIME AND CALCIUM CARBONATE

Mixture: {	85% Acid Phosphate 10% $CaCO_3$ + 5% CaO			80% Acid Phosphate 15% $CaCO_3$ + 5% CaO		
Per cent P_2O_5:	Water-Soluble	Soluble and Available	Total	Water-Soluble	Soluble and Available	Total
After standing						
24 hours.....	4.94	...	...	3.26	...	...
10 days.....	4.52	15.64	17.36	2.42	14.77	16.48

The disintegrator makes a sufficiently homogeneous mixture which passes rapidly through the machine, and which is discharged almost before reaction begins. Reaction attains its height about 30 minutes after leaving the disintegrator, which allows sufficient time for handling. The heat generated removes excess of moisture, causing a loss in weight of about 5 per cent and leaving a free, dry powder, the phosphoric acid of which consists mainly of di-calcium phosphate.

Thus with a 40-in. cage disintegrator, from 20 to 25 tons per hour may be mixed direct into containers, doing away with the handling of a very dusty material, and avoiding excessively high temperatures.

AGRICULTURAL EXPERIMENTS

With regard to the effect of reverted phosphate on growing crops, and also its commercial value, there are differences of opinion. In 1914 the state chemists of North Carolina, South Carolina, Alabama, Mississippi and Georgia were all opposed to a reverted phosphate. Dr. Cameron, then of the Bureau of Soils at Washington, is also quoted as not favoring lime being mixed with superphosphates.

Possibly in the majority of cases the water-soluble phosphate is the one used. There are exceptions, however, and we have found in numerous cases that the reverted phosphate is just as valuable or even more valuable than the water-soluble when applied to cane upon upland soils. These soils are, as a rule, highly ferruginous clays. On soils which have not been cropped for several years, the reverted phosphate gives excellent results. The accompanying photographs show the difference between cane unfertilized and that receiving per acre 90 lbs. of phosphoric acid in reverted form. In the check plot the canes per stool ranged from 5 to 9 while in the reverted phosphate plot the variation was from 9 to 15. These photographs were taken in a series of experiments run by the Hawaiian Sugar Planters' Experiment Station, on land of the Oahu Sugar Co. Experiments made by the U. S. Agricultural Experiment Station[1] upon rice, also show favorable results from reverted phosphate, particularly the Gold Seed rice which has a long growing period. A gain of 132 per cent over the check plot is recorded.

In view of these results and the fact that the reverted form is preferred by certain growers to any other, it would seem that the practice of condemning or setting arbitrarily a lower value on reverted phosphate is open to criticism.

Credit is due and acknowledgment hereby made to H. M. McCance for aid in the analytical work reported in this paper.

PACIFIC GUANO & FERTILIZER COMPANY
HONOLULU, HAWAII

ELECTRIC FURNACE SMELTING OF PHOSPHATE ROCK AND USE OF THE COTTRELL PRECIPITATOR IN COLLECTING THE VOLATILIZED PHOSPHORIC ACID

By J. N. Carothers

Received October 8, 1917

The work described in this article is a continuation, on a commercial scale, of preliminary work which was carried on more than a year ago. In the preliminary work,[2] furnace operation was not continuous for a period of days, consequently no conclusion could be drawn as to cost of installation and operation.

The work of these later tests was made possible only by the coöperation of the Bureau of Soils with several

[1] Hawaii Experiment Station Report **1907–1908**.
[2] This Journal, **9** (1917), 26.

firms which were interested in this line of investigation.[1] The apparatus was installed near the plant of the R. B. Davis Co., Hoboken, N. J. Fig. I is a view of the precipitator and furnace housing. Power was secured from the Public Service Co.

From the transformer ratings, the plant was a 200 K. W. installation. The incoming power was quarter phase, 2400 volts, which was transformed to 3 phase, 220 volts by a bank of Scott connected transformers. A second bank of transformers, and a set of double-throw switches made it possible to have either 220 volts or 110 volts in the furnace. This arrangement was adopted so as to use the higher voltage for starting and the lower voltage for operating. For the best operating conditions 110 volts were found satisfactory.

The furnace consisted of a water-cooled crucible, with the cooled section extending no higher than the region of the molten slag. It was lined with fire-clay



FIG. I—PRECIPITATOR AND FURNACE HOUSING

brick, but silica brick would prove more satisfactory. The portion not exposed to the action of slag was lined with a fire-clay brick. All gas mains and the cooling tower had a fire-clay brick lining. The heat from the gases served to harden the exposed surface, and thus improve the service of the brick. The electrodes entered through the top of the furnace, but below a line where

[1] The R. B. Davis Co. of Hoboken, N. J., first proposed the cooperative plan, and were instrumental in interesting some of the leaders of phosphate rock, and electrical machinery. The Lakeland Phosphate Co. supplied a high grade Florida pebble, the Cummer Lumber Co. a high grade Florida land rock, the Phosphate Mining Co. a screenings and two sizes of pebbles, the Farmers Ground Phosphate Co. a large tonnage of Tennessee rock, the Central Phosphate Co. a brown Tennessee rock in large lumps, and the Hoover and Mason Co. a blue Tennessee rock in lump and fine material mixed.

The General Electric Co. supplied all transformers and instruments for use in connection with the furnace. The Research Corporation furnished the electrical equipment used in connection with the treater for collecting the gas. They also gave some very helpful suggestions as to treater design, construction and operation.

the charge entered. Care should be taken in the design of such furnaces that the angle of the electrodes conform with the angle of repose of the charge. Thus as the charge falls in a natural pile, the breakage of electrodes is eliminated. Electrodes may be conveniently controlled by hand, or mechanically. Hand control was used in this experiment, with the control so located that the switchboard and instruments could be observed. Six-inch and four-inch graphite electrodes were used. The life of a 4-in. electrode was about 7 days, while the 6-in. electrodes lasted on an average of 10 days under favorable conditions. Thus it may be seen that with such a low consumption, electrodes may be operated by hand, since the chief movement of electrodes is when they are consumed. In this experiment the charge was fed by hand; however, this is obviously impractical in a large installation where mechanical apparatus should be used. During regular operation about 2000 lbs. of rock were consumed per 12-hour period.

A slag pit filled with water was used to quench the molten slag as it flowed from the furnace. The slag thus chilled slid to one end and was removed mechanically. The P_2O_5 content of the slag was approximately 2 per cent, although it is possible to reduce it to 1.5 per cent or even 1 per cent for regular operation. The P_2O_5 content of the slag is largely a matter of the mixing of the charge, and using the proper proportions of rock, sand, and coke.

The average production was 0.3 lb. H_3PO_4 per K. W. hr. absorbed; however, there were periodic yields, during times of good operating conditions, in which 0.4 lb. H_3PO_4 per K. W. hr. was produced. Judging from the average results of this experiment it seems reasonable to assume that a production of 0.6 lb. H_3PO_4 per K. W. is possible. Of course, the production is entirely dependent upon the efficiency of the furnace. In the case of this work, no means were adopted to utilize the heat absorbed by the water surrounding the crucible, or in the gases carried over from the charge. Also there were heat losses from the oxidation of phosphorus to phosphorus pentoxide (P_2O_5) and carbon monoxide (CO) to carbon dioxide (CO_2) which, if utilized, would materially have increased the efficiency of the process.

As the gases were removed from the furnace, they passed through a cooling tower before entering the treater. This tower was installed to afford sufficient radiation, so that the gases entered the treater at 250 to 300° C. Above these temperatures in the treater, electrical and mechanical difficulties arise, which make higher temperatures undesirable.

The treater consisted of a header of common brick, with a reinforced concrete top to support the pipes, and 20 treater tubes of vitrified sewer pipes, 12 in. in diameter and 15 ft. in length. All joints were packed loosely with silica to prevent air from entering at these points. The pipes were enclosed to prevent cracking, due to heat differences, and to maintain an even flow of gas.

All pipes at the top were inclosed in a common hood. Supports for the conductors rested on insulators within

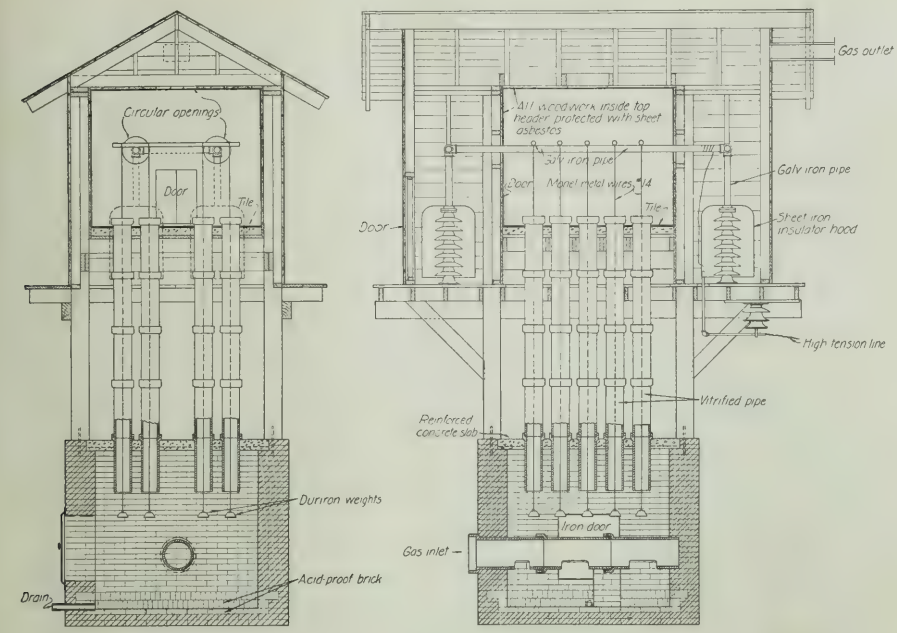


Fig. II

the treater hood. Complete clearance was given to 2,000 cu. ft. of gas entering at 300° C., with a velocity of 3 linear feet per second (see Fig. II for diagrammatic sketch of a transverse and a longitudinal section of the treater).

Power was supplied the treater from a 150-volt motor generator set, and transformed to higher voltages by a 7.5 K. V. A. transformer. A 5-point switch on the low-tension side of the transformer, connecting the various turns of the coils, made a variation of voltages possible. It was found that 70 kilo volts was sufficient to give complete precipitation of the gases, at the above stated volumes and velocity.

As the acid fell from the pipes it was caught in a receiving basin of vitrified brick set in acid-proof cement. From this basin the acid flowed out and was disposed of by pumping to a receiving vat. The concentration of the acid collected was controlled by the temperature of the gas in the treater. At a temperature of less than 100° C. the concentration is not likely to exceed 50 per cent H_3PO_4, while a temperature of 250 to 300° C. will yield an acid of 85 to 93 per cent H_3PO_4. In one case an acid of 97 per cent was produced. An acid above 85 per cent H_3PO_4 will probably solidify when it reaches atmospheric temperatures, and therefore the pumping apparatus and pipe lines should be so constructed as to prevent clogging.

Any unscreened rock is undesirable for such a process if a concentrated acid is to be collected; however, if a dilute acid be collected no difficulties are encountered. The fine dust is carried over with the phosphorous gases, and precipitated in the lower section of the treater pipes. There it reacts with the concentrated acid, and forms mono-calcium phosphate which is a stiff paste under such conditions as exist in the treater. This mass gradually accumulates until the distance to the conductors is so close that disruptive discharges set up.

It should be borne in mind that when a rock free from dust is used, the only impurities likely to be in the resultant acid are: carbon in the form of coke dust; silica dust from the sand and rock; and any volatilized fluorine or arsenic, which is absorbed in the acid as the gases pass through the treater. Therefore, if an acid of high purity is desired these impurities must be removed; however, this is largely a matter of filtering apparatus, and a question for individual installations.

Below is given an estimate as to the cost of operation for such a plant. A 3,000 K. W. unit is nominally chosen to show the production and cost of operation.

Total Annual Production.....6,480,000 lbs. H_3PO_4

Material Needed for a 300-Day Year:

7,800 tons 34 per cent P_2O_5 Phosphate Rock, assuming 90 per cent recovery
3,510 tons sand
1,758 tons coke (86 per cent carbon)

Items	Cost
7,800 tons phosphate rock @ $1.25 per ton	$ 35,100.00
3,510 tons sand @ $1.25 per cu. yd.	3,327.00
1,758 tons coke @ $4.50 per ton	7,911.00
25 tons electrodes @ $10 per 100	5,000.00
8 Laborers @ $2.00 per day	5,280.00
2 Electricians @ $100 per mo.	2,400.00
1 Analyst @ $80 per mo.	960.00
1 Superintendent @ $150 per mo.	1,800.00
Power @ $25 per H. P. Y. (equivalent to 0.285 ct. per H. P. Hr.) 28,800,000 H. P. Hr.	100,000.00
Power for machinery, lights, etc., 100 K. W.	3,283.00

Based on 0.3 lb. H_3PO_4 per K. W. hr. a 3,000 K. W. furnace would produce 21,600 lbs. H_3PO_4 per 24-hour day. Such a plant should average at least 300 operating days per year.

On this basis the cost of acid per lb. H_3PO_4 is 2.55 cents or 3.37 cents per lb. P_2O_5 for power labor, and material, but exclusive of investment charges, maintenance, and depreciation.

The cost of installation is more difficult to determine because of the present unsteady market conditions and the character of construction employed; consequently no attempt is made to make an estimate covering the cost of installation. However, it may be said that most equipment needed for a plant of this type is stock material. The furnace must be built from design, and is special. Stock transformers may be used, also switches and instruments. Likewise, all elevator equipment could be purchased from stock material. The treater may be so constructed that little special equipment is necessary. The treater base or header may be constructed of common brick, with a lining of vitrified brick or tile, while the top supporting the pipes may be built of reinforced concrete. Vitrified sewer pipes serve very well for treater tubes, although stoneware is better. If an exhaust fan be placed in the gas main before the treater, no special hood is needed for the top of the treater pipes; however, if it be desired to have the exhaust after the treater, an air-tight hood is necessary, which should be lined with vitrified sheet asbestos or tile. Some of the brick for the furnace might necessarily be of special shape, if standard shapes were not available and it were not desirable to cut standard shapes to the desired form. The foregoing briefly outlines the character of the equipment necessary for an installation for the production of phosphoric acid by means of the electric furnace, where electric precipitation is used to collect the volatilized gases.

Since most of the equipment is available from standard stock sources, the cost of an installation of this character is materially lower than it would be, were special equipment required. Also the simplicity of collecting phosphorus pentoxide, or phosphoric acid, by electrostatic precipitation is an improvement over the use of water-absorption towers, not only in tower cost of installation but in operation as well. Furthermore an acid of higher concentration may be collected. By having a gravity flow from the collecting basin to the receiving vat all pumping equipment and many of the storage tanks, which are necessary in the case of absorption towers, are eliminated. Therefore, with a lower cost of installation and operation of the treater, as compared with the absorption towers, the application of the Cottrell precipitator in collecting phosphorus pentoxide, unquestionably advances the possibilities in the application of electric smelting along this line.

It should be pointed out that the yield of this experiment was considerably below that of a furnace designed to utilize the energy from the heat in the gases. This very important feature is a large factor in the development of the process of smelting phosphate rock by means of an electric furnace.

BUREAU OF SOILS
WASHINGTON, D. C.

LABORATORY AND PLANT

A CONSTANT TEMPERATURE AND HUMIDITY ROOM FOR THE TESTING OF PAPER, TEXTILES, ETC.

By F. P. VEITCH AND E. O. REED

Received July 23, 1917

Variations in the relative humidity of the atmosphere have a decided effect on the physical properties of paper. The results of all physical tests on paper are affected to a greater or less degree by the ordinary variations of the relative humidity in the testing room and certain tests are valueless unless conducted under uniform temperature and humidity conditions. Especially is this true with the determination of the folding endurance, a most important test for indicating the flexibility and probable durability of paper. Though it is generally understood that the physical qualities of paper are affected by changes in humidity conditions, there is but little appreciation of the rapidity with which these changes affect it. Paper is so exceedingly sensitive to changes in atmospheric humidity that, in order to obtain concordant results which may be duplicated at other times and by other laboratories, it is necessary to make all physical tests upon it in a room where both uniform temperature and relative humidity are maintained.

All physical testing of paper done by the Bureau of Chemistry, U. S. Department of Agriculture, has been conducted since December, 1909, in a specially constructed and automatically controlled constant temperature and humidity room. So far as is known, this laboratory was the first in this country to maintain uniform temperature and humidity conditions in the testing of paper, textiles, leather, etc.

MEASUREMENT OF HUMIDITY

Humidity is expressed either as relative or absolute. Absolute humidity is the weight in grains of the water vapor in a cubic foot of air, while relative humidity is the percentage of saturation of the air at any particular temperature and pressure. Saturation at the designated temperature and pressure is taken as 100 per cent. The higher the temperature of the air the more moisture required to give the same percentage of saturation or relative humidity.

The measurement of humidity[1] is preferably made with a U. S. Weather Bureau sling psychrometer. Thermometers graduated to 0.1° F. should be used, since every degree difference between the wet and dry bulb temperatures gives from 4 to 6 per cent variation in relative humidity, at the ordinary temperatures of from 50 to 80° F. At lower temperatures this variation increases, as for instance at 32° F. one degree gives a difference of 12 per cent in relative humidity. The sling psychrometer, [illegible] handling and

[1] "Final Report of the Committee [illegible] Methods for the Examination of Air," *Am. J. Pub. Hygiene*, No. [illegible]

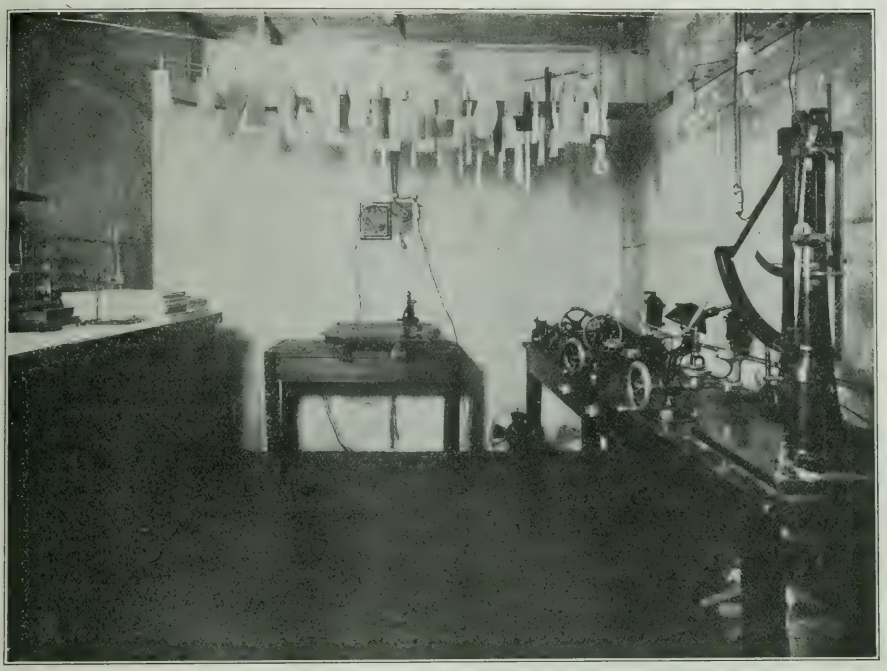


FIG. I—VIEW OF INTERIOR OF ROOM TAKEN FROM THE DOORWAY
On the Floor in the Rear Will Be Seen One of the Fans for Keeping the Air Uniform within the Room and along the Left Side and Back of the Room near the Ceiling Is the Outlet Flue.
The Method of Exposing Samples to Be Tested by Suspending with Clamps from Wires Stretched across the Room Is Also Shown

tables necessary for calculating relative humidity and dew point from the readings of the wet and dry bulb temperatures are described by the U. S. Weather Bureau.[1] There are many instruments for recording the temperature and humidity on charts, but these instruments must be frequently checked with a standard sling psychrometer or other accurate form of wet and dry bulb instrument.

INDOOR AND OUTDOOR HUMIDITY

During the six to nine months of the year when artificial heat is required in most localities, the average relative humidity indoors is as low as 20 to 40 per cent, unless mechanical means for humidifying have been installed, while the average outdoor relative humidity in most localities in the U. S. is over 65 per cent. These facts are not generally appreciated, and erroneous statements on this subject are often made. Wilson[2] states that during the winter months the normal outdoor relative humidity over the more populous portions of the United States, especially east of the Missouri and north of the Ohio Rivers, is 72 per cent and that the average diurnal range is from 60 to 85 per cent.

In Table I are given the indoor temperatures and relative humidities for Dayton, Ohio, and Washington, D. C., recorded by this laboratory, and the outdoor readings for the same localities taken from the Annual Reports of the Weather Bureau.

TABLE I—AVERAGE MONTHLY OUTDOOR AND INDOOR TEMPERATURES AND RELATIVE HUMIDITIES

Dayton Ohio	Outdoor Temp. ° F.	Outdoor Rel. Hum.	Indoor[1] Temp. ° F.	Indoor[1] Rel. Hum.	Washington D. C.	Outdoor Temp. ° F.	Outdoor Rel. Hum.	Indoor[2] Temp. ° F.	Indoor[2] Rel. Hum.
1911, Nov.	38.0	83%	74.5	29%	1912, Aug.	73.4	72%	83.5	49%
Dec.	37.8	80	74.5	28	Sept.	70.4	82	76.5	65
1912, Jan.	18.4	78	75.0	19	Oct.	59.3	75	75.0	46
Feb.	23.2	75	75.0	21	Nov.	46.9	67	74.5	39
Mar.	34.4	79	74.5	26	Dec.	40.4	69	74.0	35
Apr.	53.6	75	75.0	35	1913, Jan.	43.6	72	73.0	35
May	64.4	75	75.5	43	Feb	36.6	63	74.5	31
June	68.4	69	76.0	44	Mar.	49.0	66	74.0	31
July	74.9	76	79.5	58	Apr.	55.5	60	76.5	33
Aug.	71.0	80	78.0	60	May	64.4	65	77.5	41
Sept.	68.2	76	77.0	56	June	72.8	66	80.0	49
Oct.	56.6	71	72.5	41	July	77.6	66	87.0	44
Average	50.7	76	75.5	38	Average	57.5	68.5	77.1	41.5

[1] Readings taken by the Bureau of Chemistry in the Mercantile Corporation Factory.
[2] Readings taken in laboratory room Bureau of Chemistry. As open steam baths are located in all rooms used for laboratory purposes the indoor humidity is slightly higher than was found in other buildings.

The results given in Table I are representative of the average indoor conditions at Dayton, Ohio, as determined by observations made during several years. It has been observed in Washington, in several of the different government bureaus and in offices using large amounts of paper, that the average yearly indoor relative humidity during working hours is between 35 and 40 per cent. The average yearly indoor relative humidity is close to 40 per cent both in Dayton, Ohio, and Washington, D. C., but in no case does it approach the average outdoor relative humidity,

[1] Psychrometric Tables, U. S. Weather Bureau *Bull.* 235.
[2] "Atmospheric Moisture and Artificial Heating," Proceedings of the Convention of Weather Bureau Officers, 1898.

averaging from 30 to 40 per cent less. These results are in close agreement with those quoted by Wilson,[1] to the effect that the indoor relative humidity in heated buildings in several widely separated parts of the country on the coast and in the interior varies from 24 to 33 per cent and that during the winter months the indoor relative humidity is about 42 per cent lower than the outdoor.

The average winter indoor humidity in the United States is lower than that of the driest climate known.[1] This fact has led to investigations as to the physiological effects of temperature and humidity for the purpose of setting standards for the best living and working conditions. Such work has been conducted by the New York State Commission on Ventilation for several years.[2]

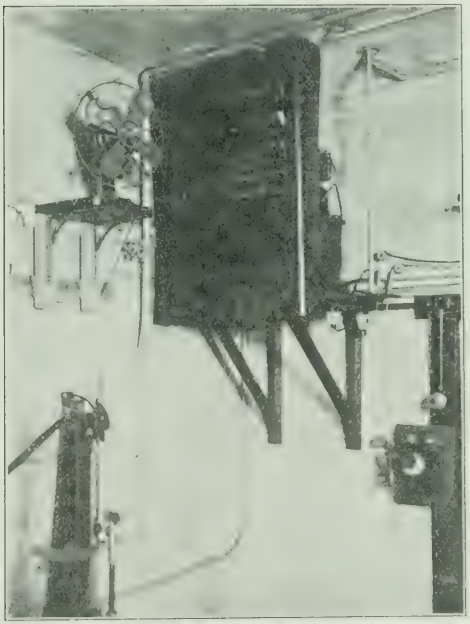


FIG. II—VIEW OF THE AIR INTAKE WHICH SUPPLIES TEMPERED AIR AND MOISTURE TO THE ROOM
Back of the Baffle Plate Will Be Seen the Motor of the Sirocco Fan, which Serves to Circulate Air through the System, in Front of It the Other Fan which Is Used to Distribute the Air throughout the Room

STANDARD TESTING CONDITIONS

The German Imperial Testing Laboratory at Gross-Lichterfelde found the variations in atmospheric humidity to produce such a decided effect on the results of physical tests of paper, that it was necessary to make all tests under constant relative humidity conditions.[3] About 1896, they accordingly adopted 65 per cent relative humidity for all physical testing of paper. It is not made clear why 65 per cent relative humidity was selected, but it appears to have been taken because of the fact that, since the average outdoor relative humidity is more than 65 per cent and the indoor humidity somewhat lower, it was easier to add moisture to the air than to remove it.

This condition has been generally accepted in this country, apparently without investigation. Since the average yearly indoor humidity in this country is, according to the data available, but 35 to 40 per cent, it does not seem rational to test paper at a relative humidity rarely obtained indoors. The testing should be done under humidity conditions more nearly like those under which the paper is used. It is doubtful, however, if it would be advisable to set the relative humidity for such work as low as 40 per cent or even 45 per cent, since for about five months of the year it will be necessary to dehumidify to secure these percentages. A relative humidity of 50 per cent is probably as low as can be maintained throughout the year without elaborate equipment. Even at this percentage it will be necessary to dehumidify the greater part of the time during the months of July, August and September.

Not only has humidity a marked effect on the results of physical tests, but also on the handling and use of paper. The printer, engraver, stationer, librarian and others using large quantities should standardize their working and storing conditions to secure the best and most satisfactory results at all times of the year. The most suitable humidity conditions for their respective purposes should be determined by investigation and means should then be taken to maintain these conditions throughout the year. The paper maker and consumer would undoubtedly profit by the maintenance of uniform humidity conditions most satisfactory for their purposes. Suggestions from the Bureau of Chemistry have led to the elimination of a number of difficulties in printing and engraving establishments of the government caused by variations in atmospheric humidity.

In most texts on paper testing it is suggested that certain definite humidity conditions may be had by placing the samples in small containers, in which the definite temperature and humidity required are maintained for 12 to 24 hours, then removing from the containers and testing under the atmospheric conditions prevailing in the room. Accurate results cannot be obtained in this way, especially on the folding endurance tester. As will be seen from Table II, results made with this machine are [illegible] made under uniform humidity conditions. Nor has it been found possible to apply accurately a formula for correction where the tests have been conducted at a different humidity than 65 per cent [illegible] of paper or even runs of the same kind of paper will necessarily permit the application of [illegible] factors—a fact that is clearly shown by comparing the results in Table II, Columns 2 and 3 with Columns 6 and 7, respectively.

The results in Table II show that the physical qualities of the paper change very rapidly with changes in

[1] "Atmospheric Moisture and Artificial Heating," Proceedings of the Convention of Weather Bureau Officers, 1898.

[2] "Some Results of the First Year's Work of the New York State Commission on Ventilation," *Am. J. Pub. Health*, No. 2, 8, p. 85.

[3] *Mitteilungen a. d. K. Technischen Versuchsanstalten*, 7 (1889), 2 8 (1890), 8 to 12.

TABLE II—RESULTS SHOWING RAPIDITY WITH WHICH THE FOLDING ENDURANCE IS AFFECTED BY HUMIDITY

Samples of Uncoated Blue-Print Paper. Results Given are Averages of 10 Tests Each

	Exposed				Exposed			
EXPOSURE	12 hrs., 71° F. and 30% rel. hum.		71° F. and 30% rel. hum.		12 hrs., 65° F. and 65% rel. hum.		65° F. and 65% rel. hum.	
TESTING	71° F. and 30% rel. hum.		Immediately at 65° F. and 65% rel. hum.		65° F. and 65% rel. hum.		Immediately at 74° F. and 25% rel. hum.	
Paper No.	Double Folds Long.	Trans.	Double Folds Long.	Trans.	Double Folds Long.	Trans.	Double Folds Long.	Trans.
28541	316	411	852	804	1431	1298	468	347
28538	104	186	229	269	843	416	329	214
28519	305	296	373	440	1561	641	Not tested	

the relative humidity of the air. They show that papers should not be exposed to a certain humidity condition and tested under other conditions even though the tests are made at once. They indicate further that paper loses moisture faster in passing to a lower relative humidity than it gains moisture in passing to a higher relative humidity. The length of time for which it is necessary to expose a paper to a certain humidity condition before it reaches equilibrium can be definitely determined by means of the folding endurance tester as well as by weighing the paper. Articles dealing with the effects of humidity on paper are in preparation and will be published in the near future.

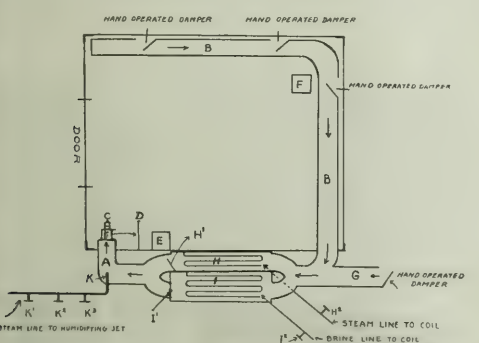


FIG. III—DIAGRAM SHOWING OPERATION OF ROOM AS DESCRIBED IN TEXT

DESCRIPTION OF THE BUREAU OF CHEMISTRY CONSTANT TEMPERATURE AND HUMIDITY ROOM

For general testing work this room has been operated up to the present at 70° F. and 65 per cent relative humidity. The temperature was at first set at 65° F. with 65 per cent relative humidity. At 65° F., the men were decidedly uncomfortable and developed frequent colds. It was, therefore, deemed advisable to adopt 70° F. as the standard temperature with the relative humidity at 65 per cent. The room can be operated automatically at any relative humidity from 20 to 85 per cent and any temperature from 40 to 95° F. Investigational work has been carried on at different humidities and temperatures to show the effects on paper and on tests made with various testing machines.

The room is 10 ft. 6 in. × 14 ft. 3 in. × 9 ft. 3 in. high and contains 1410 cu. ft. It was constructed in connection with the refrigeration plant of the Bureau. The walls and ceiling of the room are 8 in. thick and consist of an outside sheathing, 4 in. of ground cork, a thin partition and two layers of sheet cork, each $1^1/_2$ in. in thickness, the inner layer finished on the inside with cement, which is painted to prevent absorption of moisture. The floor is insulated in the same manner, cemented and covered with linoleum. The door is of the regular cold storage type. The insulation of the room is such that when the automatic controls are turned off the temperature will remain constant for several hours.

Air is drawn into the room by means of a sirocco fan (Fig. III, *C*), from the intake flue *A*, through which the tempered air and moisture are supplied. It is delivered into one corner of the room near the ceiling, against a slotted baffle plate, *D*. Two fans, *E* and *F*, are located within the room to keep the air uniform throughout; *E* is placed in front of the baffle plate where the air enters, and *F* on the floor in the diagonally opposite corner. These fans are essential in order to prevent the air from stratifying. The outlet flue *B* is located near the ceiling along the two sides of the room opposite the intake, and has three openings, each with an adjustable hand damper, through which air is removed from various parts of the room. This flue is connected with a fresh air flue, *G*, outside of the room, which supplies air to the tempering coil chambers *H* and *I*. The sirocco fan located in the intake flue maintains the air circulation, drawing air into the room and forcing it out through the outlet flue. Careful experiment shows that the two fans as placed within the room insure even humidity throughout the room.

The tempering coils, steam and refrigerated brine are located in well insulated chambers on the outside of the room and are connected both with the inlet and outlet flues. All air supplied to the room is drawn over one or the other of these coils as the demands of the room may require. The steam coil *H* contains approximately 28 sq. ft. of heating surface, and the brine coil *I* approximately 113 sq. ft. of cooling surface. They have been found ample at all seasons of the year for maintaining any temperature within the range of the controlling thermostat, 40 to 95° F. In order to obtain maximum efficiency it is necessary to keep the brine coil free from ice, and this is accomplished by opening the chamber once every two or three weeks and allowing the ice to melt off.

The automatic operation of the plant is obtained by means of air pressure and automatic air pumps maintain a pressure of approximately 12 lbs. The operating valves and dampers are worked by diaphragms. Automatic diaphragm-operated valves are located on the pipe lines leading to each of these coils; the brine valve I^1 opens when air pressure is supplied to the diaphragm operating it and the steam valve H^1 when the air pressure is released from the operating diaphragm. Each coil chamber is fitted with an automatic diaphragm-operated damper, I^2 and H^2, leading into the main flue to the room. These dampers work by means of their respective diaphragms at the same

time as the corresponding brine and steam valves on the coils. The automatic operation of these valves and dampers is controlled by a thermostat within the room to be described later. The two valve diaphragms and the two damper diaphragms are all on the same air-pipe line, the air pressure of the line being controlled by the thermostat within the room, which makes and breaks the circuit of air.

Moisture for humidifying is supplied by means of a steam jet, K, located immediately outside of the room in the intake flue. This steam jet consists of a brass pipe about 8 in. in length, perforated and wrapped with cotton wicking, which removes any water which may be in the steam. This produces a finely divided steam vapor, which has been found the most satisfactory method of humidifying. Two automatic diaphragm-operated valves, K^1 and K^2, are located on the steam line leading to this humidifier; K^1 is operated by the hygrostat within the room and opens

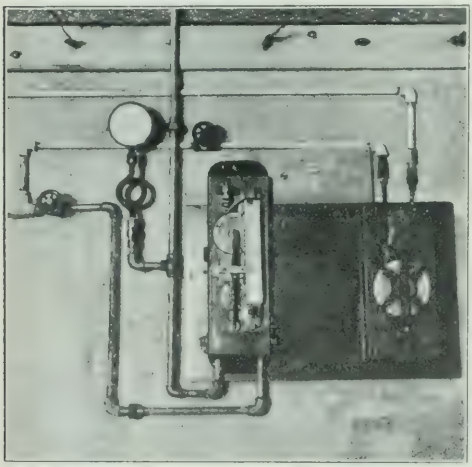


FIG. IV —VIEW OF TEMPERATURE AND HUMIDITY CONTROLLING INSTRUMENTS LOCATED WITHIN THE ROOM
Thermostat on the Right; Hygrostat on the Left

when the hygrostat releases the air pressure on the diaphragm; K^2 is a safety valve which closes with the release of the air pressure to its diaphragm and is connected with the main air supply line of the system. Since the valve controlled by the hygrostat opens with the release of air pressure, in case of a break in the main air-supply line of the plant this valve would not close and an excessive amount of steam would be supplied to the room. The safety valve is to prevent an accident of this kind. The supply of steam to the humidifying jet is controlled by a needle valve, K^3. It is important that the supply to the jet be regulated according to the capacity of the room so as not to furnish an excessive amount nor an insufficient amount of moisture for the room. A steam trap for removing the water in the steam is placed in the line in front of the valves.

AUTOMATIC [illegible]

The room is automatically operated by two separate controls, one for maintaining temperature and the other humidity. Both controls are located within the room itself.

The temperature control was installed at the time the room was constucted and has given entire satisfaction. The temperature in the room varies less than 1° F. This thermostat operates the valves on the brine and steam coils and the dampers leading from these coil chambers into the room, previously described. When the room requires warm air, the thermostat releases the air pressure and the valve on the steam line and the damper to the steam coil chamber are opened, while at the same time the valve on the brine line and the damper to the brine coil chamber are closed. When cool air is required the above operations are reversed, the thermostat permitting the air pressure to be on the operating diaphragms. The above describes the principle of operation of the equipment. As a matter of fact the action of the thermostat is gradual, allowing the room to be supplied with both warm and cool air at the same time.

Several makes of equipment for automatically con-

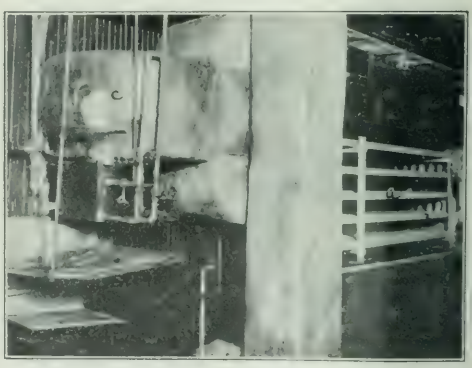
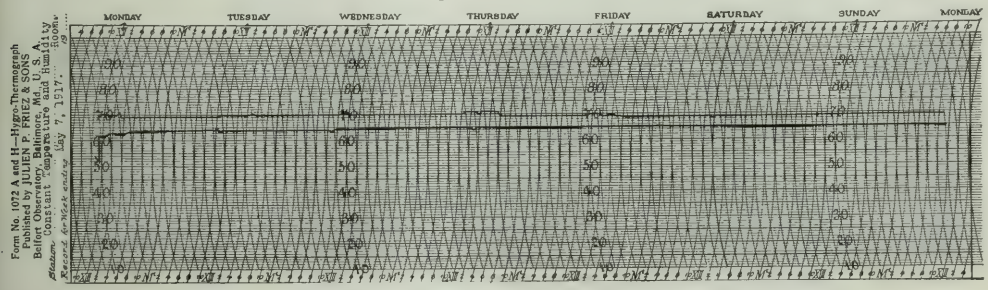


FIG. V —VIEW OUTSIDE OF THE ROOM SHOWING BRINE (J), AND STEAM COILS AND CHAMBERS (D), THE INTAKE FLUE [illegible] AND THE HUMIDITY SUPPLY LINE (J).

trolling the humidity of the room have been tried. The hygrostat now used controls the relative humidity within less than 2 per cent variation. The room has been operated fairly well by means of other controls, but none, so far used, has proved as reliable as the instrument now in use in giving uniform and accurate automatic control at all seasons of the year. The instrument is a Type F hygrostat, in which the actuating material is silk fiber. This instrument operates the diaphragm-operated valve K^1 [illegible] line to the humidifying jet. When the need of more moisture is indicated by contraction of the silk fiber the air pressure to the diaphragm is released, opening the valve and admitting steam to the jet, until the set humidity is reached, whereupon the valve is closed with the expansion of the silk fiber.

Previous to the installation of the present humidity

controller the room was operated by passing all air from the tempering coils over a vaporizing pan, in which a constant temperature was automatically maintained. This system usually gave fairly satisfactory results, but when sudden changes in the outdoor temperature or humidity occurred these were not automatically taken care of within the room. The vaporizing pan was 12 × 18 in. and built immediately outside the room in the intake flue. The pan contained 2 in. of water in which was located a thermostat connected with an automatic diaphragm-operated valve, placed in the steam line, to an open coil in the pan for heating the water. By this method moisture was uniformly and continually added to all air passing into the room. It was impracticable to take much fresh air into the room under these conditions and consequently the same air was continually recirculated, which facilitated maintaining very constant conditions but did not permit proper ventilation. The thermostat regulating the temperature of the vaporizing pan required frequent attention to allow for the changing outdoor conditions of temperature and humidity. In summer the temperature of the water in the vaporizing pan was held at 120 to 160° F. and in winter 160 to 185° F.



RECORD OF TEMPERATURE AND HUMIDITY FOR ONE WEEK BY THERMO-HYGROGRAPH RECORDING INSTRUMENT
TOP LINE—TEMPERATURE. BOTTOM LINE—HUMIDITY

in order to maintain 65 per cent relative humidity within the room. With the present system it is possible to take all air directly from outdoors or to add any amount of fresh air to that exhausted from and to be returned to the room without seasonal resetting of the controlling instrument.

As has been previously stated the room has been uniformly maintained at the desired temperature and humidity with only regular inspection to insure the proper mechanical condition of the operating equipment. It is not unusual for both temperature and relative humidity to be maintained constant for several weeks at a time as shown by the accompanying copies of the autographic records, which by the way are confirmed several times each day by wet and dry bulb readings.

CONCLUSION AND SUGGESTIONS

Seven and a half years' experience with and in developing a constant temperature and humidity room has led to the following conclusions and suggestions:

I—Owing to the intimate relation between temperature and humidity, both should be controlled, especially where exact testing conditions are desired. It is much easier to maintain uniform humidity conditions, when the temperature remains constant.

II—The source of the humidity supply should not be located within the humidity room. Experience shows that steam vapor is more satisfactory than water spray for increasing the humidity. If water spray vapor is used, mechanical moisture is likely to be deposited on the walls of the room, on the apparatus and on the materials to be tested. A steam jet or vaporizing pan has been found to be satisfactory for supplying the steam. If a water spray is used it must be installed outside of the room and the humidified air passed through a series of baffle plates to remove all excess of mechanical moisture before entering the room.

III—Uniform conditions within a room can be maintained only by the use of a number of properly located small fans. Without these the air will be stratified.

IV—Humidity may be controlled within limits in almost any room or building. It is unnecessary, even for testing laboratories, to construct such an elaborately insulated room as has been described, although a well insulated room is a great advantage. However, the best results will be obtained when the room has no outdoor exposure or windows. It is believed that a room constructed within another, leaving an air space of at least 12 inches between the walls, can be maintained at constant temperature and humidity by the control system described herein. The walls of the room may be of $^7/_8$ in. lumber and should be practically air-tight.

V—Humidity and temperature systems must be controlled more closely in paper and textile testing laboratories than in most factories, and for laboratories more or less difficulty may be experienced with many automatic systems, which are entirely satisfactory for commercial and manufacturing plants. It is, therefore, advisable to submit any installation to a thorough trial before reaching a conclusion as to its efficiency. As temperature and humidity are so closely related, a temperature effect on the actuating material of a humidity control instrument must be properly compensated for. Naturally if a humidity control is installed in a room in which the temperature is closely

controlled this practically eliminates the effect of room temperature on the humidity controller. All materials used for humidity controls are subject to temperature changes to a greater or lesser degree.

VI—Not only is the control of humidity of importance in the testing of materials, but also in many industrial lines as well. Many of the troubles and complaints of the pressman and engraver are due to humidity effects on paper and could be remedied by maintaining more uniform humidity conditions in the press and storage rooms. Low indoor humidity in winter is the cause of much inconvenience in printing, causing the paper to curl and shrink and thus interfering greatly with the work of the presses. Paper is more flexible at high humidity. This fact is of direct importance to the manufacturer of envelopes and in the folding of paper, the humidity of the room determining whether the folding is smooth or cracked. The humidity of the drying loft and the calendering end of a paper machine undoubtedly plays an important part in the finishing of paper. The expansion and contraction of the sheet caused by variations in atmospheric humidity are of controlling importance in map and chart making and in certain special uses of paper. This could be easily overcome by keeping the paper at a uniform humidity from the time it is received until the work is finished.

VII—There are many other industries in which the maintenance of uniform humidity is absolutely necessary. Among these are the manufacture of textiles, fuses for munitions, motion picture films, tobacco and many others. Humidity control is being applied to the ripening of fruit, curing of cheeses, drying of lumber, manufacture of leather goods and to many other important industries.

LEATHER AND PAPER LABORATORY
BUREAU OF CHEMISTRY, U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A METHOD FOR DETERMINING THE ABSORBENCY OF PAPER

By E. O. Reed

Received November 13, 1917

The serviceability of blotting paper, paper towels, filter paper and copying paper is largely dependent on their absorptive properties for the measuring of which several methods have been used. Since blotting is the most important of absorptive papers, the methods proposed have been especially adapted to the testing of this class of paper.

Absorption is most commonly determined by measuring the rate at which distilled water rises in a vertically suspended strip usually 15 mm. in width, the lower end of which dips beneath the surface of water contained in a trough. Either the time which it takes the water to rise to a given height or the height to which the water rises in a given time, is noted. The latter is the more common method. Apparatus for conducting this test, which is known as the "mounting test," has been designed by Klemm[1] and by Stevens.[2] Specifications for this quality in blotting paper usually require that absorption shall be not less than a certain number of millimeters in 10 min. The absorption in each minute can also be noted, though specifications generally state only the total absorption in 10 min.

There are several disadvantages in the use of the mounting test for determining the absorptive properties of a blotting paper. The strips are suspended vertically while the blotting paper is always used flat. The use of ink in this test is not practicable, due to the large surface exposed to evaporation in making the test and since most writing inks contain a colloidal precipitate, the blotter will tend to absorb only the liquid portion. There is considerable difference in the absorption of water and of ink by blotting paper. To get the true ink absorptive value, ink must be employed in the test. The chief drawback of the mounting test, however, is that it is unaffected by the bulk or weight of the paper which necessarily has a relation to serviceability. In this procedure an unlimited quantity of water is in contact with a variable thickness or bulk of paper for a definite time and the height to which the liquid rises in this definite time is recorded. Neither the width, thickness nor weight of the strip affects the results. Two papers of different bulk may give the same height of absorption, but the lighter will undoubtedly not absorb as much water as the heavier nor as rapidly. This is clearly shown in Table III, which will be discussed later. Bromley[1] suggests determining the actual weight of water absorbed. This procedure shows clearly that the mounting test does not take into consideration the bulk of the blotter, which is one of the chief factors determining the amount of water absorbed in a specified time.

Other methods have been suggested for indicating the absorbency of blotting papers. Sindall[2] describes a test for determining the absorptive qualities of blotting paper, which consists of noting the time required to absorb 0.5 cc. of ink delivered drop by drop, allowing each drop to be absorbed before another falls. Methods somewhat similar but differing in details of manipulation are described by Cross and Bevan,[3] and by Stevens.[4] The size and character of the zones formed are also noted. The thickness or bulk of the paper unquestionably plays an important part in determining the size and character of the zones. It has also been suggested that the absorptive capacity and the loss of absorbent qualities of blotting paper on repeated use can be determined by soaking it in ink, allowing to dry, and then noting the time required for the absorption of a definite quantity of ink dropped upon it.[5]

The same criticism—failure to include the effect of thickness or bulk of the paper on the quantity of ink or water absorbed in a given time—applies also to the methods suggested by Favier[6] and by Fromm.[7]

[1] "Notes on the Requirements of ... sses of Paper," *Paper Maker and British Paper Trade J.* ...

[2] "Elementary Manual of Paper Tes...

[3] "Paper Making," 4th Ed., p. 382.

[4] "Paper Mill Chemist," p. 231.

[5] *Ibid.*, p. 285.

[6] *La Papeterie*, 1894.

[7] ... *Papierfabr.*, 1909, 417.

[1] "Handbuch der Papierkunde," p. 318.

[2] "Paper Mill Chemist," p. 229.

In both of these methods absorption is measured with the paper in a horizontal position. By Favier's method the time required to saturate a square decimeter of the paper under a uniform pressure of water is noted. The absorption value is calculated by dividing the amount of water absorbed by the time required to saturate the paper. By Fromm's method five circular pieces of blotting paper are floated together on a trough of water and the time required to saturate the top piece is noted.

Though each of the methods referred to above is faulty in some particular, the results obtained with them, while varying with the procedure employed, are serviceable in judging the quality of blotting paper, if the limitations of the methods are kept in mind. It has long been felt, however, that none of the methods for indicating absorption give a true measure of the serviceability of absorbent papers, especially of blotting papers.

Investigations of the several procedures for the testing of absorbency indicate that by a modification and standardization of the procedures described by Sindall, Cross and Bevan and by Stevens, more accurate information as to absorptive qualities may be obtained than by the mounting test or the other methods mentioned. The procedure finally adopted consists in noting the time required for the absorption of one cc. of a specified standard ink or of distilled water under definitely prescribed conditions.

PROCEDURE

Place a 4-in. square of blotting paper over a beaker or tumbler and arrange a support in such a manner that a 1-cc. pipette is held in a vertical position with the delivering tip $^1/_2$ in. above the center of the surface of the paper. A suitable apparatus may be made by boring a hole in a cork through which the stem of the pipette will pass freely. Clamp it in a ring stand, so that the pipette when placed in position has the tip at the correct distance above the surface of the paper. Select a pipette with a delivery time for distilled water at 70° F. temperature of approximately 4 sec. Fill the pipette with distilled water or standard ink at 70° F. temperature. Place it in position in the support and permit the contents to flow upon the surface of the paper and record by means of a stop-watch the time required for the complete absorption of the liquid. Triplicate determinations should be made and the results averaged to secure the absorption time of the paper.

A 4-in. square of blotting paper is sufficiently large and it should be placed over a beaker or tumbler having a diameter somewhat greater than the blot made by the liquid, in order that the edge of the blot may not extend to where the paper rests upon the glass, as this may affect the time of absorption. It is important in placing the square of blotting paper upon the tumbler to dish it slightly, so that the water or ink will be received in one pool and thereby prevent buckling of the paper. If the paper is allowed to buckle, uneven distribution of the liquid will be caused and the time of absorption considerably affected, thereby rendering the test valueless. Check tests with this method in most cases differ but 2 or 3 sec. on papers absorbing the ink in less than 25 sec., and from 5 to 10 sec. on papers absorbing the ink in from 50 to 100 sec.

The results obtained using a specified standard ink are more indicative in the case of blotting paper than when water is employed. It is impossible to depend upon ink purchased on the market for use in a standard test of this character. It is therefore absolutely essential for the analyst to prepare the standard testing ink in accordance with a definite standard formula. For this purpose the formula for U. S. Government Standard[1] blue-black writing ink has been adopted. This formula is as follows:

	Grams
Pure dry tannic acid	23.4
Gallic acid, in crystals	7.7
Ferrous sulfate	30.0
Dilute hydrochloric acid (U. S. P.)	25.0
Carbolic acid	1.0
Dye, Bavarian blue (D. S. F), Schultz and Julius No. 478	2.2

Make to a volume of 1,000 cc. at 60° F. with distilled water.

All of these chemicals should be of U. S. P. quality and in addition the purity of the tannin should be determined by the hide powder method.

Dissolve the tannic and gallic acids together in about 50 cc. of warm water and allow to cool; dissolve the ferrous sulfate in about 150 cc. cold water. Add the hydrochloric acid to the ferrous sulfate and immediately mix the solutions. Add the dye dissolved in water and the carbolic acid and make up with distilled water to 1000 cc. Mix thoroughly and allow to stand for at least 4 days at room temperature. When ink is to be used for tests, draw out without shaking the bottle. Formulas for standard inks are also given in Bureau of Chemistry *Bulletin* **109**, revised, page 43, and Bureau of Standards *Bulletin* on "Some Technical Methods of Testing Miscellaneous Supplies," page 43. These formulas differ slightly from the one adopted in that gum arabic is added and the soluble dye is not included. The formula adopted gives an ink closely agreeing in composition with the normal commercial inks furnished under the above quoted formula.

To prevent oxidation and evaporation of the ink when not being used, it is essential that the ink be poured into 50-cc. dark bottles, tightly corked and stored in a dark, cool place. The use of 1 cc. of water or ink gives a sufficiently wide range in the absorption results between different papers. In the case of filter paper, copying paper and very light-weight blotting paper, a smaller amount of water or ink (0.5 cc.) should be employed.

There are several factors which affect the results, namely, the temperature of the liquid, the delivery time of the pipette, the distance of the tip above the surface of the blotting paper and the amount of liquid used. These should be standardized, if accurate and comparable results are desired. In most cases there is little difference between tests made with either the felt or wire side of the blotter up. It is advisable, however, always to place the same side of the paper up, preferably the wire side, as on that side the absorption is more uniform.

Table I shows the effect of the time of delivery

[1] "General Schedule of Supplies, 1917–1918," General Supply Committee, Item 1128, p. 60.

from the pipette on the time required for absorption of the water by the blotting paper. Ten 1-cc. pipettes were used. The pipettes were supported so that their tips were approximately 1/2 inch above the surface of the paper. The temperature of the distilled water was 70° F. and the wire sides of the papers were up.

TABLE I—RELATION BETWEEN SPEED OF DELIVERY AND TIME OF ABSORPTION OF WATER

PIPETTE No.	Time of delivery Sec.	TIME REQUIRED FOR ABSORPTION Sample 32286 Sec.	Sample 32751 Sec.	Sample 32288 Sec.
1	3	16	10	55
2	3 1/2	15	10	57
3	4	16	10	55
4	4	17	11	58
5	4	16	11	56
5	5	16	10	57
7	6	16	11	55
8	15	24	17	65
9	15	23	17	67
10	27	30	29	80

There is considerable difference in the results obtained with rapid and slow delivery pipettes. However, the results obtained with pipettes delivering the water in 3 to 6 sec. are practically the same. This is explained by the fact that with a slow delivery the rate of absorption of the fluid by the paper is nearly the same as or exceeds the rate of delivery from the pipette. Since the most uniform and accurate results are obtained with quick delivery, a pipette delivering 1 cc. in 4 sec. is regularly used in this test. The last drop delivered upon draining, unaided, is included in the test but not in noting the time of delivery.

Table II shows the effect upon the time of absorption of the distance of the point of delivery above the surface of the paper. The same pipette delivering in 4 sec. was used in all cases and the temperature of the distilled water was 70° F.

TABLE II—EFFECT ON THE TIME OF ABSORPTION OF DISTANCE OF POINT OF DELIVERY ABOVE THE PAPER

Distance of tip above surface In.	TIME REQUIRED FOR ABSORPTION Sample 32751 Sec.	Sample 32785 Sec.	Sample 32926 Sec.
4	8	19	35
2	9	20	37
1	10	24	37
1/2	10	26	38
1/8	10	26	39

The distance of point of delivery above the surface of the paper has very little effect on the time of absorption, though a slightly faster absorption with increasing distance is noted. Practically no difference, however, is observed in the average time of absorption when the tip of the pipette is from 3/8 to 1/2 inch from the paper. When the tip of the pipette is an inch or more above the surface of the paper, the liquid spatters, covering a larger area and the time of absorption is lessened. This difficulty is overcome when the tip of the pipette is placed approximately 1/2 inch above the paper.

In Table III there are given comparative results obtained by the mounting test and by the procedure outlined above, on a set of white blotting papers of the same composition and weighing 19, 32, 45, 58, 72, 96 and 140 lbs. per ream (19 × 24 — 500 sheets, respectively. The stock of these papers is all rag and the ash content varies only from 1 2 to 1 5 per cent. Distilled water at 70° F. temperature was used in both methods. The mounting test strips were all cut transversely of the sheet 15 mm. in width.

TABLE III—COMPARATIVE RESULTS OBTAINED BY THE MOUNTING TEST AND THE [illegible]

SAMPLE No.	Ream Weight 19 × 24 — 500 Lbs.	[illegible]	[illegible]	Time Required for Absorption of 1 cc. Sec.
32791(*)	19	[illegible]	[illegible]	111*
32792	32	[illegible]	[illegible]	109
32793	45	[illegible]	[illegible]	61
32794	58	[illegible]	[illegible]	58
32795	72	[illegible]	[illegible]	36
32796	96	[illegible]	[illegible]	37
32797	140	20	55	11

(*) This sample is very thin and [illegible] of water to filter through, reducing the amount [illegible]

The absorption values of these samples obtained by the mounting test are practically the same, though the weight of the paper varied from 19 to 140 lbs. per ream. These results are in harmony with the known fact that the rate of rise of water in the mounting test is independent of the weight of the paper. On the other hand, the speed of absorption in the cubic centimeter absorption method increases inversely with the weight of the paper. The effect of the weight or bulk of the blotter on the absorption value is clearly indicated by the time required for the absorption of 1 cc. of water in the horizontal position. This test shows that the speed of absorption increases with the increase in bulk of the paper and that the heavier the blotting paper the better its absorption properties.

In Table IV there are given the analyses and absorptive values of several typical samples of blotting paper measured by three different methods. Results are given by the mounting test, using distilled water, and by the 1 cc. absorption method, using distilled water and also U. S. Government Standard ink. The water and ink were used at 70° F. temperature.

The samples are arranged in the order of their absorptive values as indicated by the time required for the absorption of 1 cc. of standard ink. The order would be changed completely if the samples were arranged in the order indicated by the values obtained by the mounting test or by the absorption time for 1 cc. of distilled water. It will be noted throughout that the values by the mounting test do not give the same relative rating for absorptive qualities as those obtained by the 1 cc. time absorptive method using water or ink. It will be noted that here, too, the effect of weight is shown by the results obtained with the 1 cc. absorption method. By the 1 cc. absorption method the time varies from 9 to 203 sec., by the mounting test from 44 to 101 mm. Thus the possibility of differentiating between papers is much greater with the former than with the latter method. The results obtained by using 1 cc. of standard ink are undoubtedly of the most practical value. In this paper it is not the purpose to consider the factors in the manufacture of blotting paper which affect the absorption quality, as this will be fully dealt with in a later publication. However, the color, stock, and ash content of the [illegible] as well as the weight, will be found to explain the results in most cases.

If these samples are [illegible] to weight, that is, all samples ground [illegible] 100. So, or 60 lb. Canvas, the results by the [illegible] procedures still show difference in order of absorptive values, though the differences are [illegible]

The proposed method [illegible] to give an

TABLE IV—ANALYSES OF TYPICAL SAMPLES OF BLOTTING PAPER WITH COMPARATIVE ABSORPTION VALUES
(All Physical Tests Made at 70° F. and 65 Per cent Relative Humidity)

Sample No.	Color	Weight 19 × 24 500 Lbs.	Stock Rag Per cent	Stock Soda Per cent	Ash Per cent	Thickness 1/10,000 Inch	Bursting Strength Av. Points	Time Required for Absorption of Ink Sec.	Time Required for Absorption of Water Sec.	Mounting Test Rise in 10 Min. Mm.
32960	White	139½	81	19	8.3	365	27.0	9	9	96
28018	White	125	100	..	1.0	340	34.0	10	16	65
32956	White	102	79	21	7.7	285	21.0	13	11	101
32959	Gray	118½	70	30	7.9	330	30.0	14	10	86
28020	Blue	123½	100	..	2.6	330	30.5	15	16	65
32925	White	139	71	29	5.2	345	38.0	15	21	60
28129	White	97½	80	20	2.3	290	21.0	15	16	80
32961	Gray	135½	59	41	5.5	360	31.0	19	19	65
32924	White	119½	72	28	5.5	320	35.0	19	24	56
32955	White	77½	84	16	7.4	230	19.0	19	19	97
32799	White	100	100	..	1.3	250	19.0	21	18	61
32968	White	139½	48	52	20.1	335	21.5	21	18	67
32758	White	133	22	78	27.0	320	16.5	23	17	69
32969	Gray	137	49	51	18.4	330	26.0	24	18	63
32965	Gray	95½	52	48	17.0	260	19.5	26	16	78
32966	White	124½	51	49	19.9	305	23.5	30	22	68
32927	Pink	82½	85	15	4.7	220	23.5	30	20	75
32929	Pink	124	68	32	5.1	310	38.0	30	28	48
28030	White	93½	81	19	5.8	230	28.0	31	25	63
28024	White	101½	61	39	14.5	245	23.5	32	33	64
32760	White	114	22	78	25.5	260	24.5	38	23	69
32976	Gray	139	35	65	19.1	305	23.5	40	25	57
32962	White	80	66	34	14.4	215	18.5	40	26	80
32926	Pink	62	85	15	4.4	170	15.0	42	42	60
33852	White	63½	68	32	13.1	170	16.0	45	27	86
32973	Gray	102	26	74	20.2	240	19.0	49	29	67
32974	White	120	32	68	25.6	270	18.5	57	38	57
32970	White	83	26	74	19.8	195	17.5	62	50	66
32963	Gray	77	51	49	16.9	200	19.0	65	33	71
32922	White	77	62	38	7.6	190	26.0	65	47	63
32921	White	65½	68	32	6.3	150	22.0	74	85	57
31748	Blue	99½	60	40	23.9	230	20.0	104	69	56
28136	Blue	102	44	56	27.9	215	14.5	147	98	49
32936	Pink	58	37	63	16.0	132	13.5	203	197	44

indication of the total absorptive capacity of a paper or the loss of absorptive qualities on repeated use. In using this method to secure an indication as to the capacity of a blotting paper, a piece of paper of definite size (2 in. square is a convenient size) must be used. The test may be carried out in two ways: The paper may be saturated by running upon its surface successive 1-cc. portions of standard ink until it is completely saturated and will absorb no more. Although completely saturated with liquid in this manner, upon thoroughly drying the paper will still absorb more ink. Another plan is to allow the blotting paper to thoroughly dry between each 1 cc. of ink. Considerable time is required in the procedure, but after a certain number of applications of ink the absorption begins to decrease rapidly until finally a point is reached when the paper will absorb no more. By either procedure the number of centimeters of ink used and time required for the absorption of each centimeter is noted. The results by the procedures outlined do not give the same relative results and it is believed that the last suggested is the most indicative of the total capacity of blotting paper under service conditions.

However, the life or capacity of a blotter is so largely dependent upon the treatment it receives in service, that the results obtained by such a determination are of but little practical value. If a blotter is saturated with ink and allowed to dry, although somewhat stiffened, it will still absorb satisfactorily in most cases. In fact, it has been found that many blotting papers may be repeatedly saturated with ink and dried without materially lowering their blotting qualities. But in service the surface of the paper becomes covered with a coating of dried ink, rubbed, compressed and filled with dust, which renders it useless long before it is completely saturated with ink and its absorptive capacity gone.

Results on speed of absorption will not give an indication of the total absorption capacity of a blotting paper. For example, in Table IV, Samples 32955, 32799 and 32968 show practically the same absorptive values by the 1 cc. time absorption method for ink. Tests indicate that rated for total capacity of absorption the order would be 32799, 32955 and 32968, or in this case inversely as their ash content.

CONCLUSION

As the rate of rise of a liquid in the mounting test is independent of the bulk, an accurate indication of the absorptive qualities of a paper cannot be obtained with this test. It is our experience that the measurement of the zones formed by blots of ink on a blotting paper does not afford a reliable test for rating absorption qualities of different papers since the area of the blot is greatly affected by the thickness or weight of the paper even though the same amount of ink be used with each.

By the 1 cc. time absorption method suggested in this paper, the results obtained are apparently more indicative of the true absorption value of paper than can be obtained by other known methods. The method also has two distinct advantages: the test is made with the paper in the horizontal position and it is possible to use ink in making the test. The use of ink, provided a standard ink be used in all cases, gives the most serviceable indication as to the absorption value of blotting paper. The absorption value as indicated with water is not always the same as with ink.

The method has also been used in determining the relative absorptive values of paper toweling with very satisfactory results. In the case of copying paper, filter paper and very light weight blotting paper only 0.5 cc. of water should be used.

The method is very simple and convenient, and a number of closely agreeing results can be obtained in a very short time.

THE LEATHER AND PAPER LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

THE USE OF TEXTILE FIBERS IN MICROSCOPIC QUALITATIVE CHEMICAL ANALYSIS

By E. M. Chamot and H. I. Cole

Received September 28, 1917

III—THE DETECTION OF BORON BY MEANS OF TURMERIC VISCOSE SILK FIBERS[1]

The reaction of boric acid with turmeric paper, involving a color change from yellow to rose, was first described by Trömmsdorff[2] in 1815. Later investigators showed that this rose color was changed to blue or greenish black upon the addition of alkali.

In this reaction curcumine, the yellowish coloring matter in the turmeric root, is changed by the boric acid into another substance, rosocyanine, first described and named by Schlumberger[3] in 1866. It was so-called by him because of the fact that it forms rose colored solutions and blue colored metallic salts. Upon analysis he found that the rosocyanine contained no boron, though the latter was necessary to bring about the reaction.

Ivanow-Gajewski,[4] Ciamician and Silber,[5] Milobedzka,[6] and Jackson and Clarke[7] have since worked on this curious and interesting reaction and they found, as did Schlumberger, that rosocyanine does not contain boron. Here, then, is another of those curious chemical reactions where an element plays a mysterious rôle, for it is strange that boron alone among the elements should be able to induce a molecular rearrangement of curcumine into rosocyanine.

Emich[8] suggested that the blue color is due to a reaction of cellulose. Jackson and Clarke,[9] however, obtained the blue color when no cellulose was present and our results as given are in accordance with their findings.

In testing for boric acid in the usual manner with turmeric paper, addition of the alkali almost invariably yields a greenish black color when boron is present instead of the much more characteristic blue color. In applying this test microscopically, however, using individual fibers instead of strips of paper dyed with turmeric, it is always possible to obtain a distinct blue color. Having experienced difficulty with flax and cotton fibers impregnated with turmeric, it was thought worth while to test out the various controlling factors for the production of the best and most sensitive fiber.

After various methods of dyeing with turmeric were tested, the following one was selected as being the most satisfactory. A 50 per cent alcoholic, alkaline solution of turmeric is prepared by boiling approximately 20 g. of ground turmeric root with 50 cc. of alcohol and adding to the filtered solution an equal volume of water and $^1/_2$ to 1 cc. of dilute sodium hydroxide (10 per cent). The fibers are immersed in this solution which is then evaporated on a water bath to a syrupy consistency. The fibers are removed and immediately dipped in 95 per cent alcohol, pressed between filter paper, dipped in a dilute aqueous solution of sulfuric acid, washed with water and dried. The transference of the fibers from the hot dye to the alcohol must be done quickly as otherwise the turmeric adhering to the fibers is removed only with difficulty. Too long an immersion in the alcohol tends to remove the adsorbed dye as well as the excess dye.

If the fiber still appears to have any unadsorbed turmeric adhering to it (with viscose silk this is easily noted by the lack of luster) it can once more be dipped in alcohol and washed with water. Any unadsorbed turmeric interferes with the formation of the blue color in the boron test. This method as given yields a beautiful golden yellow product which was found to be eminently satisfactory.

Curcumine of different degrees of purity was also tested but since the delicacy of the reaction obtained by using the ordinary turmeric extract is exceedingly great, there is no necessity for other purification than that given in the above described method.

To determine the influence of the nature of the fiber on the delicacy of the reaction, the common textile fibers, flax, cotton, wool, mohair, raw silk, purified silk, viscose silk (cellulose xanthate), lustron silk (cellulose acetate) and coarse fibers of cupra-ammonium silk were dyed in turmeric solutions as stated above and then used for the boron test.

Flax, cotton, raw silk, purified silk and viscose silk dyed with turmeric give the typical boron test described below, while wool, mohair, lustron silk and cupra-ammonium silk more often give a green instead of the typical Prussian blue color upon addition of the alkali. Of the various fibers tested, viscose silk gives by far the best color reaction, flax being next best but less satisfactory in comparison. No preliminary treatment of the viscose silk to render it more adsorptive was found to be necessary.

Of the various methods tested for applying the turmeric fiber test for boron, the following procedure gives the most satisfactory results: Place a drop of the solution of the material to be tested upon an object slide and acidulate with dilute hydrochloric acid to decompose any borates that may be present. In this drop, place a turmeric fiber about 5 mm. long and allow to evaporate spontaneously, or by *gently* warming, to *complete* dryness. Cool and examine the fiber under the microscope. A rose or violet-rose color indicates boron. To confirm the test, place a drop of a 1 per cent solution of sodium hydroxide upon the rose colored fiber. The rose color immediately turns to a beautiful Prussian blue color which gradually changes to violet. Too high a temperature in the evaporation or failure to allow the fiber to go to complete dryness may lead to negative results. Too concentrated a solution of the alkali will interfere with the formation of the blue color. The fiber must be observed immediately upon addition of the alkali as the blue color is then most intense.

A mineral acid alone [illegible] fiber on evaporation to dryness gives a yellow to brown color, not the rose or pink color obtained when boron is also present. Furthermore, addition of a drop of alkali yields, instead of a blue, a yellow color changing to the

[1] For Parts I and II see This Journal, **9** (1917), 967.
[2] *J. Pharm.*, **16** (1815), 96.
[3] *Bull. soc. chim.*, [2] **5**, (1866), 194.
[4] *Ber.* **6** (1873), 1103.
[5] *Gazz. chim. ital.*, **27** (1897), 561.
[6] *Ber.*, **43** (1910), 2163.
[7] *Am. Chem. J.*, **39** (1908), 696; **45** (1911), 48.
[8] *Ann.*, **351** (1907), 429.
[9] *Am. Chem. J.*, **39** (1908), 696, **45** (1911), 48.

characteristic mahogany color produced by alkali on the turmeric fiber.

It must be remembered that a test for boron as sensitive as this one, must not be performed upon an object slide made from resistance glass containing boron as one of its ingredients. It follows also that apparatus made from such glasses cannot be used for solutions which are to be tested for the presence of boron.

The presence of hygroscopic salts is objectionable, since they prevent the complete drying of the fiber. However, when the solution to be tested contains more than traces of boron, a satisfactory test may be obtained even in the presence of large amounts of such salts.

Any strong bleaching agents, such as hydrogen peroxide or a hypochlorite, must be destroyed before the test can be applied.

Much free phosphoric or silicic acid render the detection of boron difficult though not impossible. In the turmeric paper test for boron as commonly applied, it has been pointed out that molybdenum, titanium, zirconium, columbium and tantalum may lead to error, because under certain conditions these elements give a color reaction somewhat similar to that obtained with boron when the alkali is added. This source of error has been carefully studied and we find that the presence of these elements leads to no misinterpretation of the color changes nor could we obtain with any of these elements the blue colored fiber, characteristic of boron, when no boron was present.

Boric acid can be distinguished from a simple borate in the following manner: Evaporate to dryness without the addition of a mineral acid. A rose-pink indicates boric acid; undecomposed borates yield no rose color. Add the alkali. Boric acid gives the characteristic blue color, borates do not. Commercial borates of ammonium, sodium, potassium, calcium, barium, iron, lead, nickel, copper and manganese tested as described, gave a boron test from aqueous solutions only after acidification with hydrochloric acid. Ferric borate, however, failed to give a positive test in very concentrated solution.

It must be remembered that in the presence of inorganic salts which have the power to decompose a borate, a test for boron may be obtained without the addition of an acid.

The sensitiveness of this reaction was tested according to the method already described.[1] A positive test can be obtained by means of turmeric viscose silk, in one drop of a $N/16{,}000$ solution of boric acid or of a borate, normality being computed with respect to the amount of boron present. The amount of boron actually present in a drop of a solution of this concentration is 0.000,025 mg.

SUMMARY

I—Viscose silk, dyed with turmeric, gives an exceedingly sensitive microscopic method for the detection of boron in boric acid or in borates.

II—It is possible by this method to differentiate between boron as boric acid and boron combined as borate, providing substances which will set free boric acid from borates are absent.

III—A drop of a solution containing 0.000,025 mg. of boron gives a positive test for boron by this method.

[1] *Loc. cit.*

IV— THE DETECTION OF THE HEAVY METALS BY MEANS OF ZINC SULFIDE WOOL FIBERS

The use of fibers impregnated with zinc sulfide, as a microscopic means of detecting the heavy metals, was suggested by Emich and Donau[1] in 1907. They used cotton and guncotton as the carriers for the zinc sulfide. In making these fibers, according to their method, we found that it was extremely difficult to impregnate the fiber with the zinc sulfide. In order to overcome this difficulty, we endeavored to make artificial fibers containing a zinc salt and ultimately to change this salt to zinc sulfide, as follows: An ether solution of zinc chloride was mixed with a solution of collodion or "parlodion." Artificial fibers were then made from this solution by forcing it through a fine capillary opening into a solution of sodium sulfide. The resulting fibers, while sensitive enough, were generally imperfectly formed and the manipulation necessary for their satisfactory production required such a great amount of skill and practice that the method, after many attempts, was abandoned as unreliable.

The following modification of this method was also tested. Finely divided and colloidal zinc sulfide was mixed with the collodion and then made into fibers, by extruding into a coagulating liquid, by dry spinning and by making thin films of the mixture and subsequently cutting them. Fibers made by this method also proved unreliable.

The common textile fibers were then tested as to their suitability. Fibers of cotton, true silk, viscose silk, lustron silk, flax, ramie, wool and mohair were immersed in solutions of zinc chloride for several hours, washed with water and placed in solutions of sodium sulfide for 2 hrs., then washed and dried. Of the fibers treated in this manner, in reagent solutions of different concentrations, wool and mohair alone adsorbed enough zinc sulfide to give a satisfactory color reaction with the heavy metals.

The preliminary treatment of the wool was found to be important. Fat-free and swelled fibers adsorb more of the zinc sulfide then the untreated fibers. The fat may be removed from the wool by a mixture of alcohol and ether. For swelling the fibers the best results were obtained by soaking the wool over night at room temperature in a 1 per cent solution of sodium hydroxide. This gives the maximum swelling with the minimum detriment to the fiber.

Various zinc salts and methods of impregnating the wool with the salts were tested. It was found that zinc acetate is adsorbed to a slightly greater extent than either zinc sulfate or zinc chloride. The following method for making zinc sulfide fibers was finally adopted: The defatted wool is swelled by soaking over night at room temperature, in a 1 per cent solution of sodium hydroxide. It is then washed and dipped 5 or 6 times alternately in solutions of 10 per cent zinc acetate and 10 per cent sodium sulfide, pressing out the

[1] *Ann.*, **351** (1907), 432.

excess solution but not washing between dippings. After the final dipping, the impregnated wool is washed and dried by pressing between filter paper. Zinc sulfide wool fibers made in this way are sensitive to 0.001 mg. of copper. The sodium sulfide solution should be freshly prepared by passing H_2S into a solution of NaOH until a portion removed fails to yield a precipitate with $MgCl_2$. The fibers thus prepared are employed as follows:

(*a*) Place a drop of the solution to be tested upon an object slide and add a drop of dilute HCl. Introduce into the drop a zinc sulfide wool fiber about 5 mm. long and examine under the microscope.

(*b*) Evaporate to dryness, add a drop of dilute ammonium hydroxide, examine the fiber again and introduce into the drop a new fiber to serve as a means of comparison, in order that slight changes in color may be better discerned. These color changes are yellow, orange, brown or black.

In acid solution the fiber is

Straw-yellow	Tin
Lemon yellow	Arsenic, Cadmium
Orange	Antimony
Reddish brown	Bismuth
Brown or yellow-brown	Platinum, Copper, Mercuric Mercury, Antimony (sometimes Cobalt, Iron, Manganese, Nickel)
Black (brown in very dilute solutions)	Silver, Lead, Gold, Mercurous Mercury

In acid solution no color, but in alkaline solution the fiber may turn *brown* or *yellow-brown* if cobalt, iron, manganese or nickel is present. These elements, however, rarely give good reactions with the fibers.

It must be remembered that the color of the fiber, as usually observed with transmitted light, varies with the amount of the metal present. For example, a yellow or orange color, if deep enough, may appear brown or even black. On the other hand, an element giving usually a brown or black color with the fiber may color it a light brown or yellow when only traces of the element are present.

SUMMARY

I—A reliable and sensitive method for the preparation of zinc sulfide fibers has been described.

II—Zinc sulfide wool offers a satisfactory test in minute quantities of materials for the presence or absence of metals yielding colored sulfides.

LABORATORY CHEMICAL MICROSCOPY
CORNELL UNIVERSITY, ITHACA, N. Y.

A PROXIMATE QUANTITATIVE METHOD FOR THE DETERMINATION OF RUBIDIUM AND CAESIUM IN PLANT ASH

BY W. O. ROBINSON

Received November 12, 1917

This method is based on the removal of the major portion of potassium chloride by fractional precipitation with platinic chloride and, further, by precipitation with strong hydrochloric acid. The resulting solution containing all the rubidium and caesium chlorides and a large amount of potassium chloride is compared spectroscopically with a standard solution according to the method outlined by Gooch and Phinney.[1]

[1] *Am. J. Sci.*, **44** (1892), 89.

For the determination, [illegible] of the dry plant are carefully ashed [illegible] the temperature does not exceed 525° C. The ash is dissolved in hydrochloric acid and the excess evaporated off. An excess of freshly slaked lime is added to precipitate the phosphoric [illegible]. The solution and precipitate are [illegible] minutes and then filtered. The [illegible] in the filtrate is then precipitated with ammonia and ammonium carbonates and filtered. For the [illegible] precipitation, a second precipitation of the calcium should be made. The combined filtrates are [illegible] to dryness, and the ammonium salts expelled. This operation must be most carefully done, for the rare earth chlorides are extremely volatile. It is best done in a muffle kept just below redness. The resulting alkali chlorides are filtered off with hot water, a few drops of hydrochloric acid added and then about 0.05 g. of platinic chloride. The solution is stirred well and evaporated to pastiness. Meanwhile a small carbon filter is prepared by drawing out a hard glass tube of [illegible] in. or less diameter. A [illegible] platinum foil serves to hold a small [illegible] of asbestos. The unchanged chlorides of potassium and sodium are rapidly dissolved in the minimum amount of hot water and the chloroplatinates of the rare alkalies with some potassium chloroplatinates washed on to the asbestos pad with 80 per cent alcohol. Care must be taken not to use too large an amount of hot water to dissolve and wash the unchanged chlorides. The platinic chlorides of potassium, rubidium and caesium are then reduced by connecting the carbon filter to a hydrogen generator and [illegible] gently with a Bunsen burner. The reduction takes place readily, becoming spontaneous when some platinum black is left on the pad from a previous [illegible] and the pad is somewhat moist with alcohol. The chlorides of the alkalies are washed through the filter with hot water, the filtrate evaporated to pastiness in a very small, lipped, platinum dish. The mass is then taken up with four drops of strong hydrochloric acid and filtered through a tiny filter into a vial of about 2 to 3 cc. capacity. A number of these vials are graduated to hold the same volume. The rare alkali chlorides are taken up and filtered with two more portions of acid of four drops each, each [illegible] portion being blown through the filter. The solution is made up to volume and is ready for [illegible]. Standards are made up by [illegible] known amounts of caesium and rubidium chlorides and an excess of potassium chlorides with strong hydrochloric acid as above.

A Bunsen burner is used [illegible] source of heat and is must be carefully [illegible] by the observer. The chlorides are so volatile that the flame lasts only a few minutes. Caesium [illegible] by the doublets 4215.6 and 4321.2 a. and rubidium by the double lines 4500.3 and 4555.4. These lines are different to see, and the observer must [illegible] the eye room for at least an hour before the eye becomes sensitive enough.

The comparison is made [illegible] a coil of platinum wire of sufficient [illegible] a very

large drop.[1] The coil is carefully dried high above the flame or on a radiator, taking care to avoid spattering. The unknown solution is matched with standards by means of the brilliancy of the line. An accuracy of from 5 to 10 per cent is easily obtained by different observers.

Bureau of Soils
Washington, D. C.

A QUICK METHOD FOR LIME CAKE ANALYSIS

By Alfred N. Clark

Received November 5, 1917

The usual procedure in lime cake analysis has been to weigh out 50 g. of the sample in a sugar weighing dish, add acetic acid, mix to a thin mud in the weighing dish, transfer the contents to a 200-cc. flask, add lead subacetate solution, and fill to the mark with water. All the textbooks describe a method similar to the above, and in which a flask is used. Such a procedure has four serious drawbacks which are avoided in the method described below. With the flask method, lime is liable to foam over the sides of the sugar dish when acid is added; it is difficult to thoroughly mix in such a small dish without spilling; there is danger of spilling when transferring from the weighing dish to the flask; and the whole procedure is a slow, disagreeable one.

The writer weighs the sample of lime cake in a counterbalanced, nickel-plated, copper beaker of about 300 cc. capacity, adds the calculated volume of acetic acid solution from a pipette, mixes with a small pestle, adds a charge of lead subacetate solution from a Sachs-LeDocte or a Kruger pipette, again mixes with a pestle, and pours onto a filter. The dish is large enough to avoid foaming over, and the mixture is not transferred from the weighing dish until ready to filter.

[1] A No. 27 wire B. & S. gauge, coiled seven times around a 3/16 rod, makes a good coil.

The following examples will explain the calculation required for adopting the Sachs-LeDocte or Kruger sugar pipettes to lime cake analysis:

A Sachs-LeDocte pipette delivers 177 cc. of lead solution and uses a normal weight of 26 g. Therefore, 200 cc. of solution must be added to the dry matter of the lime cake, and if it is assumed that the cake contains 50 per cent moisture, we have 13 + 10 + 177 = 200 cc. As it is necessary to add acetic acid or ammonium nitrate to decompose saccharates, the strength of acid is so adjusted that 10 cc. are required. When the filtered sample is polarized in a 200 mm. tube twice the scale reading is the per cent sugar in the cake.

With the Kruger automatic pipette the normal weight is adjusted to the size of the pipette; for instance, if the pipette delivers 123.6 cc., the normal weight is 41.2 g. for beets, and the same weight is used for lime cake. The amount of solution to add to the dry matter of the lime cake is 158.5 cc., and if the lime cake contains approximately 50 per cent of moisture the solution is made up of 20.6 + 14.3 + 123.6 = 158.5 cc. Here 14.3 cc. of acetic acid solution are used, and the polarization in a 200-mm. tube is the per cent sugar in the cake.

If the moisture content of the cake varies appreciably from 50 per cent the volume of acetic solution added is adjusted accordingly.

When "free" sugar is to be determined, water is added instead of acetic acid.

By the use of normal lead acetate solution in the place of subacetate solution, no acetic acid need be added, but in that instance a different weight of lime cake should be used in order to give the proper dilution.

900 N. Washington Avenue
Lansing, Michigan

RECOVERY OF LIGHT OILS AND REFINING OF TOLUOL

Report prepared by the Bureau of Standards in response to numerous inquiries for information regarding recovery of light oils and the refining of toluol. This report was submitted to, and revised in accordance with suggestions of the committee, consisting of representatives of the Public Service Commissions, municipalities, manufacturers of gas, and makers of toluol recovery equipment, organized under the chairmanship of Dr. E. B. Rosa of the Bureau of Standards at the request of the conference which met at the Bureau July 31, August 1 and 2, 1917.

PART I—THE TECHNICAL RELATION OF THE GAS INDUSTRY TO THE MILITARY NEEDS OF THE NATION

1. HIGH EXPLOSIVES MANUFACTURED FROM GAS BY-PRODUCTS—The importance of high explosives in the present war has been amply demonstrated. While nearly all kinds of explosives are used in some way, those which are most in favor for filling high explosive shells are manufactured from benzol and toluol, which substances have their most important commercial source in manufactured gas of one kind or another. The gas industry thus becomes directly and vitally connected with the conduct of the war and a survey of the demands which will be made upon it, and its preparedness in a technical way to meet these demands, is very important at the present time.

2. CITY GAS PLANTS MUST SUPPLEMENT COKE-OVEN PRODUCTION—The constituents of illuminating and fuel gas which are important in the manufacture of explosives at the present time are benzol and toluol, especially the latter. The removal of these constituents from the gas which is a by-product of coke-oven plants has been practiced for some time. Plants manufacturing city gas, however, have not generally removed these substances from the gas since they contribute to its light- and heat-giving qualities and the substitution of other substances to maintain the gas quality up to prescribed standards has not usually been considered profitable. Even now, although several months have elapsed since the United States entered the war, comparatively few city plants are equipped to recover these materials, but the prospects are that in the near future they must do so if the requirements for high explosives are as great as is anticipated. Major Burns of the Ordnance Department at the conference held at the Bureau of Standards on August 1 stated that the Army is dependent upon toluol for the manufacture of T. N. T. for shell filler. The amount of toluol needed depends upon the number of men engaged and how engaged. The present estimates are that toluol for shell filler will be needed in the coming year for our own army, for the allies, and the navy at a rate considerably in excess of the present or anticipated supplies from works under construction. There is at the present time about 4 million pounds per month of T. N. T. nitrating capacity and sufficient toluol is not now available to utilize it; it is therefore now impossible to place more orders for T. N. T. primarily because more toluol is not available. It is probable that any and all explosives including the picrates will be necessary eventually.

3. MANUFACTURING PROCESSES IN USE IN THE UNITED STATES—The manufactured gas distributed in the United States is of three principal kinds: Coal gas, carbureted water gas, and oil gas.

The manufacture of water gas consists essentially of an intermittent process in which a bed of anthracite coal or coke is brought to a high temperature by an air blast and then steam under pressure is blown through the fuel, forming carbon monoxide, hydrogen and a small amount of carbon dioxide, by reaction with the carbon in the fuel. The resultant gas, called blue water gas, has a heating value of approximately 300 B. t. u. per cu. ft. and almost no luminosity when burned in an open flame; it is conducted into a fire-brick-lined chamber called the carbureter, which contains staggered rows of fire bricks, called checker brick, heated to incandescence during the blow period. Gas oil or fuel oil is sprayed into the carbureter while the gas is passing through, forming an oil gas which enriches the blue water gas to any desired heating value or candlepower. Another checker-brick-filler chamber, called the superheater, converts most of the oil gas vapors into permanent gases, which will not condense again upon cooling. During the formation of the oil gas certain portions of the hydrocarbons which compose the oil are changed in their composition to form benzol, toluol, and related hydrocarbons, called aromatic compounds. Considerable tar is formed at the same time. This is condensed, scrubbed, and washed out of the gas by various means, but usually at a temperature which permits most of the aromatics to go forward with the gas. The sulfur in the gas is removed by iron oxide purifiers and the gas is metered and leaves the plant at, or slightly above, atmospheric temperature.

The manufacture of coal gas is essentially different from that of water gas. In this process certain classes of bituminous coals are distilled in fireclay or silica retorts or ovens and the resulting gases are condensed, scrubbed, washed, and purified to remove water vapor, tar, ammonia, and sulfur. As in the water-gas process, certain of the hydrocarbons given off by the coal are transformed by the heat of the retort to aromatic compounds. A small part of these aromatics are washed out of the gas by the wash water and tar, but the larger part remains in the gas; in fact, the cooling of the gas is usually so regulated that most of these substances will remain in the gas to increase its heating value and candle power. Coal gas retorts take a variety of forms; among these are coke ovens, chamber ovens, horizontal D-shaped retorts, vertical retorts, inclined retorts, etc. Even those of a given class differ among themselves in details of construction. In most of them the distillation is an intermittent process, but some continuous methods are used. In all these processes the gas produced consists of the same constituents in somewhat different proportions. The form of apparatus used in a given case depends largely upon economic considerations or is governed by certain special qualities which are desired in one or more of the products produced. In all of these coal-gas processes, coke remains in the retort after distillation. In some of them, as for example in coke ovens, coke is the principal product; but in city gas plants, gas is the chief product. The operation is carried out in any case to give most satisfactory qualities to the principal product and at the same time obtain as high yields and good quality as possible of the secondary or by-products.

Mixed gas is usually understood to be a mixture of carbureted water gas and coal or coke-oven gas. It is supplied in many cities in the United States where the requirements permit of a mixed gas being supplied.

The manufacturing installation for mixed gas is practically two complete installations, one for coal gas and one for carbureted water gas, with their auxiliary scrubbing, condensing, purifying, and metering apparatus entirely independent and separate. The manufactured mixed gas, however, is stored in common holders and delivered through a single distribution system.

The coal and water gas thus supplement each other. The uniform, but more cumbersome coal-gas production furnishes coke as fuel for the water-gas plant; this in turn takes care of the irregularities of the output and where necessary increases the quality of the gas production, especially where a high candlepower standard is in force.

The oil gas process is at present confined chiefly to the Pacific Coast states, where comparatively cheap oil and expensive coal make the coal- and water-gas processes less feasible. In oil-gas manufacture, oil alone is used as fuel for heating the checker bricks of the fixing chambers and oil is sprayed by steam into the chambers where in contact with the bricks, lampblack and permanent gases are formed. In this process also, aromatic compounds are included among the constituents of the gas.

4 AVERAGE CONTENT OF LIGHT OILS IN VARIOUS GASES—The amount of benzol and toluol formed in any one of these processes is by no means definite. It depends upon the operating conditions and the quality of the raw materials (coal or oil). It would therefore be impossible to predict exactly what the yield in a given case would be, but an extensive inquiry into the operation of several typical plants has given the following approximate figures for the various processes. These figures are averages of the results obtained in the several plants; individual results may vary widely from them in a particular case:

DATA FROM TWELVE PLANTS [illegible]

APPROXIMATE YIELD OF [illegible]

Horizontal retort coal gas	[illegible] ton coal carbonized
Coke-oven gas	[illegible] ton coal carbonized
Continuous-vertical retort coal gas[1]	1.8 gal. per short ton coal carbonized
Carbureted water gas	[illegible] volume of gas oil used

COMPOSITION OF [illegible]

	Benzol Per cent	Toluol Per cent	Solvent naphtha, wash oil, naphthalene, etc. Per cent	Paraffins
Horizontal retort coal gas	38	14	46	Less than 2 per cent[4]
Coke oven gas	58	34	8	Less than 2 per cent[4]
Continuous vertical-retort coal gas	15	15	68	1. per cent
Carbureted water gas	42	23	33	Less than 2 per cent[4]

YIELD OF PURE PRODUCTS

	Benzol	Toluol
Horizontal-retort coal gas	1.32 gal. per short ton coal carbonized	0.45 gal. per short ton coal carbonized
Coke-oven gas	1.45 gal. per short ton coal carbonized	0.85 gal. per short ton coal carbonized
Continuous vertical-retort coal gas[1]	0.27 gal. per short ton coal carbonized	0.26 gal. per short ton coal carbonized
Carbureted water gas[2]	0.15 gal. per 1000 cu. ft. of gas	0.07 gal. per 1000 cu. ft. of gas

[1] Results from only one continuous vertical installation included here.
[2] The yield of toluol is variable according to amount of oil used in manufacturing the gas, being equivalent to about 2.0 to 2.2 per cent of the gas oil used in the plants investigated, but perhaps only about 1.6 in many cases.
[3] Data obtained from various sources.
[4] This amount may be exceeded under some operating conditions, but paraffins can usually be kept down to this figure except in unusual conditions or with certain fuels.

No specific data are available for the amounts of toluol present in oil gas, though it is understood that the oil gas distributed on the Pacific Coast contains at least as much toluol as does coal gas.

Assuming that a ton of coal gives 10,000 cu. ft. of gas and that 3.5 to 4 gal. of gas oil are used per 1000 cu. ft. of carbureted water gas, it is evident from the table that the amount of toluol obtainable per 1000 cu. ft. of rich water gas is considerably greater than that obtainable from coal or coke-oven gas.

5. PROSPECTIVE TOLUOL SOURCES—It does not seem likely that it will become practicable in the near future for plants having outputs less than 100 million cu. ft. per year to recover light oils. A survey of plants of that size and larger indicates that there are about 112 plants having an aggregate annual gas output of about 135 billions cu. ft., of which about 97 billions are water gas, 25 billions coal gas, and 13 billions oil gas. What annual output of toluol could be expected from washing all this gas is problematical. It seems, however, that at least 0.05 gal. of toluol per 1000 cu. ft. of gas could be expected, which would give a prospective toluol recovery from all these companies of about 7,000,000 gal. per year. It seems likely that with an adjustment of standards the benzol production from the same amount of gas would be between three and four times as much as the toluol production, or approximately 18,000,000 gal. These yields are by no means the maximum obtainable, since the production in some existing plants is higher than 0.05 gallon of toluol per [illegible]. A few of the plants included in this estimate are already recovering part of their toluol and benzol, but by far the greater part of the available supplies are not yet recovered.

PART II PRINCIPLES UNDERLYING BENZOL AND TOLUOL RECOVERY

1 RELATION TO GAS PLANT OPERATIONS—Benzol, toluol, and the related hydrocarbons [illegible] collectively will be designated as light oils, are present [illegible] as condensable vapors and are associated with other [illegible] of the olefine and paraffin series which possess [illegible] properties similar to them. To separate some [illegible] fractions, especially the paraffins, from the light oil by [illegible] liquids, is wellnigh impossible and therefore it [illegible] to control the conditions of gas manufacture [illegible] of these substances will be present in the light oils, as is possible. The

presence of more than 2 per cent of paraffin compounds in toluol is said to make it unfit for the manufacture of explosives. Only by careful attention to the temperatures and other operating conditions maintained in the gas making process and by the use of suitable raw materials can the gas manufacturer be certain that the toluol obtained from his light oils will be salable. For example, in the recovery of light oils from water gas not only the temperature, but the rate of oil injection, spacing of checker bricks, etc., affect results. Dirty checker bricks are said to be a very common cause of high paraffin content in the toluol produced. The favorable conditions can be determined only by trial in each particular case.

For the successful operation of plants in which partial or total rectification of the light oils is carried out, careful technical control seems to be a prime essential. In smaller plants where only light oil is recovered technical supervision should be available in starting the plant and for such a time afterwards as will enable the regular operators to become familiar with the fundamentals of operation and establish a routine. It might be feasible for several small plants within a certain district to retain the services of a technical man who would divide his time among them, and make the more elaborate tests which are occasionally required for successful operation.

2. REMOVAL OF LIGHT OILS FROM THE GAS—To recover light oils from the gas, the method now almost universally employed is to bring the gas into contact with an oil which has a solvent action upon the light oils. Oil washing of gas is accomplished by a variety of apparatus. In any case to obtain complete absorption it is necessary that an adequate amount of oil at a sufficiently low temperature be brought into contact with the gas. The temperature of the wash oil should not exceed 30° C. (86° F.). The temperatures obtainable in practice will, of course, depend upon the facilities available for cooling the oil. It is desirable to have the oil a little warmer than the gas to prevent condensation of water from the gas into the oil which gives trouble in the further stages of recovery. The amount of wash oil circulated through the washers will depend upon the amount of light oil vapors present in the gas, the temperature of the oil, the amount of gas to be washed, and the saturation of the wash oil which it is feasible to obtain. About 10 gal. of wash oil per 1000 cu. ft. of gas washed, seems to be an average figure.

The oil now usually employed for this purpose in this country is a petroleum distillate called from its color, "straw oil;" some plants use a creosote oil obtained from the distillation of coal tar. The choice seems to depend largely upon which is available in a given case. The qualifications which a wash oil should possess seem to be substantially as follows:

A creosote oil upon distillation should yield not to exceed 5 per cent up to 200° C., and not less than 90 per cent between 200 and 300° C. The oil should not contain more than 7 per cent naphthalene and should not show any marked increase in viscosity down to 4° C. The oil should be as fluid as possible under the working conditions and should have as small capacity for heat as possible.

The characteristics of a straw oil for this purpose, as obtained from some operators, are substantially as follows:

I—Specific gravity not less than 0.860 at 15.5° C.
II—Flash point in open cup tester not less than 135° C.
III—Viscosity in Saybolt viscosimeter at 37.7° C. not more than 70 seconds.
IV—The pour test shall not be over —1.1° C.
V—When 500 cc. of the oil are distilled with steam at atmospheric pressure, collecting 500 cc. of condensed water, not over 5 cc. of oil shall have distilled over.
VI—The oil remaining after the steam distillation shall be poured into a 500-cc. cylinder and shall show no permanent emulsion.
VII—The oil shall not lose more than 10 per cent by volume in washing with 2½ times its volume of 100 per cent sulfuric acid, when vigorously agitated with acid for 5 mins. and allowed to stand for 2 hrs.

Some operators claim to have successfully used ordinary gas oil or water-gas tar. It is claimed by other operators, however, that when gas oil is used the paraffin and olefine compounds in it are likely to contaminate the light oil and that on account of emulsification this oil soon becomes unfit for use. Water-gas tar, it is said, soon becomes too thick for use and soon leads to serious naphthalene deposits in the distribution system. The advantages claimed for these materials are their general availability and lower cost, and the fact that most gas companies already have adequate storage facilities for these materials.

3. STRIPPING WASH OIL—To separate the light oils from the wash oil in which they are dissolved, some form of still is employed; the difference in boiling points makes possible the separation. In large plants there are used continuous stills, in which steam comes in contact with the wash oil and boils off the light oils. The light oil vapors together with the uncondensed portion of the steam ascend upward through a series of chambers, which will be described more in detail later. In their ascent they come in contact with descending wash oil carrying light oils which they assist in freeing. The light oil vapors together with some steam, naphthalene, sulfur compounds, etc., pass away from the still and are condensed. Some of the wash oil is also carried along with the light oils, and has to be separated in the subsequent treatment. In small plants either continuous or intermittent stills may be used.

4. REFINING—To obtain from the light oils those constituents which are most in demand, a further separation by distillation and chemical treatment is necessary. The light oil is distilled in some form of a still, usually equipped with a rectifying column and dephlegmator or planer which will be described in more detail later. The latter apparatus acts as a partial condenser in which part of the vapor is condensed and falling downward through the rectifying column meets the ascending vapors and washes from them a portion of the high-boiling constituents. Only the light low-boiling constituents are able to pass the dephlegmator uncondensed. What vapors shall be allowed to pass on to the condensers depends upon the temperature maintained at the dephlegmator. This temperature is regulated according to the particular oil which it is desired to separate from the light oil mixture at any particular stage of the distillation. By the use of the dephlegmator and rectifying column it is possible to obtain much more definite separation of the benzol, toluol, and other aromatics than would otherwise be possible. In making the first distillation of the light oil, it is usual to collect the distillate in three successive portions or fractions, making the "cuts" at predetermined temperatures. The first fraction is collected in a containing vessel or receiver until the temperature at the top of the still is 100° C. This fraction is called crude benzol, since benzol is its chief constituent. The flow of distillate is then diverted into another receiver and collected until a temperature of 120° C. is reached. This fraction is termed crude toluol, from its chief component. The fraction collected above 120° C. is called crude solvent naphtha from the use to which it is put, as a solvent of various materials. The boiling point of pure benzol and pure toluol are 80° and 111° C., respectively. It will be noted that one of the changes of fractions or cuts is made midway between these boiling points while the boiling point of pure toluol is midway between the other cuts.

That the first separation is by no means complete is shown by the following analysis, which is typical of a crude toluol fraction:

	Per cent
Benzol	11.1
Toluol	64.4
Solvent	8.9
Residue, etc.	15.6
TOTAL	100.0

The above procedure is not universal. Some operators collect the crude benzol and toluol together and subsequently separate them. Some of the impurities present in the crude fractions have boiling points so close to those of benzol and toluol that they cannot be separated from them by distillation. To remove a certain class of these compounds, called olefines, the fractions are washed successively with strong sulfuric acid, caustic soda, and water. The olefines form a thick, tarry mass, which settles out by gravity upon standing and is drawn off. The fractions are then redistilled in stills with very high rectifying columns and fractions are finally obtained which boil within a single degree of the temperatures which have been determined as the boiling points of pure benzol, toluol, etc.

Some operators prefer to distil the toluol fraction from water-gas light oils in a still without a rectifying column, previous to final distillation in a column still. The vapors from the still in this case pass directly through a condenser coming out in liquid form. This liquid passes upward through a tank containing a solution of caustic soda. By this process any sulfonated olefines which remain in the toluol are removed. Otherwise they would be broken up in the column still and have a destructive action on the dephlegmator and condenser. The condenser coil and connections of this intermediate still should be made of lead.

The final distillates are considered as substantially pure materials if their specific gravities also agree with those which have been determined for the pure constituents. If, however, the specific gravity is lower than that of the pure benzol or toluol, it is an indication of the presence of paraffins, and to a certain extent the lowering is a measure of the amount of paraffins present.

It is understood that there is no commercially feasible way of separating these paraffins, and in the case of toluol, if the amount exceeds 2 per cent. the toluol is unfit for the manufacture of explosives. It is stated by some operators that by regulating the speed of distillation it is sometimes possible to make the paraffins distil into other than the toluol fraction, even when present in excess in the crude toluol, but the real remedy is to adjust the gas-making conditions so that the paraffin will not be produced. It is evident that special knowledge and skill are necessary from beginning to end of the recovery process.

5. EFFECT ON GAS QUALITY—(*a*) *Oil Washing.* As has been stated above, the removal of benzol and toluol from the gas reduces its heating value and candle power. The amount of reduction will depend on the original quality of the gas before washing, the thoroughness of washing, and the process of gas making employed.

Operators of benzol recovery plants differ considerably in their opinion as to just what the average reduction would be, but the general opinion seems to be that the complete removal of light oils from gas results in reduction of at least 50 per cent in the open-flame candlepower and from 1½ to 8 per cent in the heating value (averaging about 5 per cent). Various operators have endeavored to establish ratios between light oil removal and heat reduction. One operator states that for every 0.1 of a gal. of light oil removed per 1000 cu. ft. of gas, the heating value will be reduced between 13 and 14 B. t. u. per cu. ft. and the candlepower between 2½ and 3 candles. Another states that the reduction of heating value is 10 B. t. u. for every 0.1 gal. of liquor oil remained.

Mr. J. W. Shaeffer, manager of the Milwaukee Coke and Gas Co., who has made some studies of the subject, states that the following expression gives very closely the heating value of oil-washed coal gas:

$$\frac{a - 121827\ b}{1 - 35\ b}$$

in which (*a*) is the heating value of the gas before washing, (*b*) is the number of gallons of light oils removed per cubic foot of gas washed and 35 is the number of cubic feet of vapor per gallon of light oil. The constant 121827 is the product of 17567 (the heating value per lb. of the light oils), 7.3 (the weight per gallon of these oils) and 0.95 (a factor to correct for the amount of wash oils in the light oil, which is assumed to be 5 per cent). From calorimeter tests he concludes that the theoretical loss is practically the same as the actual loss.

(*b*) *Re-enrichment.* If it is desired to recover toluol and still maintain a fairly high standard of gas quality, various methods may be employed, as follows:

(1) The light oils may be entirely removed from the gas, fractionated, and the benzol fraction returned to the gas by some suitable method.

(2) The gas may be only partially washed of its light oils by the use of insufficient wash oil for complete removal of the light oils.

(3) All the light oils may be washed from the gas and no portion returned, the enrichment up to the desired quality being accomplished by the addition of volatile petroleum distillates.

The decision as to which method should be employed in a given case would depend upon several considerations. A partial scrubbing of the gas by Process 2 would be most convenient for plants which did not fractionate its light oils, but the possible toluol recovery would be considerably less than in Methods 1 and 3. Method 3 would require the purchase of petroleum distillates, the price of which might make the method unprofitable. It is stated by some operators that more distillates must be added to gas than the quantity of light oil removed to compensate for their removal, especially where a candlepower standard is in force, since petroleum distillates do not contribute to the open flame candlepower to anything like the extent that benzol does. In order to have the re-enrichment effective the distillate would have to possess certain qualities. One operator states that it should volatilize completely below 150° C. and have a heating value of at least 23,000 B. t. u. per lb.

The gas quality standard in force in a given locality would also, to a considerable extent, determine the method of re-enrichment and the toluol yields obtainable. A company which is operating under a very high candlepower standard is forced to re-enrich heavily or to be satisfied with a small toluol recovery. A lower standard obviates this difficulty to a considerable extent. One operator in a large city which maintains a 22 candlepower standard, states that a plant now making gas of that quality could, if relieved of the candlepower requirement, still maintain over 600 B. t. u. [illegible] gal. toluol and 0.08 gal. benzol, even though no light oils were returned to the gas. In plants making other gas qualities, the yields of toluol and effect upon gas quality would, of course, be different.

Figures as to the value of the [illegible] water gas from various plants indicate that for medium candlepower gas, *viz.*, 12 to 17 candles, 0.1 gal. of benzol per 1000 cu. ft. returned to the gas raises the candle[illegible]. The effect on the heating value in these particular cases is not known, but it seems probable that Mr. Shaeffer's conclusions would also apply in these cases. This would give about 12.2 B. t. u. per cu. ft. as the increase in heating value due to the addition of 0.1 gal. of benzol per 1000 cu. ft. of gas.

PART III—CONCENTRATION AND OPERATION OF LIGHT-OIL RECOVERY PLANT

1. SCRUBBERS—The apparatus in which the gas is brought into contact with the washing oil is known as the "scrubber" or benzol washer. In different plants it assumes different forms; that is, it may be of the rotary type, some form of bubble type, the spray type, or the tower and hurdle type, this latter being in use in most of the plants at the present time.

(*a*) *Rotary Scrubbers.* A rotary scrubber may be constructed somewhat as follows. The shell is of cast-iron approximately cylindrical in shape, with the axis parallel to the floor. It is divided into a number of compartments by means of plates which are the full size of the cross section of the shell and which have circular openings at their centers; a second set of plates placed alternately with the first reach from the bottom up to the middle of the shell.

The shell is traversed lengthwise by a shaft, the axis of which coincides with the axis of the shell, and which is supported by suitable bearings on the end plates and on the second set of cross plates mentioned above. On the shaft are fastened gas baffles in the form of discs made up of wooden slats, there being one disc for each compartment of the shell, built up so that the gas can travel between the slats either from circumference of the shell to the center or *vice versa*, but not straight across the discs parallel to the shaft. The central openings of the discs are alternately closed and opened in such a manner in conjunction with the arrangement of the cross plates that, when the scrubber is filled with the washing medium to the proper level, the gas is forced to travel through the upper half of the discs from circumference to center and from center to circumference, alternately. A small engine, or some other motive power, is used to rotate the shaft and the attached discs.

The spaces between the slats are very narrow, and thus the gas in passing through the scrubber flows in thin streams over surfaces which are kept continually wet as the shaft rotates by dipping into the washing medium in the lower part of the shell. The washing medium is admitted to the end opposite that at which the gas enters, and is carried by suitable overflows from one compartment to the other until it finally leaves the scrubber at the gas-inlet end. In this way the gas most thoroughly washed, comes into contact with the freshest oil.

(*b*) *Bubble Type Scrubbers.* A scrubber of the bubble type usually consists of a series of superimposed sections, one mounted upon the other, and constructed [illegible]. Each section has a circular opening raised above its bottom, and covered with a hood or bell, the edges of which are serrated, so that any gas flowing through the openings can pass only under the edge of the hood, which edge is kept sealed with the washing medium. Likewise an overflow for the washing medium is provided for each section. The gas enters the [illegible] of the washer and, passing up, bubbles through the seal of wash oil in each section. Fresh wash oil is introduced at the [illegible] the top tray to the height of the overflow [illegible] it drains to the next section. The process is [illegible] arranged that the gas most nearly washed is brought into contact with the freshest oil.

(*c*) *Spray Type Scrubbers.* In this [illegible] type scrubber the wash oil enters the top section of a series of superimposed sections through a syphon and [illegible] a spraying cone from which it is hurled by centrifugal force out through the perforations in the cone in a very fine [illegible] mist, thus filling the entire gas space with a mist of [illegible]. The oil flows into the next lower section through the gas [illegible] again brought into contact with the gas in the same manner, finally leaving the bottom of the washer [illegible]. The gas enters from the bottom and passes [illegible] through the succes-

sive washing sections. Power is supplied to the centrifugal spraying cones by a small steam engine.

(*a*) *"Hurdle-Tower" Scrubbers.* The "hurdle-tower" scrubbers are the most common type used at the present time; they usually consist of cylindrical steel shells about 6 to 7 times as high as the diameter. Two such shells are shown as *A* and *A*1 on the diagram. These shells contain a great number of grids or trays, commonly called "hurdles," made of white-pine slats 5 or 6 in. high by 1 in. wide. Except for spaces at the bottom and top of the scrubber these grids are practically superimposed one upon the other, with the openings staggered, separated by small spacing strips.

At the top of the tower the wash oil is sprayed in from a number of nozzles; after passing through the interstices in the grids it collects at the bottom in a reservoir. The gas enters the tower at the bottom and rises through the interstices in the grids by this means coming into intimate contact with the washing medium. Thus the freshest wash oil, introduced at the top, comes into contact with the most nearly washed gas.

In one plant designed to scrub about 10,000,000 cu. ft. of gas per day in which the tower is about 75 ft. high and 11 ft. in diameter, there are 84 grids, arranged in 4 banks of 21 each. The space at the bottom of the tower is about 8 ft. high, that at the top is about 5 ft. Spaces of about 3 ft. separate the various sets of trays. In the top are 12 oil nozzles. The foundation of such a tower is constructed of concrete and extends down about 7 ft. The size of the washer is, of course, dependent upon the capacity of the plant; 30 cu. ft. of scrubber capacity per 1000 cu. ft. of gas washed per hr. is a figure given by some engineers.

In some plants, notably in those utilizing existing tanks or towers, the grids are replaced by trays on which coke is piled or by one tray set near the bottom of the tower on which coke is piled to nearly fill the tank.

The wash oil is pumped by a circulating oil pump from the oil storage tank *T*4 or circulating tank *T*3 to the nozzles in the top of the scrubber. From these nozzles the oil is sprayed into the scrubber at a temperature of 30° C. or lower. When several scrubbers are required they may be arranged either in series or in parallel. In the former case the wash oil which has passed through one scrubber is pumped to the top of the next scrubber and flows down through this scrubber also. The gas passes from the top of the first scrubber to the bottom of the second and up through the second scrubber in the same manner as previously described. In those plants in which the scrubbers are arranged in parallel, each scrubber acts as an individual unit. An additional oil pump is required for each tower scrubber which is being used.

2. HEAT EXCHANGERS—In order to utilize the heat which would ordinarily be wasted, several pieces of apparatus known as heat exchangers or interchangers may be used. One of these is known as the "vapor-to-oil" and the other as the "oil-to-oil" heat exchanger. Each of these may assume a different form in different plants, or the order of succession may be different; in some plants one or the other may be eliminated, and in very small plants, especially those which are home-made, both are frequently missing.

(*a*) *Vapor-to-Oil Heat Exchanger.* The wash oil containing the light oils is pumped from the bottom tank of the tower scrubber to the vapor-to-oil heat exchanger, shown as *E* on the diagram. This piece of apparatus usually consists of a cylindrical steel shell which contains a number of tubes. The outer shell may be twice as long as it is in diameter; in one plant designed to scrub 10,000,000 cu. ft. per day it is about 8 ft. long and 4 ft. in diameter, containing about 150 tubes 2 in. in diameter. The cold benzolized wash oil flows through the tubes, while hot vapors from the top of the continuous still (hereafter described) pass around the tubes, being directed by a series of baffle plates. At the outlet of this heat exchanger the temperature of the benzolized wash oil is about 72° C. A heavy covering of heat-insulating material aids in the conservation of the heat. It is understood that this apparatus is controlled by the patents of a single manufacturer of recovery apparatus.

(*b*) *Oil-to-Oil Heat Exchanger.* After leaving the vapor-to-oil heat exchanger, the benzolized wash oil passes to and through an oil-to-oil heat exchanger, shown as *C* on the diagram. In some plants this apparatus is an oblong box, in which the hot de-benzolized wash oil from the still passes through pipe coils, the benzolized oil passing around the outside of these coils. In other plants this apparatus is built up of a number of pipe sections, joined at the ends. Each pipe contains a number of smaller pipes. The hot de-benzolized oil from the base of the still passes through the smaller pipes, the benzolized oil passing around them. The larger pipes are arranged in several banks one above the other. The banks are connected together at each level, but the superimposed pipes are connected only in pairs.

In one plant of the size above mentioned this heat exchanger is constructed of 8 10-in. pipes, heavily covered with insulating material. Each of the large pipes contains 14 1/2-in. tubes. The overall length is about 26 ft., the height about 7 ft., and the width about 3 ft.

At the outlet of this heat exchanger the temperature of the benzolized wash oil is about 94° C. and that of the de-benzolized wash oil about 87° C.

3. SUPERHEATER—Passing from the oil-to-oil heat exchanger the benzolized wash oil enters a superheater, sometimes called a preheater, shown on the diagram as *F*. This piece of apparatus usually consists of a cylindrical tank made of steel, and is about twice as long as it is in diameter. Inside of the shell are a number of small tubes, and several baffle plates. The benzolized wash oil flows around, and steam passes through the tubes. In the plant above mentioned this superheater is about 10 ft. in length and 4 ft. in inside diameter; in this shell are about 160 2-inch tubes. The superheater is heavily insulated, and owing to great corrosive action a duplicate is usually provided. Likewise, the parts are so arranged as to be removable without great difficulty. A safety valve is placed on top of this piece of apparatus.

The temperature of the benzolized wash oil leaving the superheater is usually about 145° C., although this temperature varies in different plants.

4. CONTINUOUS STRIPPING STILLS—After the benzolized wash oil leaves the superheater, it passes into the continuous stripping still, in which the wash oil is freed from practically all of the entrained light oils. This still, shown as *D* on the diagram, is usually constructed in two main portions—each of which is built up of superimposed individual sections. The total height is usually about 4 to 5 times the diameter of the lower portion, while the diameter of the upper portion is usually three-fourths that of the lower. Each section is made of cast iron, and is from 12 to 14 in. in height. The upper portion of the still usually has about half as many sections as the lower, and acts as a partial rectifying column assisting in retaining some of the wash oil in the still, which might go over with the light-oil vapor.

In construction these sections are similar to those described under the "bubble" type of scrubbers, there being a number of openings arranged in a circular manner in each section. However, the edges of the sealing bells are not serrated.

The benzolized wash oil enters the still at the base of the upper portion and passes down through the large portion of the still, rapidly giving up the light oil which it contains. Steam is admitted at the bottom and passes up through the still, bubbling from under the sealing bells of each tray and carrying upward the light oil in the form of vapor from the wash oil which seals the bells. The steam and these vapors pass through each individual section of the still in the manner just described and mingle in the upper sections of the still with the vapor set free there.

In one plant designed for 10,000,000 cu. ft. of gas per day the still is about 27 ft. high. The lower portion is about 6 ft. in diameter and the upper about 4 1/2 ft. in diameter. The lower portion consists of about 12 sections and the upper of about 6 sections.

The temperature of the light-oil vapor leaving the top of this still is about 104° C., while the wash oil, stripped of all light oils, leaves the bottom at a temperature of 130° C. In some types of light oil recovery plants, the light oil vapors after leaving the top of the still column pass through some type of dephlegmator or planer through which a regulated amount of cooling water flows so that while the light oils are permitted to pass uncondensed, the water vapors and any wash oil vapors present condense out and run into a collecting tank. From this tank the water is drawn off and the wash oil which contains some light oil is pumped again with the benzolized oil into the still, or, if too heavy to be handled by the stripping still, it is sometimes put into the light oil to be subsequently refined in the crude still.

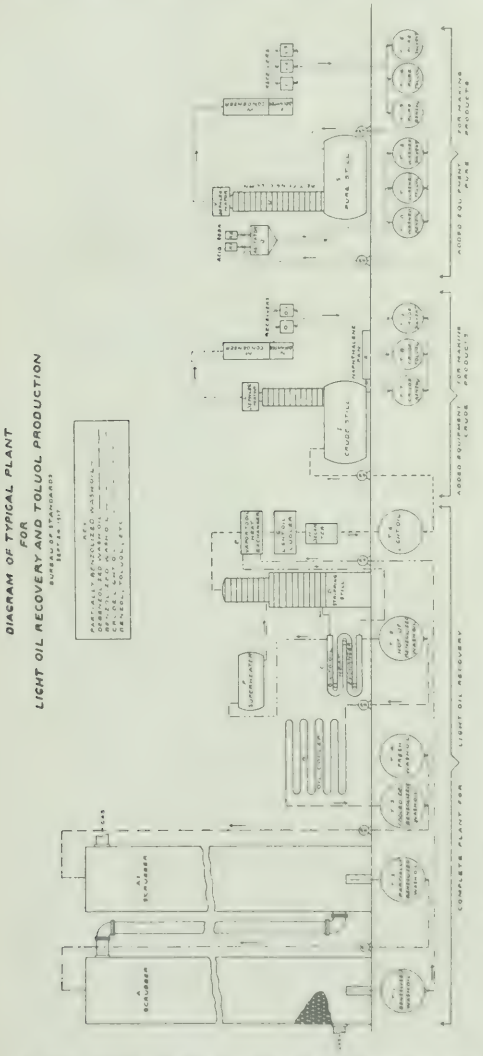
5. WASH-OIL COOLER.—The de-benzolized wash oil leaving the base of the continuous still passes into the oil-to-oil heat exchanger where its temperature is lowered to about 87° C. From this piece of apparatus the wash oil drains to a hot oil drain tank, *T*5, after which it is pumped through a wash-oil cooler, shown as *B* on the diagram. This consists of a number of pipe coils, the cooling water being showered upon the outside of the coils, while the wash oil flows through the inside.

In the plant above mentioned these coils are made up of 2-in. pipe with return bends at the ends, the whole being about

10 ft. high. At this plant there are 6 of the sets of coolers parallel to each other.

In some types of recovery plants the wash-oil cooler consists of pipe coils immersed in a tank of water. This apparatus is sometimes designated as the temperature regulator, since it determines the approximate temperature at which the oil is to enter the gas scrubbers.

From these coolers the wash oil passes to a wash-oil storage tank shown as T_3, from which it is pumped to the top of the tower scrubber to again pass through the system.



In some plants the wash oil may be pumped directly from the oil-to-oil heat exchanger through the coolers, and into the wash-oil circulating tank.

6. CONDENSER AND SEPARATOR—The crude light-oil vapors leaving the top of the continuous still with a temperature of about 104° C. pass into the vapor-to-oil heat exchanger before described. From here they pass into a condenser, shown as G on the diagram. This condenser is usually of cylindrical shape, being about $2^1/_2$ times as long as it is in diameter. Inside of the outer shell are a number of tubes into which the vapors pass and in which they are condensed to liquid form by water passing around the tubes. The light oils leaving the condenser have a temperature of about 30° C. In the plant under discussion this condenser is about 9 ft. long and 4 ft. in diameter.

In many large plants it was found advantageous to install a pipe connection with a small blower or steam jet between the outlet of the light-oil condenser and the outlet of the last gas scrubber. By this means a considerable amount of non-condensable olefines leaving the stripping still may be returned to the gas, thereby re-enriching it to a considerable extent.

From this condenser the light oil enters a separator, or decanter, shown as H on the diagram. Here any water entrained in the light oil is decanted or separated, due to the difference in specific gravity. This piece of apparatus usually consists of a small cylindrical shell provided with 2 outlets, one for oil and one for water. The water connection extends down inside of the shell nearly to the bottom, the oil outlet being near the top. The water passes off to a sewer and the crude light oils pass either to a crude light-oil storage tank, shown as $T6$, or directly into the crude rectifying or "boiler" still, if the plant is so arranged as to do away with this tank.

7. CRUDE RECTIFYING STILLS—From the crude light-oil storage tanks, the crude light oil is pumped into the crude rectifying still, or boiler still. This still is composed of 3 parts, the boiler, shown as I on the diagram, the rectifying column, and the dephlegmator L.

The boiler still consists of a cylindrical shell having bumped heads, internally braced; it is designed to handle from 5000 to 12,000 gal. of crude light oil, according to the size of the plant. The shell is covered with insulating material in order to reduce heat losses. The distillation is carried out by the use of live steam, this being introduced into coils placed in the bottom of the still. There is also a perforated pipe in the bottom of the boiler so arranged that live steam can be utilized to aid in the distillation, although this latter is not frequently made use of. Vacuum connections are also provided so that the distillation may be aided in the latter part of the cycle.

In a plant designed to wash 10,000,000 cu. ft. of gas per day this still, designed to handle a charge of 5,000 gal. of crude light oil, is made of steel, 7 ft. 6 in. in diameter and 16 ft. long, overall. The steam coils are made of 2-in. pipe, and a ball and lever safety valve is attached to the shell.

The crude light oils are pumped into the boiler still until its capacity is reached, the distillation being carried out at the temperature previously described (see p. 53). The residue which remains in the still is known as the still residue, and consists of wash oil, naphthalene, etc. It is drained to the naphthalene pans which are described later.

After the charge is fractionated a fresh charge is placed in the still. The time required to complete a run varies; in some plants 40 hrs. are required while in others 24 hrs. are deemed sufficient.

The vapors from the still pass into the rectifying column, shown on the diagram, as they are distilled off. This column consists of a number of cast-iron sections, mounted one upon the other, each section being from 12 in. to 14 in. in thickness. It is mounted upon the top of the boiler still close to one end, and is usually about 3 times as high as it is in diameter, being heavily lagged with insulating material. In construction, each section is similar to those already described. There are six "up" openings in each section, the covering bells having their edges serrated. The vapors rise through the openings and bubble through a seal composed of the heavier portions of the descending oils, which are condensed in the dephlegmator and which drain back down the rectifying column.

In this plant this rectifying column is about 12 ft. 6 in. high and 4 ft. in diameter, and is built up of 10 sections.

Mounted on top of the rectifying column is the dephlegmator or planer shown as L on the diagram. Here the vapors rising from the rectifying column are cooled by a circulation of water. The heavier portions condense and drain back down the rectifying column as before described.

The dephlegmator usually consists of a box-shaped shell about two thirds as high and wide as it is long, containing a number of water tubes. Baffles direct the course of the vapors through the dephlegmator. In this plant the dephlegmator is about 5 ft. 6 in. long and 3 ft. 6 in. high and wide, and it contains about 148 water tubes each 1" or 1¼" in diameter.

In another plant one rectifying column and dephlegmator is provided for two boiler stills. By this means a continuous flow of light-oil vapors is obtained.

In some cases the crude rectifying still and stripping still may be combined. In plants producing from 15 to 40 gal. of light oil per hour (about 1 to 3 million cu. ft. of gas per day) it may be found advantageous to have the stripping still of such size that it can strip in say 16 hrs. all the benzolized wash oil produced in 24 hrs. and to have such accessories to the still provided that it can be used as a crude rectifying still during the remaining 8 hrs. of the day. When a still is to serve both purposes it should usually be equipped with some form of dephlegmator, or planer, and with an auxiliary still base which can be valved off and used as a light-oil storage tank while the still column is stripping wash oil. This still base is equipped with closed steam coils and a live steam connection and is so connected with the still column that when in use rectifying light oil, it corresponds in effect to the boiler part of a regular rectifying still. In plants producing more than 40 gal. of light oil per hour it would probably be more practicable to have entirely separate rectifying and stripping stills. In plants producing less and probably in some producing more than 15 gal. of light oil per hour when advantageously situated, it would usually be impracticable to attempt fractionation of the light oil at all at the gas works.

8. NAPHTHALENE PANS—The still residue, containing wash oil, naphthalene, etc., is drained from the bottom of the boiler still into the naphthalene pans, shown as Z on the diagram. Here the naphthalene separates out on cooling in the form of crystals and the wash oil drains back to the circulating wash-oil tank. The naphthalene may be further dried by using a centrifugal machine.

In plants scrubbing the light oils from water gas, no naphthalene will usually be encountered.

9. CONDENSER AND SEPARATOR—The benzol, toluol, and solvent naphtha vapors leaving the dephlegmator enter a condenser, shown as M on the diagram. This is a cylindrical tank about 3 times as high as it is in diameter. Inside are a number of tubes through which water circulates; a series of baffle plates direct the flow of vapor around the coils. In this condenser the various light-oil vapors are condensed into liquid form.

In the plant above mentioned this equipment is about 8 ft. 6 in. high and 3 ft. in diameter, and contains about 90 tubes, each $1^1/_2$ in. in diameter.

From the condenser the benzol, toluol, etc., pass to a water separator, shown as N, which is similar to the one described above.

10. RECEIVERS OR SAMPLING TANKS—From the separator the benzol, toluol, etc., drains into one of two receivers, shown as O and $O1$ on the diagram. These are small graduated cylinders of about 100-gal. capacity, and are used as sampling tanks. One may be filling while a sample from the other is being tested to determine its character.

From these receivers the crude benzol, toluol, or solvent naphtha is drained into the proper one of the crude storage tanks, shown as $T7$, $T8$ and $T9$ on the diagram.

11. AGITATOR—If the plant is one which produces chemically pure products, the crude benzol, toluol, or solvent naphtha is pumped from the crude storage tanks into an agitator shown as Q on the diagram. This agitator consists of a large lead-lined, vertical, cylindrical, steel vessel nearly as high as it is in diameter. It has a conical bottom, and contains power-driven paddles. In one plant the agitator is about 8 ft. in diameter and 6 ft. high.

In the agitator the benzol, or toluol, etc., is washed with sulfuric acid, which is supplied from a small storage tank shown as $R1$. The paddles are located at a height which permits of discharging the acid in the bottom of the washer near the level of the benzol or toluol, and the distribution of it in such a manner as to obtain a thorough mixture. This mixing or washing is carried out for 30 to 90 min., after which the agitator is shut down and about 30 min. are allowed for the used acid to settle to the bottom of the agitator. The acid is used to separate the unsaturated hydrocarbons, principally olefines, which settle with the residue to the bottom of the agitator. The sludge is run off and the acid contained in it is regenerated for further use. The benzol or toluol is washed with water, after which a caustic soda solution is run into the agitator to neutralize any remaining traces of the acid in the benzol or toluol. This latter solution is stored in the tank shown as $R2$ on the diagram. After properly mixing with the light oil the soda is allowed to settle and is then drained off, the benzol or toluol being again washed with water to remove any traces of caustic soda. From the washer the washed benzol, toluol, or solvent naphtha drains into the washed-oil tanks, shown as $T10$, $T11$, and $T12$.

12. RECTIFYING STILL—From these tanks the washed benzol, toluol, or solvent naphtha is pumped into the pure rectifying still. This still consists of three parts: the boiler still, shown as S on the diagram, the rectifying column U, and the dephlegmator V. Each of these three parts fulfills the same function and is similar in construction to those described for the crude rectifying still. However, the rectifying column is usually about one-half again as high as that on the crude still, in order that closer fractionation can be accomplished. If benzol is introduced into the still, pure benzol is distilled over at a temperature between 80 and 81.5° C. If toluol is introduced into the still, pure toluol will distil over between 110 and 111.5° C. The time of distillation is usually about 5 times as long as in the crude still, and the size of the still is usually greater.

The residue is usually returned to the tanks containing the washed products while the vapors leaving the dephlegmator pass through a condenser, shown as W on the diagram, and then through a water separator, shown as X. These two pieces of apparatus are similar in all respects to those described above.

From the separator the "C. P." benzol, toluol, or solvent naphtha is run into one of three sampling tanks, shown as $Y1$, $Y2$, and $Y3$, similar to those marked O and $O1$, after which it passes to the pure tanks, shown as $T13$, $T14$, and $T15$.

13. LOCATION RELATIVE TO EXISTING PLANT—The relative position occupied by the light-oil recovery plant in reference to the remainder of the manufacturing plant varies in different localities. In some plants the washing of the gas takes place before the gas goes to the purifiers, while in others after the gas passes the purifiers. However, in any plant in which quantities of tar and ammonia are produced, the oil washing of the gas should take place after the tar and ammonia are removed.

The relative arrangement of the equipment depends largely upon the existing manufacturing plant. If possible, it should be close to the necessary steam and water supplies, and all of the parts should be so arranged that there would be only the minimum of all classes of piping required.

14. SPACE REQUIRED—Sufficient space is required for the necessary number of tower scrubbers, if the plant is to be of this type; for the building to house the stills, pumps, and other necessary accessories; and for the storage and circulating tanks and other outdoor equipment. The entire recovery plant should be in as compact form as possible, yet should not be too crowded.

The amount of floor space which is required for the building in which the stills are located, and in which some of the accessories must be placed, depends largely upon the products recovered and the daily capacity of the plant. Sufficient floor space must be provided for the stills, and the pumps should also be provided for, in estimating the amount of floor space required. It is possible to put much of the remaining apparatus at a higher level, thus economizing in floor space.

It is impossible to state with any degree of exactness the floor space requirements, but in several plants, from 2400 to 3000 sq. ft. of floor area are required for the recovery of "C. P." products. In another plant 1200 sq. ft. are required for the recovery of crude benzol, toluol, etc.

15. STORAGE OF MATERIALS—The question of storage of materials, *viz.*, wash oil, both benzolized and debenzolized, the crude light oil produced in the continuous stripping still, the crude benzol, toluol, solvent naphthas, etc., the refined products if plant carries the process to this extent, is one which must be considered carefully. Lack of adequate means of storage often means the discontinuance of the plant, unless it is possible to utilize some other equipment in the plant.

In all plants an extra supply of wash oil must be stored. It is advisable to have as a reserve from one-half to the full amount of wash oil circulated through the system in one day. This preferably should be stored in one tank, which should have a capacity at least equal to twice that of a tank car so that the unloading of incoming cars may be done promptly. It is also advisable to have sufficient tank capacity for all the wash oil being utilized in the system, one-half for the benzolized wash oil and one-half for the de-benzolized wash oil.

It is also necessary to provide a tank for the light oil recovered from the continuous still. This tank should have a capacity equal to that of the fractionating still unless there are two fractionating stills with one rectifying column, as is the case in some plants. If the plant is not equipped for fractionating the light oil, sufficient storage capacity to tide over any interruption of shipping facilities should be provided; it is suggested that capacity for a week's production should be available, but where practicable the capacity should be not less than twice that of an average tank car.

If the plant recovers crude benzol, toluol, etc., but does not further fractionate these, sufficient storage capacity should be provided to care for each of the crude fractions, so that no danger of a lack of storage will be met. In several plants the storage capacity for benzol is about twice that of the toluol, solvents, etc. It is suggested that capacity for a week's output of each of these liquids be provided. If the plant produces "C. P." products, sufficient storage capacity for each of the crude liquids should be provided, so that the pure still will be able to operate long enough to refine the preceding crude fractions.

The C. P. benzol, toluol, etc., likewise requires sufficient storage space so that if any interference with shipments occurs it will not be necessary to curtail the operation of the plant in any way. Here also the benzol storage should be about twice that for the toluol. In addition, in a C. P. plant storage must be provided for the sulfuric acid. As a summary, approximately the storage capacity indicated is required for the following materials:

When crude light oil only is recovered:
- Old wash oil de-benzolized
  - Equal to one-half the amount in circulation
- Old wash oil benzolized
  - Equal to one-half the amount in circulation
- New wash oil
  - From one-half to full amount in circulation, at least 2 car-loads.
- Crude light oil
  - Equal to capacity of crude still. If no fractionation, should be large enough to avoid difficulties caused by shipping delays, at least 2 car loads.

When crude benzol, toluol, etc., are recovered:
- Same as above and
- Crude toluol
- Crude benzol
- Crude solvent naphthas
- Heavy naphtha
- Crude intermediates
  - Benzol storage about twice as great as other fractions.
  - If further refining is done should be large enough to allow refining stills to work necessary time. If no refining, tanks should be large enough to avoid difficulties caused by shipping delays.

When C. P. products are recovered:
- Same as previously stated, and
- Washed benzol
- Washed toluol
- Washed solvent naphthas
  - Benzol about twice as great as other fractions.
  - Sufficient capacity to allow refining still to operate requisite length of time.
- Sulfuric acid
- Pure toluol
- Pure benzol
- Pure solvents
  - Benzol about twice as great as other fractions.
  - Large enough to avoid difficulties caused by shipping delays.
  - In addition, one or two spare tanks would be advisable.

The location of these tanks is largely dependent upon local conditions. In some plants they are placed underground, in other plants they are located in water-tight pits, while in still other plants part or all of the tanks are above the ground surface. They may be grouped together or they may be separated into different groups, largely depending on the amount of available space, or local fire regulations.

16. SAFETY IN OPERATION—The buildings for a light-oil recovery plant should be located as far as practicable from other plant structures; or if sufficient distance is not obtainable, owing to existing conditions, the building should be made an individual unit, by bricking up or otherwise closing all openings into adjacent buildings. Under any conditions, it is desirable that the still be located about 200 ft. from any source of flame, since the heavy benzol vapor is quite prone to travel along the ground for a considerable distance without dilution to a sufficient degree to prevent inflammability.

The buildings should be constructed of fireproof material throughout, and should be well ventilated and equipped with wire glass windows and metal fire doors. If practicable, it should be located away from railroad tracks or sidings, and the loading platform should be removed as far as practicable from the rest of the plant.

No open flames should be brought near any portion of a light-oil recovery plant, and only incandescent electric lamps, encased in vapor-proof globes with a protective wire casing around the globe, should be used around any portion of a light-oil plant. In case portable lights are required small storage battery light should be used. All electric wiring throughout the plant should be encased in iron pipe conduits, and no extension cords should be used.

A sufficient number of fire extinguishers, of the type capable of extinguishing an oil fire, and buckets containing clean, dry sand should be conveniently placed not only inside of the building, but also outside. A plentiful supply of water, under high pressure, should also be readily accessible, and an efficient corps of men, trained in fire extinguishing, should be available at all times.

Smoking should not be permitted in or near the light-oil plant at any time.

All stills and superheaters should be equipped with a positive safety valve set to blow at about 10 lbs. pressure. Likewise all tank cars and tank wagons should be equipped with safety valves. All tanks should vent to the atmosphere, the vents being provided with a screen of fine wire in order to prevent the ignition of the vapors by sparks.

All joints in the piping, stills, tanks, or any other apparatus should be kept tight so that leaking vapors do not accumulate in the buildings or their vicinity. All condensers should be supplied with adequate cooling water to prevent the escape of vapor into the air.

When necessary to clean stills special precautions are necessary to prevent the workmen from being asphyxiated. No one should enter the stills until they have been thoroughly purged of all vapors and are cool. All connecting valves should be closed and locked, and if the valves are not tight, the piping should be disconnected. At least two openings should be maintained in the still to allow a circulation of air throughout. The man entering should be provided with a life belt and rope and another man should be stationed outside of the still to assist in case of necessity. He should obtain additional assistance before entering the still to aid the man overcome by the vapors in the still.

17. TECHNICAL CONTROL—In the operation of a light-oil recovery plant, in order to obtain efficient results and good quality of product, an adequate laboratory equipment must be maintained and at least one observer, skilled in making the necessary tests, must be employed. The extent of the tests in a given plant will depend upon the final products produced by the plant. Obviously a plant producing pure benzol, toluol, etc., will require much more elaborate tests than a plant selling unrefined light oil only.

The following is a list of tests usually required in the operation of a pure products plant as furnished by the Chief Chemist of a large operating company:

A—Tests of Gas
- (1) Heating value and candlepower of gas entering scrubber.
- (2) Determination of light oil in gas entering scrubbers.
- (3) Heating value and candlepower of gas leaving scrubber.
- (4) Determination of light oil in gas leaving scrubbers.

B—Tests for Wash-oil Still Operation
- (1) Determination of light oil in benzolized wash oil.
- (2) Determination of light oil in de-benzolized wash oil.
- (3) Tests of the light oil
  - *a.* Boiling point
  - *b.* Determination of wash oil.

C—Tests for Crude Still Operation
- (1) Receiver tests; *i. e.*, boiling-point tests made to control fractionation.
- (2) Boiling-point tests of fractions (crude benzol, crude toluol, etc.) and residues sampled from their respective storage tanks.

D—Tests for Agitator Operation
- (1) Distillation and acid tests of washed benzols.
- (2) Tests for SO_2 in washed benzols.
- (3) Specific gravity of regenerated sulfuric acid.

E—Tests for Pure Still Operation
- (1) Receiver tests; *i. e.*, boiling-point tests made to control fractionation.
  - *a.* Boiling Point.
  - *b.* Acid Test.
- (2) Tests of pure products sampled from storage or running tanks or from shipments.
  - *a.* Boiling Point
  - *b.* Acid test
  - *c.* Specific Gravity
  - *d.* Freezing Point (occasional in case of benzene).
- (3) Boiling-point tests of still residues.

F—Tests of Materials Used in Operation:
- (1) Wash Oil
  - *a.* Specific Gravity.
  - *b.* Viscosity.
  - *c.* Emulsification
  - *d.* Cold Test
  - *e.* Distillation.
  - *f.* Oleines
- (2) Sulfuric Acid—Specific Gravity
- (3) Soda—Na_2O

It is evident that in a plant shipping light oil away for further refining, many of these tests could be omitted. In a very small plant, after the routine was established, occasional tests on gas before and after scrubbing and of the wash oil and light oil would probably suffice.

18. ADAPTATION OF LIGHT-OIL RECOVERY TO SMALL PLANTS—While the somewhat complicated systems of heat exchangers and the careful design of stills, described in connection with the layout of a typical light-oil recovery plant, are very important in effecting economy of operation, they are not absolutely essential to the recovery of this material. The essential equipment of a small plant recovering only light oils consists of some form of scrubber to oil wash the gas, a still for stripping the wash oil,

a condenser for condensing the light oils, and some tanks for the storage of the various materials. A plant which is so fortunate as to possess or to be able to obtain cheaply some old gas making or power-plant equipment might find it profitable to construct and operate a small plant. An old ammonia washer, water-gas scrubber, shavings scrubber, or even an old water-gas generating shell could be readily adapted for use as an oil washer by filling with wood grids, coke, or other materials which would furnish a large surface wet with the wash oil for contact with the gas. For a stripping still, an old boiler surmounted by a section of large diameter pipe filled with stones could be used and the process made an intermittent one. In this case tanks would, of course, be necessary so that a portion of the wash oil could be circulated while another portion was being de-benzolized and cooled. An old feed-water heater of the type in which the exhaust steam comes into direct contact with the cold water might be used as a continuous still, by connecting the top of it with a condenser of some kind and admitting the wash oil near the top and live steam near the bottom. For a condenser, a coil of pipe in a tank of water, an old closed coil-feed water heater, or similar apparatus, might be used. In such an improvised plant no fractionation of the light oil would probably be feasible. The light oil would be shipped to a larger plant or to a benzol refinery. In a simple plant of this kind the cool wash oil would be pumped from its storage tank to the top of the scrubber. From the bottom of the scrubber the benzolized oil would flow to a storage tank from which it could be pumped to the still. The hot de-benzolized oil from the still would be run into a storage tank to cool while another portion of benzolized oil was being distilled. After cooling, it would be again circulated through the scrubber. A fourth tank would be necessary for the storage of the condensed light oil. If sufficient old materials were available it might be possible to construct crude heat exchangers which would improve the economy of the plant. Whether or not a given small plant should attempt to make crude fractions would depend upon local conditions. In general, it does not seem practicable for a plant producing less than 1,800,000 cu. ft. of gas per day to do so.

It would hardly be expected that a simple plant of crude construction would recover the benzol as completely or economically as a large well-designed plant, but a large number of such plants would increase the total benzol and the toluol resources very materially.

In the small plant as well as in the large one all reasonable precautions should be taken to make the operation safe both to the operators and to the plant in general. The highly inflammable character of the materials handled and the explosiveness of the vapors when mixed with air should always be guarded against. The benzol plant should be located where in case of fire it will not endanger the rest of the plant. The fact that old equipment is used in the construction should put the operators on the outlook for leaks, which occur more or less frequently even in well-constructed plants.

19. TIME REQUIRED AND COST OF PLANT INSTALLATION—The time required for the construction of light-oil recovery plants seems to vary greatly. The two essentials to normal construction are sufficient labor to conduct the work in an expeditious manner, and the necessary material either at hand or arriving at a steady rate to carry on the work in logical sequence. In this period of shortage of efficient labor and of congestion of shops and railroads, the period of construction may be prolonged far beyond the normal period or it may perhaps even be halted. Of course the amount of construction and the clearing and preparing of the site necessary are large factors in the length of the construction period even in normal times.

If there is no difficulty in obtaining labor and material a plant to scrub about 10 million cu. ft. of gas per day should take approximately, 3 to 4 mo. to build. One such plant, recovering C. P. products, actually took 63 days to build. Another plant, recovering crude benzol, toluol, etc., took about 4 months to build. One plant of home-made construction throughout, and scrubbing about three-fourths of a million cu. ft. of gas per day, producing crude light oil only, took 35 days to construct and put into operation.

To present any definite figures as to the cost of installing a plant for the recovery of light oils is impossible. This is particularly true at the present time, when the price of labor and materials is steadily mounting. Each plant must be figured as a unit, and the cost is dependent upon a number of factors pertaining to each individual plant. If the plant is to be constructed of apparatus designed for the specific purpose, and practically no old equipment is utilized, it will, of course, cost more than such a plant utilizing existing equipment.

The capacity of the plant, the completeness of recovery, the available steam supply, and the available supply of condensing and cooling water are factors which must be given consideration in any estimate. The steam and water supply capacity especially should have very careful consideration since the requirements of a benzol recovery plant for steam and water are very considerable. Likewise, the location of the plant with reference to the source of material supply is of importance.

Among a number of plants visited no agreement as to cost was obtained. The figures were, in most cases, only approximate, and therefore no great reliance can be placed upon them. The year in which the plant was constructed also had a great bearing on its cost.

For example, one plant scrubbing about 11 million ft. of gas a day, and recovering C. P. products, is said to have cost about $200,000, while another plant scrubbing about the same amount of gas, but recovering only crude products, is said to have cost about $225,000. Still another plant scrubbing only $4^1/_4$ million cu. ft. of gas a day, and recovering C. P. products, is said to have cost about $200,000.

In one plant where some existing equipment was utilized 7 million cu. ft. of gas a day is scrubbed, light oil in the crude only being recovered; the cost is said to have been $25,000. Another plant, utilizing some old equipment, and scrubbing about one-half million cu. ft. of gas per day, producing only crude light oil, is said to have cost about $40,000. Another plant, made from odds and ends without heat exchangers or any other such devices, and with only a few pieces of apparatus bought, is said to have cost about $10,000. This plant scrubs about 650,000 cu. ft. of gas per day.

From the above examples it will be seen that it is impossible to draw any general conclusions as to the cost of a light-oil recovery plant. However, it will be seen that an efficient plant costs several hundred thousand dollars, but that the cost may range considerably lower for plants constructed from existing equipment, depending upon the amount of such equipment used.

20. ITEMS ENTERING INTO COST OF LIGHT-OIL RECOVERY—The Bureau is unable to give any estimate of the cost of light-oil recovery. This would necessarily vary greatly in different localities. We can only indicate some of the principal items which enter into the cost. These items are raw materials, steam, water, electric power, wages, overhead expenses, fire insurance, maintenance, depreciation, and in some cases cost of re-enriching the gas to the prescribed standard of quality.

The materials include wash oil, lubricating oils, packing and repair materials; and in plants producing pure products, sulfuric acid and soda are also needed. The wash oil consumption varies considerably in different plants, depending upon the kind of gas washed, the tightness of the circulating system and the method of operation. While wash oil does not enter into the final product, replacement is necessary at regular intervals, due to losses, depreciation of quality, etc. Some operators replace a certain percentage of wash oil each day while others replace the whole amount at stated intervals. The percentage of loss varies greatly. Operators claim a replacement of wash oil all the way from 2 to 10 per cent of the number of gallons of light oil recovered. Prices of wash oil at the present time range, according to information available, from $7^1/_2$ to 12 cents per gallon. These prices are continually changing, so no definite figure can be assigned.

In a pure product plant, sulfuric acid and soda are necessary for washing the distillates. The amounts used by various operators differ and are, of course, dependent upon the amount of the various constituents which must be washed out of the product. An average figure seems to be from 0.3 to 0.5 lb. of sulfuric acid per gallon of light oil produced, and about $^1/_{10}$ as much soda. Some operators give the amount of sulfuric acid required for washing the crude toluol as 0.8 pound per gallon of the toluol treated. The present price of acid was stated as about 4 cents per lb. and soda at about 8 cents per lb., making the cost of the materials about 1.6 cents and 0.3 cent, respectively, per gallon of light oil produced.

No figures are available as to the cost of lubricating oils for the numerous pumps, packing, gaskets, etc., but from the nature of the materials handled it seems likely that these expenses are rather heavy.

The consumption of steam, cooling water, and electric power, varying according to local conditions and the cost of the separate items are, of course, variable. The steam consumption for the stills and accessories alone is estimated by various operators as from 40 to 65 lbs., or even more in some cases, per gallon of light oil produced. The consumption depends largely upon the extent to which the heats of the still effluent and distillate are utilized to heat the incoming benzolized oil. One operator

who recovered crude fractions only from 14 million cu. ft. of lean by-product coven gas per day, stated that his steam consumption was about 65 lbs. per gallon of light oil, distributed as follows:

	Pounds
Stripping still	14.2
Superheater	36.8
Crude still	2.0
TOTAL	65.0

In this case there was no vapor-to-oil heat exchanger in use and the oil-to-oil exchanger was an improvised apparatus. The lower figure, 40 lbs. per gallon, was quoted by the operating superintendent of a chain of several plants as the requirement of the stills and accessories. No estimate could be obtained of the steam consumption of the various pumps in these plants. In many cases there seems to be no careful record kept of these items. In one plant washing about 12.5 millions cu. ft. of mixed gas per day, and producing pure products, it was stated that 250 boiler horse power was required for the entire recovery plant. As this plant produces about 3100 gallons of light oil per day, this would be equivalent to about 57 lbs. steam per gallon, assuming that the boiler horse power used was correctly estimated. One operator having several plants under his supervision gives 8 to 9 lbs. of steam per pound of pure products as an average figure in a plant having two heat exchangers. The question of installing elaborate heat exchangers in a given case to save steam must be decided by local conditions. If the cost of steam production in a plant is very low it may not be expedient to install all the equipment necessary for the fullest utilization of the waste heat. In a small plant, especially, it might not be feasible to install all this equipment and the use of steam could hardly be expected to be as low per gallon of product as in a larger plant.

The water used in a light-oil recovery plant for cooling purposes is also a very important item. In order to obtain efficient scrubbing of the gas the wash oil must be cooled to 30° C. or thereabouts, and the condensers and dephlegmators must have an adequate supply of cooling water or light-oil vapors will be lost. The amount of cooling water used will depend to a great extent upon the temperature of the water supply. A plant which is so fortunate as to have a supply of very cold water will be able to use considerably less than a plant in which the water is relatively warm. A requirement of about 60 gallons of cooling water per gallon of light oil produced seems to be an average amount. One operator of several plants gives 1.2 gallons of water per gallon of wash oil circulated as an approximate figure.

A plant which is favorably laid out may find it possible to utilize a portion of the cooling water for other purposes after it has passed through the coolers; much water may also be saved in some cases by recirculating. The cost of cooling water will in all cases be a controlling factor and will determine how elaborate should be the layout with a view to economizing water. Water can be used for cooling in many cases which would not be fit for boiler feed unless treated. In contemplating any light-oil recovery installations, especially in a small plant, one of the first considerations should be the adequacy of the existing steam and water supplies.

The labor expense in operating a benzol plant is a variable item for which only an approximate statement can be given. In starting a plant and establishing a routine a larger force is required than after the plant is under normal operating conditions. A superintendent who has general charge of the operation of several plants states that the regular operating force for a plant producing crude fractions consists of seven men during the 24 hrs. of the day, assuming that each man works an eight-hour shift. Of this force one man should be a technical man who understands the testing connected with the process. The actual operators are men of average attainments, usually of the same degree of skill as water-gas makers.

In some plants where very crude fractionations are made even a smaller force is sometimes employed, though whether a smaller force could carry on the process efficiently is questionable. In one coke-oven plant washing 14 million cu. ft. per day it was stated that the actual operation of the recovery plant required ordinarily only 2 hours of one man's time on each 12-hr. shift and about 6 hrs. of a chemist's time in 24 hrs. It was also stated that the operation of the recovery plant was much less troublesome than the operation of the ammonia equipment of the same plant.

No figures were obtainable which would permit even a rough estimate of the overhead expenses, fire insurance, maintenance, and depreciation of a light-oil recovery plant. Frederick H. Wagner, in his book entitled "Coal Gas Residuals," published in 1914, allows 10 per cent of the original cost of the plant to cover these items. We have no information to substantiate or disprove this estimate. In view of the uncertainty of the benzol and toluol market in the future and the fact that it might not be profitable for city gas companies to recover benzol and toluol without the exceptionally high prices for these products now prevailing, especially if re-enrichment of gas were necessary, it seems as though a value of 10 per cent would be much too low an estimate for a company to safely calculate upon.

ADDRESSES

CHEMICAL MICROSCOPY[1]

By E. M. Chamot

A speaker who has the temerity to address a joint meeting of two different technical societies always finds himself in an awkward predicament. He feels that he must present his subject from the viewpoint of each group of men, that he must lay equal emphasis upon all branches of the sciences represented by his audience. I find myself very much embarrassed, realizing this, and in doubt whether I am here in the guise of a microscopist or of a chemist.

This, gentlemen, is the introductory paragraph of the paper I had originally prepared. Since that time we have entered the great war and I know where I stand. I come to you as a chemist to make an appeal for a wider and more intelligent application of the microscope in every-day chemical practice.

If the talk appears rambling and fragmentary I trust you will bear with me, for with several momentous issues in the hands of my department I have had little opportunity to prepare a new paper and none to make new lantern slides. I will, however, attempt to stick to my text—Chemical Microscopy. To my mind there is no such thing as microchemistry as opposed to macrochemistry, and the term microchemical methods is a misnomer. A microchemical reaction or test may be one performed upon minute amounts of material without necessarily having recourse to the microscope.

Chemical Microscopy, on the other hand, requires that some type of magnifying optical instrument enters into the work. By chemical microscopy, therefore, we mean simply the application of microscopic methods to the solutions of problems arising in the chemical laboratory or in the chemical industries.

No instrument at our command can do so much or throw so much light upon obscure problems with so little an expenditure of time, labor and material. We chemists have been wasting golden hours and slaving over sloppy methods to accomplish ends which could have been reached easily and leisurely and with a degree of certainty unsurpassed by anything we have at our command with test tubes and beakers. Why spend hours on a qualitative analysis that can be better done through the medium of the microscope in several minutes?

The time has come when we can no longer be satisfied with time-consuming operations. Industries must be speeded up, production increased, better inspection methods introduced, quality thereby raised and final cost in consequence reduced. I am simply preaching good conservation. If we fail to do so and disappear as a nation it will be because we have failed to equip industries to produce the necessary material and the requisite quality. I cannot recall a single great industry to-day where microscope methods intelligently applied will not lead to more or less marked improvements.

[1] Address delivered before a joint meeting of the Chicago Section of the American Chemical Society and the State Microscopical Society of Illinois, at the City Club, Chicago, on April 20, 1917, Messrs. A. V. H. Mory, Chairman of the Chemical Society, and N. S. Amstutz, President of the Microscopical Society, presiding.

MICROSCOPIC METHODS NOT APPRECIATED

The causes of our failure to fully appreciate the value of microscopic methods are not hard to find. In the first place, in the educational system of our chemists no adequate training has been given in the multiplicity of uses of the microscope and its potential industrial applications. In the second place, too much emphasis has been laid upon biologic microscopy, so that the generally accepted view is that this instrument is intended for studies in biology or medicine. As a result, the development of the modern so-called high-grade microscope has followed strictly biological lines and has drifted farther and farther away from stands applicable for general work in the chemical laboratory. For example, the best of our present-day stands no longer have the mirror mounted upon a swinging bar capable of movements far to one side, or even above the stage for oblique illumination. In refractive index work, in the observation of melting points, in the study of fatigue failure in metals, in the general examination of alloys, cements, protective coatings, etc., and in the preparation of photomicrographs of certain preparations, this old device now abandoned is really essential, and it is necessary to remove the mirror from the stand and fasten it to a holder of some sort in order that it may be properly employed.

It is also unfortunate that the objectives of small angle, long available working distance and marked penetrating power are not obtainable save at second hand. The modern microscope objective is a marvel in its performance, yet it is limited to the study of mounted materials covered with a standard cover glass if over a moderate power is required for the examination; but, unfortunately, we chemists must work with uncovered preparations and we must sacrifice resolving power for penetrating power and for stereoscopic effects. We need instruments of moderate cost, substantially built, and which will withstand the corrosive atmosphere of most of our industrial laboratories. Thus the third reason for the backwardness of chemists to use the microscope has been the lack of suitable models and accessories. Even our good friends and near chemists, the petrographers, have never gone out of their narrow way to try and impress the chemist with the fact that the polarizing microscope is an indispensable adjunct of the research laboratory. The modern petrographic microscope is a measuring instrument of great precision. By its means alone a vast number of chemical compounds can be positively identified. The manufacturer of organic compounds, especially, cannot afford to ignore it as a means of increasing the ease of control work. In the hands of a skilled worker this type of instrument offers untold advantages.

The application of microscopic methods to analytical problems should appeal to every chemist. Not only can he perform qualitative chemical analyses easier, but he can measure refractive indices of both solids and liquids, determine melting and boiling points with exceptional accuracy and upon minute amounts of material which cannot be isolated, determine molecular weights and can study the structure of most of our commercial materials. Dr. Harvey W. Wiley, in one of his happy moods, once defined chemistry as "the astronomy of things infinitely small." Our telescope is the microscope. To make suitable progress we must, like astronomers, construct special instruments for special purposes, and like the astronomers we must become specialists in narrow fields within our vast science. We chemists must have analogues to the students of double stars, to the investigators of nebulae, to the seekers for comets, etc. When this day comes the results reported will be comparable to the discoveries of our astronomical friends. Americans make the finest telescopes in the world. Why not microscopes as well? Unfortunately the scientific world in the United States has been obsessed with the idea that no microscopes were worth using, unless made in Europe. We are all to blame for the present difficulties. Can you obtain an ultramicroscope, a luminescense microscope or even a polarization microscope in the United States this 20th day of April? Not one, nor can you obtain condensers, lenses and eye-pieces of quartz suitable for photography with ultra-violet rays, nor spectroscopic oculars; nor can we purchase a really satisfactory moderate priced metallograph, although in this line there is hope that instruments will soon be on the market.

AMERICANS MUST STAND BY AMERICAN-MADE INSTRUMENTS

If each one of us here to-night will agree hereafter to stand by American manufacturers and buy American-made instruments, we will soon have special microscopes and accessories ranking with the best obtainable. Our artisans have no superiors and few equals, but in order that we may persuade them to undertake the construction of the apparatus we require, it is essential that we must support them with advice and hard dollars and not with empty applause. It is easy to find fault and refuse to coöperate; but it takes time and tact to call attention to defects and suggest improvements.

If those using special microscopes would stop and consider the care and labor involved in their manufacture and would be a trifle more tolerant toward mistakes in construction, far greater progress would be made than at present. Let us all agree to try and stimulate the development of American types of microscopes which will do our work better and easier, and cease being mere copyists. Let us become "boosters" instead of "knockers."

I have already asserted this evening that the chemical microscope will do more for the chemist than any other instrument or group of instruments, and it behooves me to prove my contention. In the first place, microscopic methods are the simplest and shortest for the identification of a compound. Let us assume that the analyst has in his hands a crystalline salt, and by qualitative analysis in the usual manner he decides after about an hour's examination that it contains sodium and phosphoric acid—nothing else. It is manifestly a sodium phosphate, but which one? Mono, di or tri? This he can answer satisfactorily only by quantitative analysis, and actually only by a determination of Na and PO_4. If, however, he possesses a polarizing microscope, the problem is quite simple. The mono-sodium salt is orthorhombic, the di-sodium, monoclinic, while the tri-sodium phosphate is hexagonal. He can clinch his opinion with one or more simple optical measurements and prove his case by refractive index determinations by the immersion method. Why is it that the chemist never uses refractive index determinations by means of the microscope as an aid in qualitative analysis? It is inconceivable that we have had these methods used for years by mineralogists and petrographers, yet never had sense enough to apply them to our own ends and thereby save ourselves hours of time.

But to go back to our phosphate; had we made the qualitative analysis by microscopic means it would not have taken us an hour, but say not over half that time. We would have been seated comfortably at a table and would have satisfied ourselves in a very few minutes that the salt was di-sodium phosphate badly effloresced and of commercial, not C. P., quality. This case is actually a typical one and very simple. I have selected it because it illustrates quite clearly the way in which a simple salt may be identified. But I hear some of you say this requires a knowledge of crystallography. What of it? If this knowledge will save us time and labor let us by all means do a little reading.

EASE, CHEAPNESS AND QUICKNESS OF MICROSCOPIC QUALITATIVE ANALYSES

Of all the inorganic salts we will meet with in industrial work only a very few belong to the isometric system and have no effect upon polarized light. Very few are tetragonal and triclinic and fewer still hexagonal. There is rarely need for expert training to enable the analyst to properly place the compound under examination in one of these systems. Suppose again the analyst has an inorganic crystalline salt, and under the microscope it separates

from water in what appears to be large colorless octahedra which are isotropic. The salt must be an alum, or strontium, barium, or lead nitrate, or one of several chlorostannates. The addition of a tiny drop of nitron sulfate gives no crystalline precipitate, therefore it cannot be Sr, Ba or Pb, or other nitrate. A little calcium acetate gives crystals of calcium sulfate. The salt presumably, therefore, is an alum. A refractive index determination will show which alum, or we can go ahead and test qualitatively for the bases present.

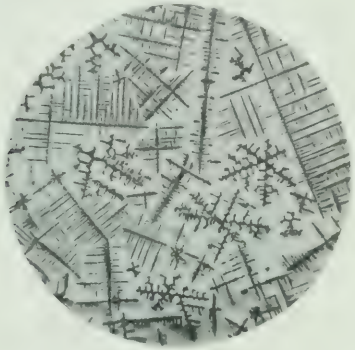


FIG. 1 × 50

The point I wish to emphasize is that in the identification of many substances a systematic time-consuming analysis is unnecessary. Note well also that all the work is done upon an object slide, that only low powers are employed and the amount of reagent required is negligible. Five grams of practically any reagent used should last an analyst, even in daily examination, almost a lifetime.

I find that the prevailing idea among chemists is that qualitative analysis, by means of the microscope, has for its purpose the detection of such infinitesimal traces of material that all



FIG. 3 × 50—$Cu(CNS)_2Hg(CNS)_2$

other methods fail. Although it is true that microscopic methods can be thus employed, by far the greatest points in their favor are the rapidity of obtaining results and the certainty of the reaction. Actually the relative proportion of material to solvent is very great; we are apt to be working with high concentrations. We take a fragment of the unknown material, not quite as large as a pin head, and dissolve it in a minute drop of water or acid. The microscope enlarges this drop of solution until it appears to have the diameter of a ten cent piece. This is almost equivalent to taking a handful of the unknown and dissolving it in a liter of solvent. The identity test is made by adding a reagent which will lead to the formation and separation of a crystalline phase.

VALUE OF MICROSCOPE IN ORGANIC ANALYSIS

It is in the field of organic analysis that the microscope stands without any possible competitor. Differentiation of isomeric compounds, recognition of different degrees of sulfonation, nitration, etc., is so simple in most cases as to be mere child's

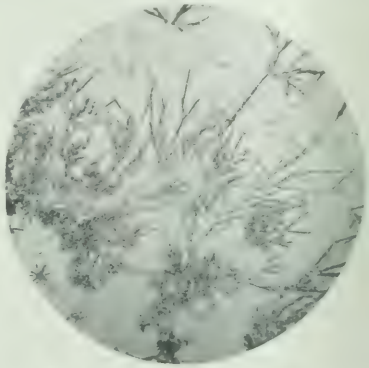


FIG. 2 × 50—$Cu(CNS)_2Hg(CNS)_2H_2O$

play. Take the case of the phenolsulfonic acids. Recognition of the different acids, mono or di, ortho, meta or para, or mixtures, was a stumbling block for years until Pratt showed that the barium salts were easily differentiated under the microscope. The di-acid salt forms stout monoclinic prisms, the mono-ortho acid long slender rods, and the para acid tufts of fine needles. Quite recently the microscope was called upon to aid a large plant in controlling the completion of a certain process. It was found that the manganese salt of a certain organic compound crystallized in plates with vivid polarization colors; the other

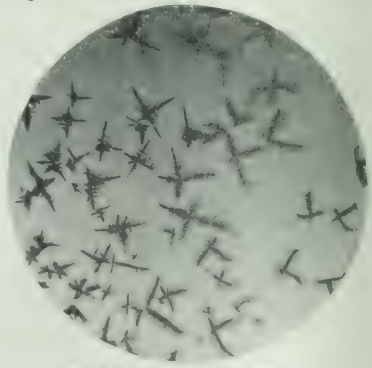


FIG. 4 × 50—$Zn(CNS)_2$

product which it was desirable to eliminate crystallized only with difficulty in sphaero crystals polarizing feebly. A glance under the polarizing microscope showed at once the stage in the transformation of one form into the other. The [illegible] control took not less than twenty four hours, the latter [illegible] twenty minutes.

By far the majority of organic compounds cannot be differentiated and identified without time-consuming quantitative determinations. Judicious application of the methods of what Lehmann years ago called crystal analysis will give the necessary information at once.

By means of an electrically heated stage not only can we determine melting points with greater ease than by the usual methods, but the accuracy of our observations is considerably increased. Amounts of material so small as to be practically invisible to the naked eye can be employed. A further advantage lies in the fact that the melting points of several different substances existing in a mixture may be ascertained without having recourse to long and arduous separations, involving loss of material and time.

Very reliable melting points of fats may also be obtained as well as the boiling and subliming points of small quantities of material.

MELTING-POINT DETERMINATIONS BY MICROSCOPE

The advantages of microscopic melting-point determinations will become more apparent when we recall that when we separate one compound from another at our laboratory work table, we so proceed that the final products stand upon our table a few inches apart in suitable containers. If we spread a small quantity of the original mixture upon a bit of cover glass and examine the preparation with a magnification of say 50 diameters, a decided space will be seen to exist between most of the different components. Gentle tapping will usually increase this space. To all intents and purposes the magnification has done exactly what we accomplished in our long chemical separation; *i. e.*, removed the components from apparent contact with one another, and interposed space between them. In most instances even very rapid crystallization of two or more salts upon a slide by quick evaporation of their solution will yield a preparation in which the salts will be found to have separated without intermixture, and with a sufficient space between them to allow a melting-point determination being made.



FIG. 5 × 50—$Cd(CNS)_2.Hg(CNS)_2$

This fact is clearly shown in Fig. 1. Evaporation has been pushed so fast as to force the salts to crystallize in dendritic forms, yet each group of dendrites is clear and distinct. Were such a preparation heated carefully and watched with the microscope, I think you will all agree that as one of the components begins to melt it will easily be discerned and will not interfere with the other. When, however, the temperature is raised to the melting point of the second component, the chances are that the two liquids will flow together. Nevertheless the moment of fusion is easily ascertained. If in melting point observations, as I pointed out some years ago, we make use of the polarization microscope, the transition from a solid anisotropic body to a completely fused isotropic body is instantly recognized.

Doubtless that branch of chemical microscopy of greatest general applicability is in qualitative analysis. The addition of a suitable reagent induces the formation of a distinctive compound and its subsequent separation as a solid crystalline phase. These crystals are easily recognized and are so characteristic that there is little danger of mistaking those given by one element or compound for those of another. Add to the distinctive morphology the fact that color also enters into the identification scheme, and it will be even more apparent why microscopic methods offer such ready means of identification.

In a large number of cases one and the same reagent will cause distinctive crystal separations with a number of substances. One of the best examples of this is potassium (or sodium) mercuric sulfocyanate, $K_2Hg(CNS)_4$ [or $2KCNS.Hg(CNS)_2$] which gives characteristic crystals with copper, yellowish green (Fig. 2); cobalt, deep blue (Fig. 3); zinc, white (Fig. 4); cadmium, colorless (Fig. 5); lead, colorless (Fig. 6); manganese, colorless (Fig. 7); gold, yellow; silver colorless; and a red color with iron. Thus the addition of a single reagent will show at once the presence or absence of a number of elements, and at the same time produce an identity test for each, thereby saving an enormous amount of time and material. There are a number of such reagents available, and by carefully choosing them we can complete in a few minutes a qualitative analysis, intricate though it may be.

Time will not permit me to show slides[1] of more than one more of these multiple test reagents. I have selected cesium chloride, which gives us reactions for bismuth, antimony, tin, copper, silver and lead, and occasionally, aluminum and magnesium. You will note that the crystals obtained are just as different from each other and just as easily recognized as those formed by the mercuric sulfocyanates. Furthermore, in the characteristic reactions for the common acids the crystal forms are so different and so easily remembered that there can result no confusion when the tests are properly applied.

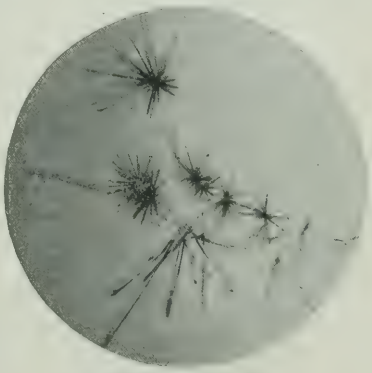


FIG. 6 × 50—$Pb(CNS)_2.Hg(CNS)_2$

SMALL AMOUNTS USED IN TESTS

The amount of material required for our tests is shown by the tiny fragment clinging to an ordinary No. 7 sewing needle (equivalent to a fragment whose diameter is approximately that of a period(.). The manner in which a test is performed I have tried to show in this lantern slide (Fig. 8.) An ordinary 3-in. × 1-in. object slide with the steps in the analysis of an alloy has been photographed natural size in order that the relative sizes of the drops may be better judged. The tiny black spot (0.8 mm. × 0.1 × 0.1 mm.) is a piece of the alloy of the exact size of that employed for the analysis. The large spot at the corner is the space occupied by the solution of the alloy after repeated evaporations with tiny drops of nitric acid to render insoluble any tin present. The nitric acid-soluble portion has been decanted to the second spot.

[1] Not shown here.

The residue has been tested and found to contain tin, antimony and copper. The nitric acid solution has been divided into three drops as seen in the slide: the first shows the dry residue after finding lead, copper and antimony present; the third spot is what remains on the slide after testing for other elements and finding zinc and iron in traces, in addition to those already found. The fourth spot has been used for testing for the remaining possible metals which were not disclosed in the other tests.

We have thus carried out upon an object slide the entire qualitative analysis of a bearing metal containing tin, antimony, lead, and a small amount of copper, and having traces of iron and zinc present. Actually it took little more time to perform the analysis than it has taken to tell it. The worker has been seated at a small table and has used less than five cents worth of reagents and gas. Instead of cutting off a small portion of the alloy we could just as well have rubbed it over a piece of ground glass or unglazed porcelain, dissolved off portions of the streak with acid and made our analysis as just outlined. The next lantern slide[1] shows this method together with the results obtained and the time required for the analysis. These cases are fair illustrations of what is possible in the saving of time, money and labor, through the employment of microscopic methods.

Other valuable applications of qualitative tests are those involving testing for the purity of precipitates in gravimetric an-

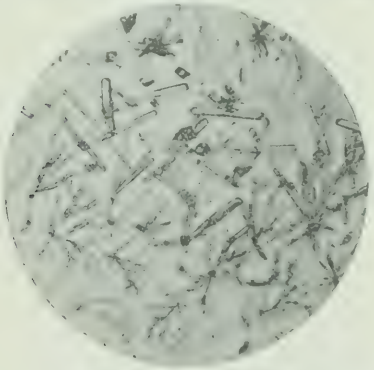


FIG. 7 × 50—$Mn(CNS)_2.Hg(CNS)_2$

alyses in order to avoid the time and trouble involved in resolution and reprecipitation, in testing for complete precipitation, especially in electrolytic analysis and also in testing for complete washing.

Another valuable application of microscopic chemical methods is in the analysis of the total solid residue in water analyses. We generally speak of the hypothetical combinations present. I do not wish to raise the question of reporting ions or combinations, but I do desire to lay emphasis upon the fact that it is possible and practicable, in most cases, to identify the salts present in the solid residue through their habit and optical properties, providing the work is properly done. I know of several instances where identification of the principal compounds present threw much light upon obscure problems. Traces or more of the heavy metals, such as lead, copper, etc., are far more readily detected by microscopic qualitative analysis methods than by any other means at our disposal.

Water analysts pay altogether too little attention to microscopic examinations of sediments and suspended matters, and to the deposits at the bottom of springs, wells and cisterns. Much valuable information is also to be derived from the examination of the muddy ooze at the bottom of streams, ponds and reservoirs, and from the study of the coated sands from rapid filter beds to learn the extent and character of the adsorption of aluminum hydroxide by the sand grains. When we speak of the "microscopy of drinking water," we generally mean researches upon the flora and fauna giving rise to disagreeable odors and tastes, but this is in reality only a very narrow portion of a huge field which is by no means restricted to biological problems or even to investigations made with the ordinary microscope, since it comprises problems soluble only by means of such specialized instruments as the ultramicroscope and the luminescence microscope.

[1] Not shown here.

EXAMPLES OF RANGE OF APPLICATIONS

The remaining lantern slides[1] have been chosen to illustrate the application of microscopic methods to the solution of problems in some of the great industries. I can do no more than touch upon them. Permit me, therefore, merely to outline the nature of the information given.

ABRASIVES—Proper grinding requires adequate speed without undue heating; cutting of uniform depth; wheels which wear well. In other words, the selection of the proper sort of wheel and speed for the specific purpose. There enters, in addition, the size of particles of abrasive and the nature of the bonding material giving a hard or soft wheel. Much of the manufacturing has been done upon a purely empirical basis and by rule of thumb methods.

Microscopic examinations of particles torn off show how the wheels have acted, while a similar examination of the abraded surface shows the character of the cutting done.

It is surprising how much information may be gained in this way, and how it may be used to guide one in making proper selections.

I will be able to demonstrate that a grinding wheel of a certain kind will tear off the surface of tool steel in such a manner as to heat the steel and draw its temper to such a degree that the particles you will see under the microscope have been fused into tiny spheres. Another wheel rotating with the same surface velocity will cut off the material in ribbons. You will note how few melted fragments are present as shown by the absence of tiny spherical masses. Such a wheel can be employed for purposes for which the other is obviously unsuited.

CEMENT, CONCRETE, CERAMICS ETC.—By microscopic examination it is possible to determine the character of the final product, its component parts and their volume per cent; the prevalence of an undue proportion of air and water voids; the thoroughness of wetting of the cement mixtures, etc.

Not less important is the recognition of improper bonding and valuable information is obtainable as to the actual strength of the concrete or its liability to failure. There is here a huge field for the investigator offering untold possibilities.

The whole field of ceramics, both clay products and porcelains, needs intensive microscopic research. Even our ordinary bricks offer a most attractive subject for the investigator.

The thickness of glaze and the thoroughness of its bond with the body-making material can readily be determined. I have prepared slides of two high-grade porcelains; in one of these (Fig. 9) you will note the glaze is thick and between it and the porcelain are a vast number of tiny gas voids. In some cases these gas voids penetrate the glaze as minutely fine capillary tubes. The other porcelain of far higher quality has a much thinner glaze and as you see (Fig. 10) has almost no gas voids—the bonding is almost perfect. Examinations of this sort employed in the industry go a long way to improve the products turned out.

FOODS AND BEVERAGES—Doubtless the earliest application of microscopic methods by the chemist was in the examination of foods, food accessories and drugs for adulteration or deterioration. Examinations of this sort are based largely upon vegetable and animal histology, and differ but little, if any, from the ordinary technique of histology. No other methods are available to ac-

[1] Only two figured.

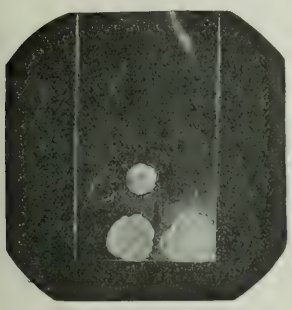


FIG. 8

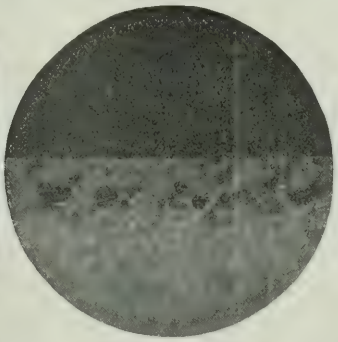


FIG. 9

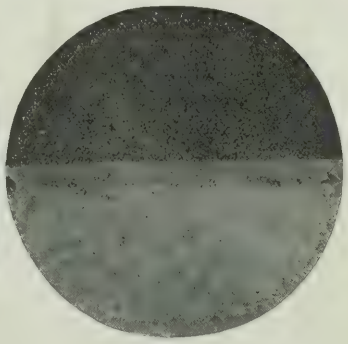


FIG. 10

complish the ends in view, and we can therefore assume that in this line at least the microscope is indispensable, training in the necessary technique imperative, and every food analyst and expert must perforce train himself to undertake studies of this sort.

This field of activity is so well understood and so firmly established that we can dismiss it without further comment. But there is in this whole question of the microscopy of foods and drugs, another phase, which chemists have greatly neglected—that of the amazing possibilities of microscopic qualitative and quantitative analysis. To even enumerate the list of substances whose detection becomes simpler, more certain and much more rapid than by our ordinary routine tests, would require more than the remaining time at my disposal. These "micro" tests are applicable to organic, as well as inorganic substances, as I have already pointed out. We have nothing better than microscopic methods for the detection of the poisonous metals, for the recognition of the organic acids, for the detection of preservatives, for the vegetable alkaloids, glucosides, and other active principles of plants; nor can we find other methods available for the quantitative analysis of starch mixtures and for similar analyses of mixed powders and meals of vegetable origin.

The recognition of our commercial synthetic drugs also is considerably simplified. In fact it is no exaggeration to say that proper analyses of this sort cannot be conducted unless the microscope is employed.

In the canning industry, especially that employing tin cans and other containers, the microscope gives information of untold value. Soldered and crimped joints yield up their secrets, as also the tinned surface or other protective coating which may have been applied to metal or paper surfaces. The possibilities are, in fact, without end.

METALLURGICAL INDUSTRIES—The microscopic study of metals and alloys has been so firmly established within the last few years, and the close relation between structure and physical properties so generally recognized and its importance proved in practice, that I need not spend time upon this question. Although these methods have been placed upon a firm foundation in the iron and steel industries, there is much work to be done in the great field of commercial alloys. We generally think of heat treatments in terms of steel only. As a matter of fact many alloys may be greatly improved by carefully conducted heat treatments. In order that such work may be properly done, microscopic studies of structure are imperative. This is well shown in the photographs of a copper-zinc, and of a copper-aluminum alloy.

Often the microscopic appearance of a roughly polished and etched specimen taken in conjunction with a hasty qualitative analysis will give the investigator all the information he may require to deduce the quantitative composition and to make a shrewd guess at the physical properties.

A most fruitful field leading to improved practices is the study of welds and brazes under the microscope. At least one expert in welding by means of oxyacetylene owes much of his remarkable success to microscopic studies of welded materials.

Not infrequently the microscope shows that a poor product is due to improper temperatures of casting or coating, and not to bad raw materials or wrong percentage composition. This is especially the case in babbitts and in tinned goods. In these photographs showing the great difference in the structure of a babbitt cast at too high a temperature and the same one poured just right, it is obvious that in the one case friction will be considerably greater than in the other, particularly if in a high-speed bearing.

PAINTS, PIGMENTS, PROTECTIVE COATINGS—The microscopic studies of materials falling in this group of commercial products may be classed under three heads: (1) The examination of the raw materials, (2) that of the coated surfaces and (3) studies of the methods and results of applying the coatings to the objects to be protected.

Briefly stated, the raw materials under the microscope (chiefly pigments, etc.) reveal their source and nature, often the process of manufacture and their suitability for the purposes for which they have been purchased. Take for example the mere question of size in the selection of the pigments for a mixed color paint. It is a simple matter to obtain a whole series of different shades by using, say two pigments and having them vary in the ultimate size of their particles, although the per cent by weight of each remains constant. The actual shape of the particles also probably seriously affects the length of time the paint really acts as an efficient protector, especially in paints containing silica, graphite, or both. The microscope also throws light upon the nature of the changes taking place in the pigments of paints exposed to air, light and the weather. A good illustration is to be found in the study of the cause of the darkening lithopones.

Examination of the weathered, coated objects, both of the surface and of sections cut through the thin films of coatings, not infrequently will permit the formation of an immediate opinion as to the quality of the paints or coatings, and the skill of the workmen who applied them.

Too little attention has been paid in the past to the study of sections. I believe all of you will be interested in the preparations[1] I have to show you. I have selected them because they exhibit in a striking manner the differences between good and bad paints, and between good and bad workmanship in their application. You will also note that the appearance under the microscope of these samples of japanned steel show very clearly the superiority of the one method of baking over the other; in actual

[1] Not shown here.

practice the superior surface costs less to apply than the inferior and wears longer and better.

The microscope in the hands of the chemist dealing with this class of commercial material enables him to evaluate rapidly the products handled by his firm, to improve faulty products and to determine whether the materials supplied to the trade are being properly applied.

Nor must we omit from mention the valuable information we may obtain from the microscopic study of woods to which fire- or decay-proofing substances have been applied.

PAPER—I have thus far failed to mention one great industry based largely upon microscopical control—the paper industry. Practically, an analysis of paper without reference to its ultimate composition as shown by the microscope is of little or no value. Actually, much paper is manufactured and employed for various purposes without studies under this instrument. As a necessary consequence we frequently meet with paper-fiber goods manufactured with little regard for the ends to be attained other than to sell at a profit. A fair criticism of our American paper products are that they are too good; that is to say, the quality is higher than need be, and the cost to the consumer is greater than it should be for many of the objects to be attained. By that I mean that a less expensive product would serve equally well and not infrequently better. This is poor business and poorer conservation. Let me cite a case in point:

A few years ago a firm manufacturing a product (which must be nameless, since the investigation was conducted in confidence) appealed to the laboratory for advice. Their product, and that of their competitors also, was failing to stand up under new conditions of use. In desperation the chemist of the firm wanted to know whether the microscope would reveal the source of the trouble. A day or two's critical study of new and failed material showed that changes made by the paper firms were probably the cause of the trouble. A commercially better grade of paper was being supplied. The matter was taken up with the paper firm. The answer was quick and to the point. The paper supplied was the highest grade that could be produced at that price and further they didn't propose to have any men, mere analysts, tell them their business. They had been manufacturing papers before the questioning men were born, etc., etc. In fact the same old story, and the same old trouble with many well-meaning American firms. All you industrial men have had similar experiences. I need not go further.

A small firm was prevailed upon to make a paper of the kind which, it was believed, would eliminate certain features which the microscope seemed to indicate to be the cause, or at least one of the causes of the trouble. This new paper was then treated in the proper manner and tested out. The results were so satisfactory that a contract was placed to take almost the entire output of the paper firm with specifications as to the kind of paper needed. The net result was that a product was obtained in which, not only were the old defects eliminated, but the cost of production was decreased, the final profit greatly increased, and the stability of this industry assured. But I am not sure that the paper firm which lost a large contract is even to day convinced that the new methods of microscopic investigations are of value.

There is little doubt that similar conditions obtain in many of the other varied paper-fiber industries. Microscopic methods are the only ones which enable the analyst to identify the nature of the paper and to indicate its fitness and adaptability for the specific uses to which it will be put.

The technique for the recognition of the nature of the fibers present and for their quantitative determinations are fairly well established and are on the whole quite satisfactory. But a phase of microscopic investigation has been neglected, viz., a study of the finished surface with references to the uses to which the paper is to be applied. A study of paper surfaces with vertical illuminator and with oblique light yields most interesting results. Were these methods more often employed there would be in many cases a decided modification in certain papers on the market.

THE TEXTILE INDUSTRIES—Like papers, the analyses of textiles and the recognition of the fibers of commerce are dependent entirely upon the proper application of microscopic methods. At the present time no other satisfactory methods are available for differentiating between the species of fibers employed, the specific treatment they have received, or the loom arrangement by which the yarns have been woven into fabrics. In not a few instances the information thus obtainable may go even further and disclose the nature of the method used in dyeing the yarn or the fabric. Uneven adsorption, variable penetration, etc., are easily recognized. The skilled investigator may go even further and discriminate between different qualities of the same species.

The technical microscopy of the textile fibers is still in its infancy: its literature teems with inaccuracies and contradictions. Too little attention has been devoted to the investigation of the reactions of reagents and the selection of proper differentiating stains, and the potential possibilities of dark field condensers having very oblique ray illumination (ultramicroscope) and of luminescence illumination (ultra-violet rays) have not yet received the attention they deserve.

By way of illustration of what the microscope reveals, I call your attention to several lantern slides[1] selected to show how neglect to employ this instrument led to the failure of a manufacturer to reproduce a fabric which the firm was called upon to manufacture because of war conditions. The reproduction involved producing a similar yarn from like fibers, a similar weave in the fabric, and a similar colored printed pattern. The slides show that in no case was he successful and that his different attempts were a waste of time, material and energy, since he apparently lacked the fundamental microscopic information necessary for success.

I trust that in these rambling remarks I may have converted some skeptics to a belief in the importance of chemical microscopy in our industries, and may stimulate a wider interest in a branch of chemical analysis whose value has been greatly underestimated and whose development has been sadly neglected.

DEPARTMENT OF CHEMISTRY
CORNELL UNIVERSITY, ITHACA, N. Y.

THE BUREAU OF MARKETS IN ITS RELATION TO THE CONSERVATION OF FOODS[2]

By CHARLES J. BRAND

Recently, I noted a peculiar typographical error in one of the western newspapers. An editorial, a half column in length, seriously discussed the need of food conservation, but through the carelessness of the typesetter the article was entitled "Food Conversation." Much of the matter that is going the rounds of the press in these days may be called not improperly "food conversation." Your section of the American Chemical Society and the Bureau of Markets are, I hope not interested in, nor indulging in, careless and uninformed talk about food problems, but are taking serious steps to save the food of the country and to effect its more economical use.

Before proceeding to outline the relations of the Bureau of Markets to food conservation, let us first determine why the saving of food is so unusually important at this time. Roughly speaking, the diet of the average person in the United States is obtained from the following sources:

39 per cent Animal
31 per cent Cereal
25 per cent Fruits and Vegetables
5 per cent Sugar, Condiments and Miscellaneous

[1] Not shown here.

[2] Presented before the Division of Agricultural and Food Chemistry, 55th Meeting, of the American Chemical Society, Boston, September 10 to 13, 1917.

Therefore, if we examine into the world situation as to the consumptive requirement and supply of animal and grain food products, which total 70 per cent of the whole, the need of conservation will become apparent immediately.

As we have associated ourselves with the Allies across the water in a grim determination to win the war, we cannot think in terms of our own needs only, but must have in mind, in addition, those of our allies and those of deserving neutrals dependent upon us. The problem of the neutrals is intricate and delicate. Recent developments force the consideration seriously of a most severe extension of the embargoes on foodstuffs and other important materials.

As stated above, food animals and meats constitute 39 per cent of the average diet. On account of the inroads that war has made upon the herds and flocks of the world, it is estimated that there has been a decrease of over 115,000,000 head of cattle, hogs and sheep. Although our own animal production has been increasing slightly during recent years after a long period of serious decline, it has not kept pace with our increase in population, to say nothing of our growth in meat exports. The average exportation of American meats during the three years preceding the war was something over 493,000,000 lbs. During the war year extending from July 1, 1915, to June 30, 1916, the total exportation was almost 1,000,000,000 lbs. It is, of course, impossible to increase animal production quickly enough to produce this requirement, hence conservation must be called upon in order to provide what is needed.

In the case of the cereals, the crop situation in the allied countries, while fairly satisfactory in view of the vast amounts of labor diverted to war, still leaves an enormous total requirement that must be supplied largely by North America. The pre-war consumption and current import needs of wheat of Great Britain, France and Italy, our most important allies, expressed in terms of bushels, are as follows:

	Pre-war Consumption	Current Import Needs
Great Britain	268,000,000	203,280,000
France	360,000,000	118,400,000
Italy	236,000,000	59,800,000
TOTAL	864,000,000	381,480,000

The normal needs beyond their own production of the neutral nations dependent upon us are about 192,000,000 bu. Hence, the total import needs of our allies and the neutrals for wheat alone are in the neighborhood of 570,000,000 bu. On the basis of existing crop prospects, the United States, Canada, Argentine, Australia, North Africa, India and Russia will be able to supply about 500,000,000 bu. The long haul from Australia, requiring three times the tonnage that shipments from North America require, the uncertainty of being able to move any considerable quantities from India, and the almost impossible transportation situation in Russia, leave the burden upon the wheat fields of North and South America. The crop in the River Plate territory has not proven as large as usual, hence an added responsibility for us.

The normal consumption requirement of the United States is about 575,000,000 bu. The Bureau of Crop Estimates anticipates a crop this year of about 678,000,000 bu., hence our exportable surplus will be about 100,000,000 bu. By conservation it is of the highest importance that this quantity be increased to the greatest possible extent in order that the foreign deficit of 70,000,000 bu. may in some way be covered. The extent of this shortage will be more quickly grasped if we remember that it requires $4\frac{1}{2}$ bu. of wheat to make a barrel of flour, and that a barrel of flour under average conditions of efficiency in modern bakeries produces 275 loaves of bread. Our 70,000,000 bu. shortage, therefore, converted into barrels of flour would amount roughly to 15,500,000 bbls. or a shortage of over 4,000,000,000 loaves of bread. As there are about 103,000,000 people in the United States, this would represent a little less than 32 loaves for each person.

I have cited these two important food sources to indicate the amount and character of our needs.

In the case of two of our great food crops, the prospect is for a large increase. The corn crop will probably exceed 3,000,000,000 bu. as compared with a five-year average of 2,600,000,000. The potato prospect is for a crop of considerably over 400,000,000 bu. while last year's crop totaled only 285,000,000.

From this general review, let us proceed to a brief examination of what the Bureau of Markets is undertaking to do to improve conditions, not only as a war measure, but for peace times.

In the first place, we are trying to get the facts. An important desideratum in all work on food problems has been authoritative information regarding food habits, supplies, consumption, ownership, location and the like. This lack of authoritative information has been due primarily to lack of authority to obtain it. It seems incredible, but up to August 10 no branch of the Government had the legal power to force the divulging of information regarding food stocks held in any hands whatsoever.

On the recommendation of the Bureau of Markets, there was included in the so-called Food Production and Food Survey Bill (Public No. 40, 65th Congress) a section delegating quite comprehensive information-getting powers. This section, which is Section 2, and that part of Section 8 making appropriations are of sufficient interest in this connection to be read in their entirety:

SEC. 2. That the Secretary of Agriculture, with the approval of the President, is authorized to investigate and ascertain the demand for, the supply, consumption, costs, and prices of, and the basic facts relating to the ownership, production, transportation, manufacture, storage, and distribution of, foods, food materials, feeds, seeds, fertilizers, agricultural implements and machinery, and any article required in connection with the production, distribution, or utilization of food. It shall be the duty of any person, when requested by the Secretary of Agriculture, or any agent acting under his instructions, to answer correctly, to the best of his knowledge, under oath or otherwise, all questions touching his knowledge of any matter authorized to be investigated under this section, or to produce all books, letters, papers or documents in his possession, or under his control, relating to such matter. Any person who shall, within a reasonable time to be prescribed by the Secretary of Agriculture, not exceeding thirty days from the date of the receipt of the request, willfully fail or refuse to answer such questions or to produce such books, letters, papers, or documents, or who shall willfully give any answer that is false or misleading, shall be guilty of a misdemeanor, and upon conviction thereof, shall be punished by a fine not exceeding $1,000 or by imprisonment not exceeding one year, or both.

SEC. 8. * * * * * * For gathering authoritative information in connection with the demand for, and the production, supply, distribution, and utilization of food, and otherwise carrying out the purpose of section two of this Act; extending and enlarging the market news service; and preventing waste of food in storage, in transit, or held for sale; advise concerning the market movement or distribution of perishable products; for enabling the Secretary of Agriculture to investigate and certify to shippers the condition as to soundness of fruits, vegetables and other food products, when received at such important central markets as the Secretary of Agriculture may from time to time designate and under such rules and regulations as he may prescribe; PROVIDED, That certificates issued by the authorized agents of the department shall be received in all courts as prima facie evidence of the truth of the statements therein contained; and otherwise carrying out the purposes of this Act, $2,522,000; PROVIDED FURTHER, That the Secretary of Agriculture shall, so far as practicable, engage the services of women for the work herein provided for.

FOOD SURVEYS OF THE UNITED STATES

The plans which are now in operation contemplate a preliminary survey as of August 31, monthly reports on the important food commodities and a far more detailed survey about the first of December when all of the crops of the year have been gathered

and threshed. The preliminary inventory is now in progress and up to Monday noon 135,000 schedules had been returned from the enterprises called upon for reports. The August 31st survey requires the reporting of stocks on hand and in transit for eighteen of the most important commodities or classes of commodities. Included are the following:

1—Wheat
2—Corn
3—Beans, navy (pea beans), medium white and large white
4—Wheat flour, all kinds (bbls. of 196 lbs.)
5—Corn food-products
6—Rice, cleaned or milled
7—Rolled oats and oatmeal
8—Salted and cured beef
9—Cured hams, bacon, and shoulders
10—Other cured and salted pork
11—Lard, lard compounds, and lard substitutes
12—Salt fish, dry and in brine
13—Vegetable oils suitable for food, cottonseed, olive, peanut, etc.
14—Solid vegetable cooking fats (labels state whether vegetable or not)
15—Sugar, all kinds
16—Sirup and molasses, excluding any unsuitable for human food
17—Condensed and evaporated milk
18—Canned salmon.

Reports are also requested for purposes of comparison of stocks on hand one year ago on the same date. The eighteen items included in the preliminary survey will be used as the basis of the monthly reports already mentioned. Both the preliminary survey and the more comprehensive one to be made after the crops are harvested contemplate the obtaining of four classes of information:

I—Stocks on hand on farms.

II—Stocks in wholesale, jobbing, storing, manufacturing and other commercial establishments.

III—Stocks in retail establishments.

IV—Consumers' stocks, consumption records and dietary study.

I—STOCKS ON HAND ON FARMS

The determination of the quantities of the various classes of food products on farms, necessarily involving principally the quantity of cereals and the numbers of live stock and poultry, is being made by the Bureau of Crop Estimates through its existing machinery and usual methods. Their inquiry includes all of the grains, buckwheat, flaxseed, the sorghums, peanuts, beans of all kinds, peas, cottonseed, forage crops, milch cows, calves, beef cattle, sheep and lambs, swine, and poultry. The Bureau's figures for the total will, of course, be based on estimates, but the estimates will be somewhat more inclusive than those customarily made. Reports will be received for the preliminary survey from over 30,000 of the Bureau's regular township reporters. For the more comprehensive survey after the crops have been gathered, returns will be requested not only from the state, county and 30,000 regular township reporters, but also from 10 farmers in the vicinity of each such reporter.

II—STOCKS IN WHOLESALE, JOBBING, STORING, MANUFACTURING, AND OTHER COMMERCIAL ESTABLISHMENTS

Information regarding holdings in manufacturing, storing, jobbing, wholesale and other commercial establishments, is obtained by requesting from each such concern a statement of the exact amount, as nearly as possible, of each commodity on hand.

In the distribution of the schedules for the August 31st survey, there was included a list of the more than one hundred separate items upon which reports will be requested in the later inventory. Approximately, 384,000 schedules were sent out to the various food handling and distributing enterprises. As an indication of their character and number, I will cite some of the more important groups:

Grain elevators, mills, and wholesale dealers	38,900
Grain, flour and feed dealers and proprietary [illegible]ers	18,000
Breweries	1,200
Distilleries	800
Rice mill and storages	800
Canners of fruits, vegetables, meats and [illegible]	6,500
Milk, refineries and exclusive dealers of [illegible]	1,400
Sugar and sirup mills and refineries	1,300
Wholesale and retail bakers	32,000
Manufacturing and wholesale confectioners	1,800
Fish freezing plants and dry and salt fish packers	1,040
Slaughter and meat packers	3,700
Lard compound and oleomargarine manufacturers	169
Wholesale poultry, butter, egg and cheese dealers	5,000
Poultry packing and fattening plants, and live poultry shippers	5,000
Wholesale fruit and vegetable dealers	1,500
Wholesale grocers and merchandise brokers with stocks	7,500
Creameries and milk condenseries (condenseries 393)	7,000
Cheese factories	5,000

III—STOCKS IN RETAIL ESTABLISHMENTS

On account of the great difficulty, in fact, practical impossibility of making a complete inventory of the stocks of the smaller retail concerns, the retail survey has been confined to retail grocers carrying stocks of $1000 and over and to general stores selling foodstuffs carrying total stocks of $3000 and up. In addition to this, the work already under way includes a detailed survey of the stocks of smaller retail concerns in a number of representative cities and rural districts. The figures thus secured will be used as a basis for estimating the total stocks for the entire country. In the general survey, schedules have been sent to 64,000 retail grocers, 63,000 retail meat markets, 60,000 general stores carrying foodstuffs, 100 chain store companies (a single chain store company operates as many as 3400 retail stores), 1200 department stores handling groceries, and 1200 hotels and restaurants.

For the purpose of estimating the stocks of the entire country the counties of the United States have been divided into groups according to the population of the largest city, town or village in each county. This classification includes as a separate class 44 large metropolitan districts. 43 counties have been selected for a detailed or intensive survey, which is being conducted by personal canvass. With the careful classification of all counties, and applying the returns obtained from the 43 counties selected, we hope to determine with a valuable degree of accuracy the retail holdings of the entire country.

A similar detailed canvass has been made of New York City with the coöperation of Dr. L. P. Brown, of the Bureau of Food and Drugs of the Department of Health and of the Police Department, New York City. The great importance of New York as a consuming center and the problem involved in supplying its foodstuffs from great distances give the canvass of that city especial importance.

IV—CONSUMERS' STOCKS, CONSUMPTION RECORDS AND DIETARY STUDY

For determining consumers' stocks a detailed survey has been made of the amounts held by a large number of representative families. 10,000 families in all parts of the United States were visited and a record was made of all food materials found in their possession. From this an estimate is to be made of the household stocks of the country. This is admittedly unsatisfactory but represented the best compromise which for the immediate purpose could be found between ignoring household stocks entirely or attempting to get returns from the 20,000,000 families in the United States, a manifest impossibility.

In passing, it should be said with reference to the preliminary survey as a whole that while it will yield information of unquestionable value, one of its greatest uses will be the organization of an efficient machine and the elaboration of satisfactory methods for making the more accurate survey in November and December.

In connection with the determination of consumers' stocks, a careful estimate of the weekly consumption of the more important

articles of food is being made among 3,500 typical families. A carefully prepared schedule for a week's consumption of 54 items of table food is being used and the coöperation of a suitable number of families has been enlisted in filling it out. Each was asked to keep a daily record of the food used by her family for 7 days. In case of food purchased, the cost was also recorded. If home-produced, that fact was set forth. All of these facts are, of course, held in confidence except so far as their use in general statements of totals and conditions are to be made.

A supplementary dietary study is being made in connection with the determination of consumers' stocks in which information was also collected as to the occupation, age, sex, health, racial stock, income and general economic condition of the families. While 3,500 families may seem a small number upon which to base any statement regarding the dietary of 100,000,000 people, it should be borne in mind that Atwater's American figures supplemented by some secured by Langworthy a number of years ago based upon a total of 400 families are the most satisfactory now available. In addition, it should be borne in mind that these figures have been used as the basis of the British Royal Commission's food supply investigations and in part also by Eltzbacher's commission which investigated Germany's food supply.

In the dietary study, all food on hand at the beginning, all procured during the course of the study, and all remaining at the end, are carefully weighed and recorded. Waste and refuse are taken into account, and from these figures the amounts actually used are determined. Over 400 institutions of learning scattered throughout all of the States are assisting through their teaching staffs and through their graduates in home economics. In addition, about 700 families, mostly members of the American Home Economics Association, are furnishing schedules either for their own homes or for families coöperating in the study[1].

When the comprehensive survey of the early winter has been finished it is believed that the food information of the United States will be more complete, detailed and accurate than any in the world.

In passing, may I say in correction of many statements that have run the course of the press that only $600,000 of the $2,500,000 appropriated for all marketing and distribution investigations are to be used in the conduct of the food surveys of the United States throughout the year.

I have described the food survey work in some slight detail as I believe it to be a subject of especial interest to your membership, whether engaged in physiological or other chemical lines. With thoroughgoing information, far more can be accomplished than without it. Nevertheless, we have in the past four years proceeded upon many lines of conservation work, which will be greatly emphasized during the coming year. A description of the chief lines with some examples of their operation and utility follows.[2]

The following titles describe to a degree those activities of the Bureau of Markets which most specifically relate to the conservation of foods.

(1)—The promotion of equitable distribution through the dissemination of market information by telegraph, telephone and mail.

(2)—Investigations and demonstrations in the conservation of food products in transportation and storage.

(3)—Market inspection of perishable foods.

(4)—City market service for the distribution and utilization of the home and commercial garden surplus.

(5)—Conservation of grain food supplies through the work in grain marketing, standardization and the supervision of grain inspection.

(6)—Reports on cold storage holdings of food products, available supply of space, and cold storage management.

(7)—Miscellaneous publicity activities designed to bring about consumption of products especially plentiful at certain seasons.

BUREAU OF MARKETS
WASHINGTON, D. C.

[1] As a working hypothesis, a daily requirement of from 90 to 100 g. of protein for a 150-pound man at full vigor with 3,000 calories of energy if he does a moderate amount of muscular work, has been generally adopted.

[2] On account of lack of space we are forced to omit this descriptive matter.—EDITOR.

THE CANNING INDUSTRY—SOME ACCOMPLISHMENTS AND OPPORTUNITIES ALONG TECHNICAL LINES[1]

By H. A. BAKER

There are produced in the United States at the present time about thirty-two million base boxes of tin plate per annum. About five million base boxes are exported, and approximately one-half the balance is used in making containers for canned food; that is, the equivalent of nearly five billion No. 2 or 1¼ lb. cans are being packed this year.

The canning industry is nothing more nor less than kitchen activity carried out on a large scale, with mechanical labor-saving devices. Food laws and evolved trade custom and ethics define canned food as natural products, with or without added salt and sugar, plus water when desirable or necessary, sterilized and preserved by heat alone. The point that naturally arises is, Why should any chemists be needed in an industry that is so simple as this? Some developments and work in this connection might therefore prove interesting, because more chemists are needed than are engaged in the industry at the present time.

Up to about nine years ago chemists exerted very little influence in the development of this industry. Of course, every one is familiar with the fact that the industry was founded on a basic scientific discovery, but it was developed largely by shrewd experimenters, usually without technical education. It is true that valuable assistance was rendered from time to time by technical men, usually associated with colleges, but the industry, until lately, did not have on its own pay-rolls men with technical training.

The Department of Agriculture gave some attention to canned foods, which was helpful, but for considerable time their help was along critical and not constructive lines, which is in sharp contrast to their present activities.

In 1912 the canning industry had become sufficiently progressive to have developed a strong national organization for self-development, education, dissemination of statistics, and activities along many lines other than marketing. It was then prepared to go one step further and establish a National Association Technical and Research Laboratory. This was accomplished through the assistance of generous donations from some of the allied industries. This development opened the opportunities for much experimental work on a large scale of a coöperative nature, that hitherto had been difficult, if not impossible. The Department of Agriculture has looked very favorably on the Association Laboratory, and has coöperated with it on several large investigations in connection with various industrial manufacturing concerns, supplying the tin plate, steel and cans for the trade. This machinery for coöperation is so complete and safeguarded from bias that investigations of national scope can be carried out and the results accepted, both by the trade and the technical men of the country.

It might be well at this point to give an outline of some of the problems that are studied, as well as those yet to be worked on. In doing this we will not attempt to make any individual mention of technical men or laboratories, the main point being to disclose somewhat the nature of the work, and the field for technical men in the canning and allied industries.

To begin with, we would point out that it has been found the work involves two sets of technical men: those who are straight technical men with superficial knowledge of the practical end of the work, and technical men with a broad and adequate knowledge of laboratory work, who are primarily business men with some executive ability. It will be readily seen that this arrangement is much more satisfactory than the usual one where purely practical and business men have the responsibility for the direction of technical activities. While

[1] Address presented before the New York Section of the American Chemical Society, November 9, 1917.

canning work is merely kitchen work on a large scale, it involves the use of high-speed machinery, concentrating and cooking devices, elimination of air and gas in the product, proper sealing temperatures and exhaust, proper closure, proper cooking temperature, as well as proper preparation of the food for canning.

Innumerable problems arise connected with spoilage, quality, appearance, discoloration, consistency, etc. Many of them can hardly be answered from the laboratory, and must be worked out by practical experimentation in a factory. For instance, a few parts per million of copper in canned corn from cooking utensils will turn it a dark gray. A very minute amount of copper will turn canned shrimp black. If evaporated milk does not receive the proper heat treatment after condensing, it will not stand sufficient processing to sterilize it without causing coagulation of casein and separation of cream. If condensed milk is not properly prepared in regard to the proportions of milk solids, sugar and water, and if the cans are not properly sterilized before filling, and aseptic methods of filling are not used, yellow discoloration of the product and spoilage will occur. If corn is not properly preheated before canning, the resultant product is watery, and separates. If string beans are not properly blanched, the product is either too tough, or is slimy. If red cherries are held in cold water too long, they will turn brown after canning. If cherries are packed in too heavy a syrup they will become very tough. If clam juice is extracted at too high a temperature it will turn black in the can. It will be seen that any of these problems, if carried to a consulting chemist outside of the industry, would cause him endless trouble, and could not be solved by analytical work.

A curious difficulty arose some time ago in connection with canned apples from a certain section of the country. These apples perforated tin containers very badly, spoilage was enormous, and there seemed no way of stopping the trouble. A peculiar thing was that these apples which caused trouble only contained about one-half as much acid as apples packed in neighboring states that caused no trouble. A certain chemist figured out from observing the drop in the water line of the cans that there must have been more air in these apples than in those that did not perforate. Actual tests showed this to be the case. It was found practicable to vacuumize these apples under water, in which case the exhausted air cells became filled with water when the vacuum was released, and it was found that apples packed after this treatment, on a large commercial scale, had not the slightest tendency to perforate the containers. Because of the urgency and extremely heavy losses, it was necessary to jump directly from a small laboratory experiment in glass to a factory installation capable of handling millions of pounds of apples in a season. Peculiarly enough, the installation worked perfectly from the outset.

About three-quarters of all the Hawaiian pineapple that is packed is vacuumized for quite another reason. It was found if the sliced pineapple was vacuumized that on the releasing of the vacuum the free juice on the outside of the slice, entering into the emptied air cells of the fruit, would change the color instantly from a rather unattractive white color to a rather standard yellowish color, which gives the appearance of perfectly ripened fruit.

For a long time the waste of the trimmings and the small pineapples was a dead loss. Some chemists went to work and now small pineapples and trimmings are crushed, the juice clarified, acid removed, and the syrup concentrated and used in canning in place of cane sugar. There is approximately a pound to a pound and one-half of cane sugar in one gallon of fresh pineapple juice. This is now being used, and has lowered the cost to the consumer of canned pineapple.

Great changes have taken place in the methods of meat packing in the last few years, and have saved over half the labor cost of canning. It was considered for a long time necessary to seal meat products in cans under vacuum on account of the sensitiveness of meat products to discoloration when cooked in the presence of air. It was pointed out and demonstrated by chemists that by changing the type of can, filling it so full that very little air space is left in it, and by merely steam-heating the product before sealing, that better results could be obtained than was possible with the vacuum system. The labor cost was cut in half, and an enormous saving resulted.

Cooking large cans of approximately gallon size had always been an expensive matter, and involved much loss on account of the internal strain on a can of large area. Extremely heavy weights of tin plate were demanded, and still buckles occurred, tin plate was broken, and spoilage resulted in cooking retorts when the surrounding counterbalancing steam pressure on the outside of the cans was released. Simple pressure cooling devices were evolved, which eliminate all trouble and loss on this score, besides reducing the cost of the container.

Methods of analyzing tin plate have been developed in a certain laboratory which designed a machine that enables four men in an 8-hr. day to turn out one thousand analyses of tin plate.

Much technical work has been done on tomato products. Sanitary methods of handling, sorting and cleansing have been devised so that it is possible to make tomato pulp, puree, ketchup, etc., with a minimum count of yeasts, mold and spores. Methods have been worked out that are simple enough to be applied by the average factory to control the finishing point, or density, of tomato concentrated products. Chaos previously reigned in this manufacture, and the loss and miscalculations were surprisingly large. Some canners boiled their product, allowed it to stand, drained off the liquor which settled at the bottom, little dreaming that in this way they were losing most of the sugar and flavor, and a very high percentage of solids. Much more profitable manufacture and elimination of waste resulted from concentrating the liquor as well as the pulp.

A great deal of work has been done on the cause of bacterial spoilage in canned food. This trouble is always occasioned by one of two things: either a minute defect in the can, or understerilization. All of the arts of the can maker, all the devices for testing, and the cunning of the bacteriologist is necessary in arriving at the cause of spoilage in many instances. It will be readily understood that successful work along these lines means the elimination of loss; that is, conservation of food materials and reduction in the cost of food to the consumer. It is not necessary to cite innumerable examples along these lines, for enough has been given to indicate the nature of the problem and possibilities of their solution. We should, however, mention two pieces of work that were done coöperatively through the organization previously described in connection with the National Canners Association Laboratory.

A general survey was made of the absorbed tin in all types of canned food in all types of containers, with various weights, or thicknesses of tin coating, both plain and enameled. It can be predicted at the present time approximately how many milligrams of tin per kilogram of food there will be in any tin can, with any product, in a given space of time, and whether or not the can should be plain or enameled.

Another extremely large experiment was carried out on determining the relative value of different weights of tin coatings on tin containers, and it was found that for all general purposes, except one, there was practically no difference in the protective value of tin coating running between one [illegible] and two pounds of tin per base box. Approximately the same number of breaks, or minute defective spots, in tin coating is found irrespective of the weight of tin coating, and if [illegible] trouble develops, it cannot be taken care of by extra weight of tin coating. The

product itself must be so prepared and handled that it will not attack the container in such a way as to cause discoloration.

Consider for a moment the element of conservation involved in this. Supposing tin plate were to be manufactured which carried half a pound of tin coating more per base box than was of value, the industry would be carrying a burden of 20 to 25 cents per base box, which, of course, would be passed on to the consumer. On thirty million base boxes of tin plate this would be fifteen million pounds of tin a year, or approximately seven million dollars. Not only would there be the burden of unnecessary cost, but the actual waste of the world's mineral resources which should be conserved. The experiment itself cost only about fifty thousand dollars.

When one speaks of conservation in food industry the usual thought is merely the saving of some waste or by-product; the question narrows down in people's minds to some such question as taking care of potato peelings. Conservation on its broader side is mostly concerned with developing new and better ways of doing things, involving a saving of labor, money and materials, together with the enhancement of quality, and benefit to the public. It is true that there are plenty of waste products to work up in the canning industry, but it is also true that the more promising field is new developments. At the present time only 50 per cent of tomatoes delivered at the factory are turned out in the canned fruit product. Thousands of tons of pear peelings are wasted because they do not make a vinegar that tastes like vinegar. Thousands of tons of fish scrap, particularly on the Pacific Coast and Alaska, are wasted because easy and profitable methods of getting the values out of them have not been devised. Enormous quantities of green corn cobs are allowed to ferment and are used for fertilizer and cattle food, when it is well known that there is more sugar left in the cob than was taken off in the corn. Probably many kinds of bacteria which at present only destroy food could be made to do useful work, producing useful substances and chemicals, if they were thoroughly studied and put to work. Enormous quantities of sea food, which cost nothing to grow, are at present unused by the human family because no one has prepared them in a way that would make them palatable and attractive. Enormous quantities of shark and gray fish are not used because they happen to contain a small quantity of urea which in cooking turns into ammonia. The Department of Agriculture is giving this matter attention, and they, or other chemists, shall probably succeed in making this sea food as palatable and popular as Tuna fish, which for a long time was absolutely ignored. It was a huge, slimy, soft, unattractive looking fish that was so repulsive in its natural state that no housewife or cook would buy it and prepare it for the table. Somebody found out that if it was properly heated the soft flesh coagulated into firm flesh of attractive appearance. When it was cut up into small portions and canned, it became very popular, and millions of cases of this fish are now consumed.

It is not necessary to point out specifically a lot of things that lie waiting for chemists to do in the food industry and allied industries, because specific definitions tend to paralyze the imagination, and it is much better for individuals to hammer out their work along their own lines than to assign them definite and limited tasks.

It is of course proper to tell the American public that it should not neglect its chemists, and that if it will give the chemists a chance they will show how to save waste, reduce costs, and make life more comfortable and easy. This is one end of the problem, the other end being the chemist himself. He has to go out and dig up things for himself to do, and then act as salesman and sell himself to do them. After all, is that not fair, provided the chemist is fully warned and told by his teachers that that is what the game is, and that is the way he shall have to play it?

The canning field is broadening every day, and inviting some men of technical training to its assistance. Many other technical men should invite themselves because the work is there, and the results are to be obtained, and the public is waiting for the results.

AMERICAN CAN COMPANY
120 BROADWAY
NEW YORK CITY

EDIBLE FATS, IN WAR AND LAW[1]

By DAVID WESSON

With our country starting to take an active part in the World War, the food question becomes of vital importance. It is estimated at the present time that the United States has 1,600,000 men in its Army and Navy. Great Britain has nearly 7,000,000 and France 3,000,000. Our country is only beginning to build the Army which will be needed before the war is over.

No matter how well our Army is equipped with artillery, ammunition, and other tools of warfare, it will not be able to do its work properly unless it is well fed. We might as well expect the Empire State Express to make schedule time running on slack coal as to expect our armies and those of our allies to achieve great victories on improper or insufficient food.

The great advances made in the science of nutrition during the last 25 years have given us means to measure the amount of food required for men doing various kinds of work. When Atwater was making his painstaking investigations it did not seem probable to any of us that the results obtained with the calorimeter bomb were going to help decide the battle of today. Atwater has shown that persons engaged in very active work require far more food than when doing ordinary work. Some of his figures are very instructive. Without going too much into detail, the following will prove interesting as showing the different requirements:

	CALORIES
Rowing Clubs in New England	3,955
Bicyclists in New York	5,005
Football Teams, Connecticut and California	6,500
Prussian Machinists	4,270
Swedish Mechanics	4,500
Farmers' Families, United States	3,415
Mechanics' Families, United States	3,335
Laborers' Families, large cities	2,925
Lawyers, Teachers, etc., United States	3,220
College Clubs, United States	3,580

Judging from the intensive training our men are receiving in the several camps, and the active work they will have to perform on the battlefield in the cold, damp European climate, it is quite evident they belong in the football class, and will need about 6,000 calories per day per man.

Atwater gives in his table the following make-up of the football players' diet:

	Actually Eaten	Digested
Protein	226	208
Fat	354	336
Carbohydrates	634	615
Fuel Value, calories	...	6500

The fat in this diet would furnish 2,536 calories, or 39 per cent of the total, while in weight it amounts to one-third of the food elements.

When we consider the enormous demands on the world supply of fats by the warring nations, and the terrible curtailments which have taken place in production, due to the decrease in fat-yielding animals, the shortage of crops and the difficulties in transportation, it can readily be seen that the edible fat problem is a vital one, not only for the proper supply of our armies and those of our allies, but for the workers at home who have to supply the armies with fighting materials, and last but not least, the large civilian population.

[1] Address presented before the New York Section of the American Chemical Society, November 9, 1917.

No attempt can be made to go into statistics, which had better be left in the hands of our able food administrator, Mr. Hoover. It is sufficient to say that the edible fat supply in this country is now being greatly augmented by the increased production of peanut oil, which largely offsets the decrease in cotton-oil production due to the relatively small crops of the last two years. The country is also importing large quantities of copra and cocoanut oils, which formerly went to Europe Soya beans and bean oil are also used in large quantities, but there is not enough to supply our needs here and those abroad, unless the strictest economy is enforced.

Attention need only be called in passing to the fact that large quantities of perfectly good edible oils are used in soapmaking and metal cutting, and also in mixing illuminating and signal oils. The use of edible oils should be rigidly controlled and substitutes prescribed for use in the arts, wherever possible. Waste should be cut down in the use of soap, which should be made of inedible materials to the greatest extent.

Where the housekeeper most feels the shortage of edible fat is in the high price of butter. Butter is high because it is scarce; substitutes, however, can be found to take its place, but because the manufacture and sale of them are so hampered by legal restrictions the public has but little opportunity to become acquainted with their merits.

You all remember the Bible story of how the children of Israel during the absence of Moses on Mount Sinai persuaded Aaron to make a golden calf, which they all fell down and worshiped, and when Moses came down with the ten commandments and saw what was happening he was so overcome with wrath that he broke all the commandments on the spot. Many of us engaged in the production of edible fat sympathize with Moses, because in the year 1886 our great American Congress, not to be outdone by the Israelites in worshiping a calf, deified the great American cow, and have been worshiping her ever since. I refer to the oleomargarine law which, with its amendments and regulations, covers over 90 pages of an octavo volume. It imposes a tax of $600 on every person who manufactures oleomargarine. It says expressly that any person who sells, vends, or furnishes oleomargarine for the use and consumption of others, except to his own family table without compensation, who shall add to or mix with such oleomargarine any artificial coloration that causes it to look like butter of any shade of yellow, shall also be held to be a manufacturer of oleomargarine within the meaning of the act.

Wholesale dealers are taxed $400 a year; retail dealers who sell less than 10 pounds at one time are taxed $6 a year. Anyone who manufactures oleomargarine without paying the tax is liable to a fine of not less than $1,000 nor more than $5,000, while wholesale dealers are subject to a fine of $500 to $2,000 and retailers from $50 to $500. The law provides for two kinds of oleomargarine: colored, paying a tax of 10 cents per pound; uncolored, paying 1/4 cent per pound. The law has worked out somewhat as follows

For the fiscal year ending June 30, 1917, the tax receipts on oleomargarine were $1,995,720, of which $792,838 came from special taxes on dealers and manufacturers in addition to those on the product.

The quantities made were:

Colored	6,327,000 lbs., paying 10 cents per lb.
Uncolored	228,066,000 lbs., paying 1/4 cent per lb.
TOTAL	234,393,000 lbs.

The year previous the consumption was 152,124,000 lbs. The figures show the increased demand in spite of restrictions

When the oleomargarine laws were passed in 1886 the only materials at the command of the manufacturers were oleo oil, neutral lard and imperfectly refined cottonseed oil, with small quantities of imported peanut and sesame oils.

At the present time, with improved refining methods, the whole field of vegetable oils is open to us, and several choice brands of vegetable oleomargarine are being made of cocoanut, peanut and other oils which are sold at about 30 cents per pound as against butter at 50 cents, and, except in the case of growing children, are every bit as satisfactory from a food standpoint as the more expensive products of the cow.

Under reasonable laws, the average consumption of oleomargarine in Great Britain is 8 lbs., against 17 lbs. of butter. Denmark, one of the greatest butter-making and consuming countries of the world, has an annual consumption of 43 lbs. of oleomargarine per inhabitant, Norway 33 1/2 lbs., and Holland 20 lbs. The United States consumed last year 2.34 lbs. of oleomargarine and 18 lbs. of butter per inhabitant.

While practically nearly all the oleomargarine in this country is sold uncolored, color is furnished with it and the consumer can color the material to suit his state.

Congress did so well with the oleomargarine law that in 1888 it tried to deify the hog in like manner by passing similar legislation against compound lard which, in those days, was a mixture of lard, oleostearine and cottonseed oil. Fortunately, the cottonseed oil product was able to present a better bill of health than the hog product and as a result the lard-compound industry grew.

Thanks to the chemist, a flavorless, odorless and almost colorless cotton oil was placed on the market in 1900, which, combined with oleostearine, made a lard substitute preferred by its users to the hog product.

Now with the hydrogenation process, lard substitutes, better than lard, are made without the use of any animal fat whatever. The lard supply of the country receives a much needed assistance, and the Southern farmer is obtaining about 8 times as much as he did for his cottonseed, at the time Congress tried to strangle the industry.

The oleomargarine law is not our only grievance against our statute books. About 1872, dairymen became very much concerned about the manufacture of cheese from skimmed milk and oleomargarine, which ten years later was superseded by the use of lard under patents issued in 1873 and 1881. The cheese was made by emulsifying skimmed milk with the melted fat, using two or three parts milk to one of fat, then treating the emulsion in the cheese factory in the usual way. Very good cheese was the result; it was not injurious to health, but it committed a sacrilege against the products of the sacred cow, whose high priests in Congress June 6, 1896, passed the filled cheese law promulgating regulations as onerous as those of the oleomargarine laws. Manufacturers are taxed $400 per annum; wholesale dealers $250; retailers $12, with fines and regulations galore, besides a tax of 1 cent a pound on the product. Naturally the industry languished, and though the bill was passed as a revenue measure, the last report of the Collector of Internal Revenue shows there is no longer any "filled" cheese made. If there was any good excuse for the passage of the bill at the time, there is none now. There is no reason why a compound cheese made from skimmed milk and carefully refined vegetable oils should not be perfectly wholesome as an article of diet, and with proper methods of manufacture be better than many of the cheeses now on the market. It would undoubtedly be better than skim-milk cheese, for example, which would not fall under the ban of the law.

When the war started I immediately set to look for available fat and protein. I knew the value of the various vegetable oils as food and realized that to utilize them to the best advantage they should be combined with protein. Such a combination spells cheese. One of the most concentrated forms of food, and skimmed milk at once suggested itself as the best available material. The first thing encountered in the

literature was the filled cheese law. This put a bar against experimenting on a suitable scale, otherwise I would have had some products here to-night. It will not, however, prevent us from contemplating some figures which in the present food crisis are worth considering.

The census of 1914 shows that the creamery production of butter in this country was 769,810,000 lbs., which would call for not much less than 20 times that much of skimmed milk and buttermilk, amounting in round numbers to say 15,400,000,000 lbs. of material containing about 3 per cent of casein, say. 460,000,000,000 lbs. If this were worked up into a standard cheese of 28 per cent casein and 36 per cent fat, it would produce 1,650,000,000 lbs. of cheese and require 594,000,000 lbs. of oil, equal to 1,485,000 bbls. This amount of cheese would furnish our present Army and Navy with 1,000 lbs. per man per year, or, if divided with the armies of Great Britain, France, England, and Italy, 13,000,000 men, each man would have 127 lbs. a year, or 0.35 lb. per day, furnishing 719 calories or about 12 per cent of his daily ration.

Even if only half the skimmed milk from the creameries could be worked up in this way, the figures are well worth considering.

When we think of the oleomargarine and filled cheese laws which allow any farmer working under unsanitary conditions to color the white butter from winter-fed cows and foist his product on the public as "golden June butter," and at the same time subject the makers and sellers of wholesome food products to more taxes, fines and restrictions than are imposed on whiskey dealers and saloon-keepers, we cannot help hoping that the day may soon come when the members of Congress will be guided by patriotism rather than politics and wipe these iniquitous laws from our statute books.

Southern Cotton Oil Company
25 Broad Street
New York City

CURRENT INDUSTRIAL NEWS

PERFUMERY FOR SIAM

Perfumery and cosmetics were imported into Siam during the year 1915–16 to the value of over $105,000, the United Kingdom being the chief supplier to the value of $30,000, followed by Japan with $26,000. Under this classification are included all kinds of perfumes and scented toilet waters, face powders, talc powders, tooth pastes and powders, shaving soaps and creams, cosmetics and lotions for the hair and face. American toilet requisites, according to the *Times Trade Supplement*, seem to be taking well on the market. The import duty on goods of this class is 3 per cent *ad valorem*.—A. McMillan.

DESULFURATION OF HYDROCARBONS

The removal of sulfur from petroleum is a problem of first importance and the following method adopted by La Fresnaye et Suchy and for which a patent has been taken, is of interest. The process hitherto adopted involving the use of ozone and sulfur dioxide is only effective up to a certain point.

According to a report in the *Chemical Trade Journal*, **61** (1917), 331, it has been found that the sulfur can be removed by a simple process of precipitation and without any decomposition, by treating the oils to be purified with a metallic compound under certain conditions after the addition of certain organic compounds, such as ether and phenol compounds, trioxybenzoic acid and trioxybenzole. The sulfur combines with the metal and may be removed by filtration. Suitable metallic compounds for this purpose are zinc carbonate, lead oxide and other compounds of the heavy metals having great affinity for sulfur. The amount of the metallic compound to be added depends, of course, on the percentage of sulfur in the oil, and it is advisable to use the metallic compound in excess.

One example of the process is as follows: 20 liters of oil having sulfur content of approximately 0.5 to 1 per cent are mixed with 300 cc. acetic ethyl ether in which are dissolved 5 to 7 g. trioxybenzoic acid or trioxybenzole. To this are added 50 to 70 g. lead carbonate or other suitable metallic compound, and the mixture heated to a few degrees above the boiling point using a reflux condenser or a closed vessel until a black precipitate is formed or until the liquid, at first turbid, becomes clear. If the end-point is too yellow, the liquid is ozonized to saturation and then washed with caustic soda until the pyrogallol is removed. An oil containing a high percentage of sulfur should be converted into a liquid oil by addition of ether and, if necessary, slightly heated before adding the metallic salts corresponding to the sulfur content. At the conclusion of the process the ether added is removed by distillation and the black residue is filtered off.—M.

LAMPBLACK MANUFACTURE

A process for the manufacture of lampblack from hydrocarbons is the subject of a recent German patent, says *Chemical Trade Journal*, **61** (1917), 348. According to this invention a vessel is charged with an inflammable mixture of gaseous hydrocarbons and oxygen under pressure, the bottom of the vessel containing a layer of liquid hydrocarbon in which a slow tension arc is set up between two electrodes and decomposes the liquid with the formation of lampblack, while at the same time the overlying mixture is ignited. A tension of 200 volts is generally used and must not in any case exceed 1,000 volts. By modifying the composition of the mixture, the decomposition can be retarded so as to prevent excessive pressure and temperature. As an example, a vessel with a capacity of 2 cm. is charged with $^2/_3$ gas and $^1/_3$ liquid hydrocarbon, the first-named constituent being acetylene, and the hydrocarbon consisting of high fractions from the distillate of brown coal tar or crude petroleum. In addition to lampblack, hydrogen, methane, carbon monoxide, ethylene and heavy hydrocarbons are produced, the carbon remaining in the liquid while the gases pass into the acetylene mixture. Air is blown into the vessel and decomposes the acetylene, the resulting hydrocarbons splitting up into carbon and hydrogen. As the liquid charge thickens from the deposited carbon, it is drawn off, filtered and returned with a fresh portion of charge. Such of the carbon as is not deposited passes off with the effluent vapors and is collected in a second vessel.—M.

BORIC ACID AND BORAX

In the September issue of *La Science et la Vie*, an interesting account is given of the utilization of the natural steam from the volcanic area of Tuscany and of the manufacture of boric acid and borax. The highly saturated steam issues from the ground often at fairly high pressures, but, for purposes of conversion, it is utilized for heating a series of tubes containing water, the steam pressure in these tubes being two atmospheres (30 lbs. per sq. in.). The steam drives low-pressure turbines which, in turn, are coupled to alternators. The steam and water of these "soffioni," as they are termed, contain quantities of boric acid which is concentrated in a special apparatus and gives a product of about 99 per cent purity. The acid, treated with sodium carbonate, gives borax, which is produced in the form of crystals and powder. Ammonium carbonate is also manufactured, the carbonic acid necessary for the process being also obtained from the "soffioni." Investigation is also being carried out on the radioactivity of the gases of the "soffioni" and on the separation of the helium which is found to be present.—M.

POWER FROM REFUSE

In a circular illustrating some of their standard types of refuse destructors, Messrs. Meldrums, Manchester, state that, although with small amounts of refuse up to, say 1 or 2 cwt. daily, it is not usually worth while to use the heat produced for raising steam, a water heater can be combined even with the smallest destructor where a need for hot water exists, while with the larger sizes burning a ton an hour or more it almost invariably pays to install a boiler for purposes of steam raising, power, or heating. A portion of the steam is advantageously employed in providing forced draught for the destructor, since, in this way, the burning capacity is increased at least 50 per cent for a given grate area. Several typical examples of the utilization of refuse are given. At a large tannery in the Midlands a destructor, placed in front of a Lancashire boiler and dealing with 150 tons of spent tan a week, provides the whole of the steam required for drying without any other fuel. By means of a three-grate plant in conjunction with a Babcock and Wilcox water-tube boiler, all the steam required for running a textile mill at Rochdale is generated from shoddy waste.—M.

MINERAL PRODUCTION IN CANADA

The following statistics of the mineral production in Canada during 1916 are taken from the report recently issued by the Canadian Department of Mines.

	1916		1915	
	Quantity	Value	Quantity	Value
Nickel	82,958,564 lbs.	$29,035,497	68,308,657 lbs.	$20,492,397
Lead	41,593,680 lbs.	3,540,870	46,316,450 lbs.	2,593,721
Asbestos (1 ton = 2000 lbs.)	136,016 tons	5,133,332	111,142 tons	3,553,166
Natural Gas (1000 ft. unit)	25,238,568	3,924,632	20,124,162	3,706,035
Pyrites	309,411 tons	1,084,019	286,038 tons	985,190
Gypsum	341,618 tons	730,831	474,815 tons	854,929
Salt	124,033 tons	668,627	119,900 tons	600,226
Petroleum	198,123 bbls.	392,284	215,464 bbls.	300,572
Zinc (from zinc ores)	23,515,030 lbs.	3,010,864	.....	.....

According to the report of the British Columbian Minister of Mines, the output of zinc from the smelter at Trail in 1915 was approximately 1,500,000 lbs. At the beginning of 1917 the output of the smelter was from 25 to 30 tons per day.—M.

COPPER AMALGAM AS METAL CEMENT

The Vienna metal cement, which is sometimes mentioned in description of apparatus, is a copper amalgam. The *Giesserei Zeitung* recommends the following method for the preparation of this cement:

A strip of zinc is placed in a solution of copper sulfate and the powdery copper which is precipitated is put into a mortar and kneaded with mercurous nitrate, mercury and water into a plastic paste; three parts copper are used to seven parts mercury. When metals are to be cemented with this amalgam which is brought into the market in small cylinders, the parts are polished and heated up. The amalgam is heated up also to 80 or 90° C. and the parts are pressed together. The amalgam, itself can be hammered, rolled and put under a die; it takes a good polish. Placed in boiling water it softens sufficiently to use it as a material for taking casts. It is rolled into a thin strip which is applied to the heated object; the replica obtained is afterwards backed with type metal.—M.

JUTE SACKS FOR ARGENTINA

It is estimated that the stocks of jute sacks available in the Argentine Republic for carrying this season's crop of wheat, oats, and linseed amount to 50,000,000, which are sufficient to contain 3,000,000 tons of grain. As, however, the total crop is expected to be more than double that amount, a further 50,000,000 sacks or containers of some description will be wanted.—M.

JAPAN PEPPERMINT CULTIVATION

We hear, says the *Monthly Trade Journal*, that steps will soon be taken at Hokkaido, where the chief peppermint cultivation of Japan is carried on, to systematize the cultivation of the planting and the manufacture of menthol. In the past the sun-drying process especially has left much to be desired and, while the peppermint in the shape of crude oil has so far been shipped to Yokohama and Kobe where it is distilled in the factories, it is now proposed to erect factories in the chief farming districts on a coöperative basis.

Peppermint oil derived from the residue of oil after being properly refined is finding every year a larger demand abroad. Before the war the largest customer of Japanese menthol crystal was Germany, while to-day America is taking at least 88 per cent of the total output. The average price has been between $1 and $1.50 per lb., while several factories at the end of 1916 sent circulars to their chief customers announcing that, owing to circumstances, prices were likely to go up during 1917. This did not happen owing to improved factory conditions. During 1916 about 525,000 lbs., valued at $1,031,250, were produced.—M.

NON-INFLAMMABLE PLASTIC MATERIAL

A recent French patent, says the *Chemical Trade Journal*, 61 (1917), 365, describes a new plastic material which is non-inflammable and inodorous. The material is produced by transforming gelatines, glues and such substances of animal origin by suitable chemical reagents giving them plastic and malleable properties which allow them to be used industrially in a manner similar to natural products.

The gelatine or glues are first melted in a water bath at a temperature of 90° C. A decoction of hop-flowers is then prepared and mixed with dilute oxalic acid or any dibasic acid of that series and the solution is added to the melted gelatines or glues in varying proportions according to the quality of the materials used. The addition of this solution causes the gelatine to become more supple and also causes the impurities to deposit at the bottom of the vessel. When the gelatines are liquefied, they are poured out in the form of thin sheets or sticks of the desired thickness and left to dry in the cold air.

The coloring of the material is then proceeded with, natural or artificial dyes being employed. The sheets, when colored, are plunged into a bath of approximately the following composition: 25 to 35 per cent formaldehyde, 25 to 35 per cent water, 25 to 35 per cent alcohol and the rest composed of oxalic acid, tannin and glycerine. The oxalic acid may be replaced by any acid of that series. In the case of rich gelatines, a larger percentage of alcohol is used.

The substances may serve for the manufacture of combs, buttons, etc., and as imitation of tortoise, horn amber or ivory and is unlike cellulose products in being absolutely non-inflammable and odorless.—M.

ELECTRIC LAMP TRADE IN JAPAN

Japan, says the *Electrician*, appears likely to be a serious competitor in the incandescent lamp trade. In 1916, the Japanese exports of incandescent lamps were valued at $335,000 and in the first four months of the current year at $440,000 or at the rate of $1,250,000 per year. These figures are to be compared with no exports and with exports of the value of $150,000 in the year prior to the war. The one difficulty the Japanese lamp manufacturers have had, was in the supply of filaments, practically all of which used to be imported. Now, however, only a small fraction of the filaments used are imported. Large factories have been constructed and the Japanese manufacturers are now in a position to supply their own requirements.—M.

IMITATION LEATHER FOR SWITZERLAND

Supplies of imitation leather on the Swiss market and the scarcity of real leather have produced an exceptional demand in that country. French manufacturers are supplying an acceptable quality with a waterproof lining of rubber but are not now in a position to give good deliveries. Their total output comes far short of Switzerland's present needs in imitation leather.

Some of the uses to which imitation leather is put are drivers' seats and upholstering of motor cars, upholstering of furniture, cabinets and in making school satchels, while heavier qualities are employed in book-binding.

Manufacturers are recommended to equip agents with the necessary catalogs, price-lists and samples. Light but strong packing material is essential, this being important on account of tariff treatment. Motor-car upholsterers ask for antique or Moorish designs. A favorable dimension is 36 ft. long by 4 ft. to 4 ft. 9 in. wide. The price paid per piece varies from $2 to $8. It is not thought likely that the Swiss boot manufacturers will as yet adopt artificial leather.—M.

NEW MAGNESIUM ALLOY

The new magnesium alloy which the *Chemische Fabrik Griesham Elektron* is introducing under the name of Elektron Light Metal seems to be a war substitute only likely to subsist under war conditions. It is described as a silvery white metal, density 1.8, which melts at 620° C., and will burn only in shape of thin foil. It resists the action of caustic alkalies which would attack aluminum, and is said to be sufficiently strong and otherwise suitable to serve in the place of aluminum, copper and brass, also as an electric conductor. It is, however, acknowledged that the alloy is corroded by dilute acids and oxidizes in the air, though not superficially.—M.

ELECTRO-STEEL WORKS IN GERMANY

During the past two years, says *Engineering*, **104** (1917), 469, ten electro-steel works of the Lindenberg type have been built and put into operation in Germany and Austria, their aggregate capacity being 125,000 tons annually. Another eleven works are in course of construction with an aggregate capacity of 220,000 tons per annum and they will be started in the course of the next few months.

The Lindenberg Steel Works of Remscheid-Hasten showed a surplus for last year of $606,261 against $337,081 for the previous year. The dividend is given as 25 per cent in addition to a bonus of 10 per cent.

The German Electro-Steel Company has raised its capital to $200,000 and a further increase of $400,000 is contemplated, the domicile of the company being removed from Berlin to Saxony.—M.

FATS AND OILS

According to a recent German patent, the greases recovered from technical processes dealing with such substances as wool, leather, faeces, etc., by extraction, mostly contain saponifiable and unsaponifiable matters which can be separated by a treatment based on the fact that the latter can be volatilized by the vapors of inert liquids. For example, crude sewage fat is first saponified as completely as possible by the treatment with an alkaline earth or a metallic oxide, and the dry, anhydrous mass of soap is subjected to the action of superheated steam in a suitable still at a temperature above 200° C. The unsaponifiable oil passes over with the steam, leaving behind in the still a soap which, when decomposed with acid, yields fatty acids free from unsaponifiable fats and oils. The steam may be replaced by highly heated vapors of benzine, carbon tetrachloride, etc.—M.

NEW BRITISH DYE

The announcement has been made by the British Dyes, Ltd., Huddersfield, that they are now placing on the market two brands of a yellow vat dyestuff of the anthracene series under the name of chloranthrene yellow D. & G. This yellow, it is said, will be of great value to the textile trade as a self-color on account of its fastness to light, milling, washing and bleaching. It may also be used with great advantage in conjunction with chloranthrene blue for the production of various shades of fast green on vegetable fibers. The investigation of other dyes of the same class is being pursued successfully and these will shortly be available to the dyeing industry.—M.

WATER-PROOF GOODS FOR SOUTH AMERICA

Fully 70 per cent of the water-proof goods imported into Argentina are of British origin, but in some of the other states, such as Chile, Colombia and Venezuela, the last few years have witnessed a not inconsiderable increase of German and French made goods of this description. This market, says the *Times Trade Supplement*, is well worth attention and now that the competition from Germany is, for the moment, out of the way, it seems an opportune time for manufacturers to press their wares. The duty payable on water-proof coats—*ponchos*—large square-shaped sheets of water-proofed material provided with a hole in the centre for the reception of the head, with neck capes, etc., for men and women, is 42 per cent upon an arbitrary value of $6, and one-half of that rate for children's garments. The growth of the import trade has been notable, since in five years it has doubled itself. Thus, in 1909, the number of water-proof articles did not exceed 12,179, worth $70,377; while, by the end of 1913, the total was 24,328 articles valued at $137,313. Of these, the United Kingdom provided 70 per cent, Germany 10 per cent and France 15 per cent. Only the cheapest grades are manufactured locally. Silky materials are not much in demand, as the heavy rains of the country usually penetrate any but the thickest materials. Those with a proportion of wool are sometimes asked for.—M.

JAPANESE GLYCERINE

The British Commercial Attaché at Yokohama reports that the manufacture of glycerine was first commenced in Japan in 1916, when new plants were established by Government subsidies. The output of glycerine from these works is increasing, but is not sufficient for home demands, and refined glycerine is still imported from the United States. One Japanese company produces 70 tons glycerine monthly. The imports of glycerine to Japan in 1916 were 800,830 Kin (1 Kin = $1^1/_3$ lb.), compared with 1,712,912 Kin in 1914 and 1,430,922 Kin in 1913. Until recently Japanese fish oil was used as the basis for the manufacture of glycerine, but, with the expansion of the industry, animal fat from Australia and cocoanut oil from the South Seas are being used. The use of bean oil for this purpose is also under investigation, but the stability of the product for use as a constituent of dynamite has not yet been determined.—M.

WATER-PROOF AND DUST-PROOF FABRICS

The skin which forms on the surface of some oil paints and varnishes is practically air-tight. *Engineering*, **104** (1917), 340, quoting from a German contemporary, says that such a skin, which seems to be water-proof and dust-proof, can be formed on sacks of jute and on bags of cardboard, etc., for the transport of lime, chalk, cement and dextrine as well as for packing greasy and oily materials. The process is described as the Plüss-Stauffer process, but there are no further particulars. It is merely stated that the skin is pressed upon the material, which need not be a texture, by special machinery.—M.

RECOVERY OF PLATINUM METALS FROM CANADIAN NICKEL

The Report of the Royal Ontario Commission on Nickel, issued recently, states that although the presence of gold and silver and of metals of the platinum group in practically all nickeliferous pyrrhotites has long been known, their importance in connection with the Ontario nickel industry is not recognized except by those who recover and sell them. The nickel-copper ores of Sudbury are said to be capable of producing more palladium than the whole of the present world supply together with a large proportion of platinum, iridium and other metals of this group. The quantity of palladium present is much in excess of the platinum, but iridium, rhodium, ruthenium and osmium are also found. Although it is not possible to state exactly the actual quantity of the platinum metals present in the ores, the quantity recovered can be ascertained from the assay of the matte, provided the number of tons of ore smelted per ton of matte is known. In the year ending Dec. 31, 1916, the total ore smelted at Sudbury amounted to 1,521,689 tons with a production of 80,010 tons of matte. One company, which produced 63,567 tons of the total given above, states that the average content of precious metals per ton of matte for the three years ending 1915 was as follows: Gold, 0.050 oz. troy; silver, 1.75 oz. troy; platinum, 0.10 oz. troy; palladium, 0.15 oz. The report also discusses the advisability of utilizing the large quantity of sulfur at present expelled as sulfurous anhydride (SO_2) in roasting, it being estimated at not less than 300,000 tons of sulfur which would produce 1,000,000 tons sulfuric acid.—M.

GUTTA-PERCHA FROM THE SHEA BUTTER TREE

A supplement to the official *Nigeria Gazette* for August publishes a note to the effect that a trade in what is known locally as gutta-percha—a substance prepared from the latex of the Shea butter tree—has sprung up during the last two years in the Province of Bornu. The local price of the product at Nafada is 8 cents per lb. The method of collecting and preparing the product is given as follows: Small pieces of the bark are chipped out of the tree with a narrow native axe. The latex that slowly exudes from these cuts is scraped off as it contains impurities such as dirt, bark, etc. It is then boiled until the impurities float to the top when they are removed. The latex then coagulates and, in this form, is known as gutta-percha. It is not advisable to tap trees of less girth than 30 inches. The Shea butter tree is abundant in many parts of the Northern Provinces, and especially so in Meko, Shaki and Oyo districts of the Southern Provinces and in Ilorin. When collecting this product, the tappers could with advantage collect the Shea nuts and thus help to stimulate the trade in Shea butter.—M.

BRITISH PAPER EXPORTS

Since the war started, the export trade in paper from Britain has been seriously affected. The total quantity exported last year amounted to 2,556,621 cwt., a decline of 198,063 cwt. compared with 1915, 567,685 cwt. compared with 1914, 942,293 cwt. compared with 1913, and 772,840 cwt. compared with 1912. Of the year's total 72.70 per cent represented the shipments to British Possessions, and 27.3 per cent to foreign countries. Taking the figures for 1912, the trade with British Possessions represented 70.7 per cent of the total exports and that with foreign countries 29.3 per cent. Of course, some markets have suffered more than others in regard to reduced supplies, e. g., a substantial shrinkage in shipments to India is shown, while the position of S. Africa and Australia appears to be favorable. France received more paper from Britain last year than in the pre-war period.—M.

LOW-GRADE ORE UTILIZATION

According to a report in *Stahl und Eisen* of July, 1917, we see that the war, the stopping of imports and the rise in prices have forced German metallurgists to make use of raw materials which were considered too poor in peace times. In several cases, sufficient success has been obtained by new methods to justify the working of low-grade ores even in normal times. Thus copper schists were hardly utilized when they contained only 2.5 per cent copper. Now ores of 1 per cent and even 0.7 per cent find utilization. As regards iron and steel, there has not been much change, but poor pyrites and phosphatic ores are no longer rejected. The vanadium for steel is found in sufficient bulk in slags which do not contain more than 0.7 per cent vanadium; the wolframite of old waste heaps is a raw material for tungsten; chrome ore of 24 per cent is welcome—half the percentage formerly deemed worth mining—and sources of nickel are worked if they contain 1.5 per cent of nickel; bauxite of 40 per cent aluminum is considered sufficiently rich. It is also stated that the aluminum can, after all, be got out of clay. There is no change as to arsenic and antimony. Sulfur, no longer obtainable as such, is gained from gypsum and anhydrite and phosphates of 20 per cent are converted into manure.—M.

SWEDISH INDUSTRIAL DEVELOPMENTS

The Helsungborg Copper Works, among other extensions, are about to begin the manufacture of electrolytic copper on a large scale. Detailed plans have been prepared and the work will be proceeded with as fast as the necessary raw materials can be obtained. One of the most important departures is the formation of a large chemical company with plenty of capital and excellent men at its back, in addition to which a large number of chemical engineers have been connected with the undertaking which will boast the largest laboratory in Sweden. The program is a very comprehensive one and is based not only upon home consumption but also to some degree at least upon exports. So far the preliminary labors have principally been confined to dyestuffs of which Sweden formerly imported 1,000 tons from Germany. Benzole is the principal raw material; but this, as well as most of the chemical substances required, can be produced within the country, as is also the case with most of the plants. The work is intended to commence in 1918.—M.

BRITISH BOARD OF TRADE

During the month of October, the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which might be able to give information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

CHEMICALS:
- Arsenious oxide, pure, snow-white
- Carbonate of lime, granulated
- Carbonate of sodium
- Sulfate of sodium
- Vanadate of lead or mottramite
- Borate of magnesium
- Tartaric acid substitute

Bone pitch (2 tons)
Composition fittings for glass syringes
Composition with shellac base for gramophone records
Davy thermometers
Ebony goods, toilet brushes, trays, mirrors
Hair-slides, metal fittings for
Jettoline asphaltum
Lawyers' bodkins and paper pierrers
Leather, suede

M[illegible] PLANT FOR:
- [illegible] in, for cutting paper for dice cups
- [illegible] wire articles such
- [illegible] wool cones
- [illegible] for making small
- [illegible] wood for mending fish-ne[illegible]
- [illegible] ointment
- [illegible] ding papers for
- [illegible] ts of synthetic [illegible]erial
- [illegible]e saponified, solid
- [illegible]ap, silt carded
- [illegible] briar, plated
- [illegible]ap, for West

—M.

SCIENTIFIC SOCIETIES

DECENNIAL INDEX PATRONS

In order to print the Decennial Index to *Chemical Abstracts* it became necessary to ask the friends of the American Chemical Society among the chemical corporations to assist in the work of donating $10,000 toward the fund required. This was done after $25,000 had been subscribed by members of the Society and others directly interested in purchasing the publication. The donations were asked for first through the local sections. The Philadelphia Section secured donations in the amount of $1,510.00; the Indiana Section, $50.00; the Pittsburgh Section, $50.00; the Detroit Section, $25.00; and the New York Section, $25.00, from local firms. A general request was then sent from the Secretary's office to the chemical industries of the country, asking for help on this important publication. The response was immediate. The Society desires to acknowledge with thanks the help of its friends listed below:

Alberene Stone Company	$ 10.00
Aluminum Castings Company	50.00
Aluminum Company of America	100.00
American Can Company	150.00
American Cotton Oil Company	50.00
American Glyco Metal Company	25.00
American High Explosives Company	25.00
American Smelting & Refining Company	250.00
American Zinc Lead & Smelting Company	100.00
Anaconda Copper Mining Company	250.00
Arlington Mills	100.00
Atlantic Refining Company	50.00
Ault & Wiborg Company	100.00
Badger & Sons, E. B.	100.00
Baker & Company, Incorporated	100.00
Barrett Company, The	250.00
Bausch & Lomb Optical Company	100.00
Berlin Mills Company	100.00
Buffalo Foundry & Machine Company	100.00
Butterworth Judson Corporation	50.00
Castner Electrolytic Alkali Company	25.00
Celluloid Zapon Company	25.00
Columbia Chemical Company	25.00
Commonwealth Edison Company	100.00
Detroit Testing Laboratory	10.00
Devine Company, J. P.	100.00
Digestive Ferments Company	5.00
Dow Chemical Company	50.00
Du Pont de Nemours Company, E. I.	1,000.00
Duriron Castings Company	25.00
Eastern Manufacturing Company	100.00
Eastman Kodak Company	50.00
Edison, Thos. A., Inc	100.00
Eimer & Amend	100.00
Elyria Enameled Products Company	50.00
Fels & Company	25.00
Fisk Rubber Company	100.00
General Bakelite Company	100.00
General Chemical Company	500.00
General Electric Company	250.00
Grasselli Chemical Company	50.00
Harshaw Fuller-Goodwin Company	100.00
Heinz Company, H. J.	100.00
Heyden Chemical Works	250.00
Hurlburt, E. B.	25.00
Interocean Oil Company	25.00
Jeffery-Dewitt Company	25.00
Knight, Maurice A.	100.00
Lennig Company, Charles	25.00
Lilly & Company, Eli	50.00
Lindsay Light Company	100.00
Mallinckrodt Chemical Works	50.00
Marden, Orth & Hastings	25.00
Mathieson Alkali Works	250.00
McElwain Company, W. H.	100.00
Merck & Company	250.00
Monsanto Chemical Works	50.00
Morgan & Wright	25.00
National Aniline & Chemical Company	200.00
National Carbon Company	70.00
National Lamp Works of the General Electric Company	50.00
National Lead Company	100.00
Niagara Alkali Company	50.00
Norton Company	100.00
Oakland Chemical Company	50.00
Pacific Coast Borax Company	100.00
Pennsylvania Rubber Company	50.00
Pennsylvania Salt Company	100.00
Plaudler Company	25.00
Philadelphia Quartz Company	15.00
Pittsburgh Plate Glass Company	100.00
Powers-Weightman-Rosengarten Company	50.00
Primos Chemical Company	25.00
Procter & Gamble Company, The	250.00
Raymond Bros. Impact Pulverizer Company	25.00
Republic Chemical Company, Inc	25.00
Roessler & Hasslacher Chemical Company	100.00
Rohm & Haas	25.00
Rome Soap Manufacturing Company	25.00
Rosenwald, Julius	100.00
Sargent & Company, E. H.	100.00
Schaar & Company	10.00
Schoellkopf, J. F.	200.00
Scoville Manufacturing Company	100.00
Sellner, Albert	5.00
Smith, Kline & French Company	20.00
Sowers Manufacturing Company	25.00
Sprague, Warner & Company	25.00
Squibb & Sons, E. R.	50.00
Standard Oil Company of New Jersey	250.00
Swenson Evaporator Company	25.00
Textor, Oscar	5.00
Thomas, Arthur H., Company	100.00
Thorkildsen Mather Company	100.00
Toch Brothers	25.00
Union Oil Company of California	100.00
Union Sulfur Company	100.00
United Engineering & Foundry Company	25.00
United States Smelting & Refining Company	100.00
Victor Talking Machine Company	100.00
Virginia-Carolina Chemical Company	100.00
Washington Steel & Ordnance Company	100.00
Weston, Edward	100.00
Whitall Tatum Company	100.00
Anonymous	100.00

TENTH ANNUAL MEETING
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
ST. LOUIS, MO., DECEMBER 5–8, 1917

The tenth annual meeting of the American Institute of Chemical Engineers was called to order at Hotel Statler, St. Louis, at 9.45 A.M., by President G. W. Thompson. As the local section of the American Chemical Society participated in the meeting, the Chairman of the Section, Mr. A. C. Boylston, assisted President Thompson in conducting this and other sessions of the meeting.

The address of welcome was delivered by Mr. Wm. T. Findly, representing Hon. Henry W. Kiel, Mayor of St. Louis. President Thompson responded to the address of welcome.

The ballots for officers were canvassed by a committee consisting of F. E. Dodge, R. S. Bicknell and S. F. Grove. The following officers were elected: G. W. Thompson, *President*, J. C. Olsen, *Secretary*, F. W. Frerichs, *Treasurer*, M. Toch, *Auditor*, and A. W. Smith, T. B. Wagner, D. Wesson, *Directors*.

The Council reported the appointment of a committee to consider the advisability of appointing a representative of the Institute on the joint committee of the Engineering Societies in coöperation with the United States Government in its war activities. The committee consists of: G. W. Thompson, *Chairman*, Chas. F. McKenna, M. H. Ittner, J. C. Olsen.

The Council has also authorized the purchase of $750.00 of Bonds of the second U. S. Liberty Loan.

The membership of the Institute at present is 283, consisting of 1 honorary member, 241 active and 41 junior members. The membership during the past six months has been increased by 12 active and 3 junior members. During the past year the increase has been 28 active and 5 junior members, making a net increase of 33 members, which is a larger increase than during any previous year.

The Secretary reported that six members had received commissions in the United States Government service as follows:

Edward Bartow, Major in Sanitary Corps in National Army.

Hardee Chambliss, Major, Ordnance Sec., Officers' Reserve Corps.

A. R. Chandler, Captain, Ordnance Dept., U. S. R., Rock Island Arsenal, Rock Island, Ill.

A. S. Cushman, Major, Ordnance Dept., U. S. R., Frankford Arsenal.

R. M. Gage, First Lieutenant, Sanitary Corps, U. S. Army.

A. H. White, Captain, Ordnance Dept., U. S. R.

The Treasurer reported a balance on hand of $1616.00.

The Committee on Meetings reported the following localities under consideration for the summer meeting to be held the latter part of June: Chicago, Ill., Syracuse, N. Y., Providence, R. I., and Newark, N. J. After some discussion the matter was referred to the Council for decision.

The first paper on the program was "The Relation between Efficiency of Refrigerating Plants and the Purity of Their Ammonia Charge," by Dr. F. W. Frerichs of St. Louis. In a preliminary statement Dr. Frerichs stated that a large amount of ammonium nitrate is required for the manufacture of explosives and that most of the ammonia obtained from the by-product coke-oven plants is in the form of ammonium sulfate.

There is only one plant in the United States, *viz.*, that of Herf and Frerichs in St. Louis in which aqua ammonia can be made from ammonium sulfate, and this plant is engaged in producing liquid ammonia for the refrigerating industry. Upon request of the Food Administration of the United States, the capacity of this plant is being increased 50 per cent in order to secure an ample supply of liquid ammonia for the cold-storage warehouses and the ice plants so as to conserve the food supply.

In order to obtain an adequate supply of aqua ammonia for the manufacture of ammonium nitrate, in the manufacture of explosives, Dr. Frerichs has been requested by the United States Government to erect eight new plants, the size of the St. Louis plant, at various points. Dr. Frerichs has generously offered the Government complete plans and specifications and the use of his patents for the duration of the war, the plants to be dismantled at the close of the war. In the paper presented, the results of tests made by the Bureau of Standards were given which showed that the ammonia made by Dr. Frerichs contained only one-thousandth of one per cent of organic impurities and that other samples of commercial liquid ammonia contained as high as 450 thousandths of one per cent of such impurities. Impurities of this kind produce permanent gases in ice machines which greatly reduce the efficiency of the process. This was shown in a practical test with two identical ice machines. With pure ammonia 57 tons of ice were made while with impure ammonia only 42–44 tons were made daily. During the entire test period 16,862 tons of ice were made in the first machine, while only 11,308 tons were made in the second. A very much greater amount of the impure ammonia was required so that the cost of ammonia per ton of ice using pure ammonia was only 1.27 cents per ton while the cost was 15.16 cents with impure ammonia. The coal consumption was one ton for eight tons of ice with pure ammonia, and only $5^1/_2$ tons of ice per ton of coal with impure ammonia.

Serious leaks due to corrosion were observed in the machine using impure ammonia, while there was no trouble of this kind in the machine using pure ammonia.

A paper by Wm. M. Booth of Syracuse, N. Y., on "Distilled Water" was then read. The author presented the results of many analyses of distilled water, rain and snow water, and also the requirements for purity in various industries. This was supplemented by a large number of letters from users and producers of distilled water. Various types of apparatus for the production of distilled water were then presented.

Wednesday afternoon members of the Institute and St. Louis Section of the American Chemical Society went by automobile to the very large ice plant of the Anheuser-Busch Brewing Association. This plant has a capacity of 1200 tons of ice per day and is the largest plant of its kind in the world.

The party then proceeded to the plant of the Herf and Frerichs Chemical Works. Construction work was here going on both on the extension of the ammonium sulfate plant and on a new plant designed to use ammonia liquors from gas works. Large circular reinforced concrete tanks were being constructed for the storage of ammonia gas liquors. To prevent leakage these tanks were placed within a larger rectangular concrete tank which is kept full of water.

The liquid anhydrous ammonia was being produced from ammonium sulfate. This salt is treated with lime and the gaseous ammonia absorbed in water. From this it is distilled, dried by lime and compressed to 250 lbs. The gas is washed by means of liquid ammonia, then cooled and charged into steel cylinders. The purity of the liquid ammonia is assured by testing a sample drawn from each cylinder.

The party then visited the By-Product Coking Plant of the Laclede Gas Light Company. The rich portion of the gas from the coke ovens is sold as illuminating gas, while the leaner portion is used for heating the by-product coke ovens. The illuminating gas for St. Louis is sold on the B. t. u. standard of 650 per 1000 cu. ft.

The gas is first cooled which removes the tar and about one-fifth of the ammonia, the remainder being absorbed in dilute sulfuric acid. The gas is then passed through a tower containing paraffine oil which removes the benzene and toluene. The light oil is distilled out of the paraffine oil which is used again for scrubbing the gas.

The party was very much interested in inspecting the stills in which the light oil is fractionated to separate the benzene from the toluene.

On Wednesday evening the members of the Institute and of the local section of the American Chemical Society took dinner at the St. Louis Club as the guests of Dr. F. W. Frerichs. The very handsome club house was much admired. The dinner was held in the spacious dining-room on the second floor, which was beautifully decorated with flags. Covers were spread for about eighty. After dinner, Dr. Frerichs gave a cordial welcome to his guests in a few well-chosen remarks. President Thompson and Mr. A. C. Boylston, chairman of the local section of the American Chemical Society, responded

President Thompson then delivered an address on "Our Resources." Attention was called to not only the natural products in which the United States abounds but also to deficiencies, and suggestions were made as to measures which should be taken to render the United States independent of foreign sources of supply. The achievements of the American chemists during the war period were especially emphasized with reference to platinum supplies. President Thompson suggested that there were large quantities of platinum in the form of jewelry which should be made available for the war needs of our country.

The Secretary, Dr. J. C. Olsen, expressed the appreciation of the members of the Institute and of the American Chemical Society for the very delightful dinner which had been provided by Dr. Frerichs, affording such an opportunity for making the acquaintance of the local chemists; of Dr. Frerichs' courtesy in showing his ammonia plant, at which the purest ammonia made in the United States is manufactured; and of the patriotism of Dr. Frerichs, who, although born and educated in Germany, offered his services so freely to the Government. Vigorous applause indicated hearty endorsement of the sentiments expressed.

Mr. O. F. Soule, of the Merrill-Soule Co. of Syracuse, then explained briefly the process of evaporating milk by atomizing it under high pressure into a chamber, through which a current of warm air was passing. The entire process was illustrated by moving pictures. Samples were shown of evaporated skimmed milk, and also evaporated cream containing 74 per cent of butter fat. The remainder of the evening was spent in getting acquainted, the occasion being voted by all as a highly enjoyable one.

Thursday morning the party proceeded by automobile from Hotel Statler to the City Water Works. Mr. E. E. Wall, water commissioner of the City of St. Louis, explained the history of the development of water purification in St. Louis and gave an outline of the process employed for purifying water. This consists of pumping the water through a settling chamber where about 25 per cent of the solids, consisting mostly of sand, settles out. The water is then treated with lime which reduces the hardness from over 300 to slightly over 100 parts per million.

Sulfate of iron is then added which produces flocks of hydrate of iron which remove the finely suspended impurities. A charge of aluminum sulfate is also given to remove coloring matter. The water is then pumped into large settling basins where most of the sludge settles out. The remainder of the suspended matter is removed by filtering through sand filters, after which the water is treated with liquid chlorine to remove the remainder of the bacteria.

The party then inspected the plant. The washing of one of the sand filters was watched with the greatest of interest. The automatic devices for adding the lime, ferrous sulfate and aluminum sulfate were carefully examined. The lime is added as milk of lime, the ferrous sulfate automatically fed in powdered form, while the aluminum sulfate is added as a solution of standard strength. The excellent condition of the entire plant and its simple operation were greatly admired.

The party was then taken to the Riverside Club where luncheon was served in the spacious and beautifully decorated dancing pavilion of the Club.

After luncheon the party drove to Granite City where the plant of the National Enameling & Stamping Company was visited. Here the production of the enamel, grinding and dipping of the enamel ware were shown, as well as the furnaces in which the material is baked. The stamping machines were also inspected with great interest, as well as the electric welding of handles and other parts of the enamel ware.

On Thursday evening, a joint meeting with the local section was held at Hotel Statler. A paper by Gaston Du Bois of the local section on "Engineering and Chemical Works" was first read. Dr. Du Bois called attention to the deficiency of many chemists in knowledge of engineering problems met with in the construction or operation of chemical works, and pointed out the deficiency of the preparatory education of many chemists in this respect. A very lively discussion followed the paper as to the amount of chemical engineering training which should be given in the schools and the amount which could only be learned by experience in the chemical industry.

A paper on "Organization of Chemical Companies" was read by Mr. Frank Hemingway. The author showed that the lack of coöperation between the business interests and the technical staff of corporations lead to lack of efficiency and in many cases to failure of companies which otherwise had every prospect for success.

On Friday morning the members and their guests left the Hotel Statler by automobile for the plant of the Commercial Acid Company. At this plant the sulfuric acid chambers were inspected. Louisiana sulfur was used as the raw material. The capacity of the chamber plant was 240 tons of 66 Bé. acid. The nitric acid plant was then inspected, special interest being shown in the horizontal cast iron retorts and in the sewer pipe condensers. The manufacture of hydrochloric acid was then shown, shallow iron pans being used for the salt and acid. The phenol plant was also inspected. In this plant benzene is treated with sulfuric acid. The resulting product is neutralized with lime and sodium carbonate and is then added to fused caustic soda. After neutralization, the phenol is distilled off into iron drums.

Some of the members then visited the plant of the Laclede Christy Fire Clay Company.

During the forenoon, three papers were read on the general subject of Evaporation and Drying. Mr. Hugh K. Moore, of Berlin Mills, N. H., read the first paper on "Some General Aspects of Evaporation and Drying." Mr. Moore gave an outline of all methods of evaporation and drying which are possible or available, and he gave the conditions under which each method could be used to advantage. He discussed at greater length heat conductivity phenomena in evaporator tubes and more particularly forward and backward flow in multiple effect evaporation, and showed the great advantages to be derived from backward flow operation. This phase of his paper was discussed at considerable length.

Mr. F. M. deBeers read the paper on "Some Problems in Evaporation and Drying" presented by Mr. P. B. Sadtler and F. M. deBeers. Mr. deBeers presented the practical difficulties which are met with in designing evaporators and especially methods of overcoming such difficultieswhen very viscous liquids must be evaporated.

Mr. H. McCormack, of Chicago, read a paper on "Evaporation and Drying of Tannin Extracts by the Carden Process." In this process the tannin extract is atomized and the spray evaporated by a stream of warm air. The product produced is superior in every respect to the extract produced by other methods of evaporation.

Friday evening the subscription dinner was held at Hotel Statler. The attendance of sixty-three was about equally divided between members of the Institute and of the American Chemical Society. Music was furnished by Mr. F. W. Saltan, violinist and Miss Elsa Diemer soloist accompanied by Miss Mina Neaman.

President Thompson acted as toastmaster and presented Alex. S. Landsdorf, Professor of Electrical Engineering and Dean of the School of Engineering of Washington University. Professor Landsdorf described the work carried on by the University and exhibited a considerable number of lantern slides showing the buildings, grounds and laboratories of the University.

Dr. B. M. Duggar of Shaws Garden explained the founding of this remarkable botanical collection, and the work which is being done at present at the Garden.

Secretary Olsen gave a toast to the ladies, and pointed out that the attendance of the ladies at this meeting was the largest in the history of the organization and that much of the pleasure at the meeting was due to their presence.

Dr. Chas. E. Caspari, of the St. Louis College of Pharmacy, was introduced as the recently elected Chairman of the local section of the American Chemical Society, and spoke of the work being carried on by this section, and also of his high opinion of the influence of the American Institute of Chemical Engineers on the chemical profession.

On Saturday, the plant of the National Lead Company at Collinsville, Mo., was visited, the mechanical furnace being of special interest to those who made the trip.

A special program had been arranged by the local Ladies' Committee under the chairmanship of Mrs. A. A. L. Veillon for the entertainment of the visiting ladies. This program included on Wednesday a luncheon with members of the Institute at Hotel Statler; a sight-seeing trip of St. Louis by automobile; a dinner at the Hotel in the evening, followed by a theatre party. On Thursday the ladies accompanied the men during the visit and inspection of the City Water Works as well as at the complimentary luncheon at the Riverside Club. During the afternoon the ladies were entertained at tea by Mrs. Queeny at her residence, 3453 Hawthorne Boulevard. On Thursday evening the ladies attended a theatre party at the Jefferson Theatre. On Friday morning Mrs. Veillon gave a musicale at her residence, 4222 Flora Boulevard. During the afternoon, Shaws Garden was visited, and in the evening the subscription banquet was attended.

Although a considerable number of members could not attend the meeting on account of urgent war duties, the usual number were present at most of the meetings and functions, the attendance ranging from 50 to 100.

The St. Louis members proved to be very royal hosts, and the members of the Institute were interested to find so many important chemical industries in this locality.

Cooper Union
December 15, 1917

J. C. Olsen, *Secretary*

AMERICAN CHEMICAL SOCIETY PIN

Arrangements have been made for obtaining the Society pin at a cheaper price, one of 14 kt. gold of the same quality as the one now used, and one in rolled-gold which will have the same appearance, but will be cheaper. The pin will have a safety catch and will be of such length that the wearers will not be subject to being scratched. Members will please note the following:

1—The pins are ready for delivery.

2—The solid 14 kt. pin will be carried in stock at $3.00, plus 3 per cent war tax—total, $3.09.

3—The rolled gold pin will be carried in stock at $1.00 plus 3 per cent war tax—total, $1.03.

4—To obtain pins members must be in good standing and obtain an order from the Secretary of the Society, to whom no money should be sent.

5—Orders obtained from the Secretary should be sent or delivered to the C. G. Braxmar Company, 10 Maiden Lane, New York City, together with cash, check or money order in payment of the pin, whereupon the pin will be delivered post free.

The pin adopted by the Society is an unusually attractive emblem, and the Society's colors, cobalt-blue and gold, are now being worn by many of our members. It serves as a means of introduction and will frequently enable you to meet fellow chemists whom you might not otherwise know are in the same profession. It is important that the members of the American Chemical Society wear this insignia as regularly as the members of the engineering societies display their distinguishing emblem. Show that you are proud of your Society and its work. Write to the Secretary for an order. CHAS. L. PARSONS, *Secretary*

THE NICHOLS MEDAL AWARD

The Nichols Medal for 1917 will be conferred on Dr. Treat B. Johnson of the Sheffield Scientific School of Yale University.

The Medal, founded by Dr. William H. Nichols in 1902, is awarded annually by the New York Section of the American Chemical Society on the merit of the original communications published in the journals of the Society.

The formal presentation to Dr. Johnson will be made on March 8, 1918, in Rumford Hall, Chemists' Club, New York City.

THE PERKIN MEDAL AWARD

The Perkin Medal for 1918 has been awarded to Dr. Auguste J. Rossi, Ph.D., of Niagara Falls, N. Y., for his work on titanium.

The Medal will be presented by Dr. W. H. Nichols at the regular meeting of the New York Section of the Society of Chemical Industry to be held at the Chemists' Club, January 18, 1918. Mr. F. A. J. FitzGerald, past-president of the American Electrochemical Society, will deliver an address on Dr. Rossi and his work. Owing to illness, Dr. C. F. Chandler will not be able to participate in the program.

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

Centralization of activities pertaining to chemicals, the lack of which has been so glaringly apparent for many months, is now being accomplished by the formation of a chemical section of the Raw Materials Division of the War Industries Board. This board, which consists of L. L. Summers, M. F. Chase, C. H. MacDowell and M. T. Bogert, is acting as a clearing house for all matters of chemical interest related to the war. This applies to the purchases of the allied governments as well as to domestic matters having a bearing on chemical supplies.

The chemical specialists attached to the War Industries Board are making no effort to occupy the anomalous position of representing the government and the industry at the same time. That such a plan is not feasible was shown in the collapse of the coöperative committee section of the Council of National Defense. Out of this experience, however, has grown the plan for war service committees representing each industry. These committees will form the point of contact with the government and will be representative of nearly 100 separate industries. The war service committees now are being formed through the medium of the Chamber of Commerce of the United States. Every effort is being made to complete their organization, as the War Industries Board now is working at a considerable disadvantage through the lack of a unit organized to act for an industry.

The formation of a chemical section of the War Industries Board will in no way effect the research activities of the National Research Council. Dr. Bogert continues at the head of its Committee on Chemistry and will divide his time between his duties with that committee and with the War Industries Board. Mr. MacDowell severed his connection with Armour and Company, where he was in charge of fertilizers and other by-products, to aid the government. Mr. MacDowell refers to himself as a "layman" chemist. For many years he has specialized in potash. He was closely in touch with the development of the alunite deposits at Marysvale, Utah. Prior to the war, he made a careful study of the German potash deposits.

Organizations of various industries interested in commodities which require import licenses have been called upon by the War Trade Board to select committees to cooperate with it in securing an equitable distribution of certain imported commodities. These committees are given no authority in the granting or refusing of import licenses or in determining who shall import the commodities requiring licenses. The representatives of the industry are to act as consignees and will release commodities as instructed by the War Trade Board. The committee is to obtain from importers such guarantees and agreements as the War Trade Board may require. Each committee will keep itself informed as to the use and disposition of the imports and will keep full records of all the shipments received. A few of these committees have been announced already, but the majority of them are still to be selected. Two of the most important committees will be those which will coöperate with the War Trade Board in the importation of manganese ores and iron pyrites. Other imports of chemical interest which require license are antimony, asbestos, chrome, cobalt, all ferro-alloys, iridium, molybdenum, emery, sodium, potassium and calcium nitrates, platinum, scheelite, titanium, tungsten and vanadium.

Exports of sulfuric acid during 1917 will not fall as far behind those of 1916 as had been anticipated earlier in the year. An increase of more than 1,000,000 lbs. took place in the exports of October. November figures are not available but even a more substantial gain is known to have taken place during that month. According to the Department of Commerce, there were exported in October 4,492,200 lbs. of sulfuric acid, as compared with 3,466,818 lbs. in October of 1916. During the first ten months of 1917, 53,487,786 lbs. of sulfuric acid were sent out of the country. This compares with 57,386,036 lbs. for the first ten months of 1916. That such a good showing is being made this year with the tremendous increase of domestic requirements is a source of much favorable comment among chemists here.

Dr. C. L. Parsons, chief chemist of the Bureau of Mines, called together the chemical advisory committee of that bureau on December 17th and went carefully over the war work under his direction. Dr. Parsons, owing to the [illegible] amount of war work being done by the Bureau of Mines, has been forced to turn over to others the direction of the [illegible] being done on other chemical matters. Dr. Parsons has submitted his report on the method used in the oxidation of ammonia which was developed at the Semet Solvay [illegible], N. Y. This work was done under a [illegible] between the Semet Solvay Company and the [illegible].

An important and timely report on the sulfuric acid situation has been prepared by A. F. Wells [illegible] of Mines staff. Mr. Wells is working in close co[illegible] Parsons and M. F. Chase, of the War Industries [illegible] survey of the sulfuric acid situation.

Important developments in the manganese and pyrite situations, which will have a bearing [illegible] minerals, are expected within the very near future. [illegible] been reached where unusual steps must be taken to stimulate domestic produc-

tion of manganese, pyrite and other products. Precedents will be broken, in all probability, in the legislation which will be proposed to provide means to secure increased domestic production, so as to save shipping.

. . . . . .

Changes which will alter permanently conditions of international competition in the chemical industries and which will have a direct bearing on the volume of foreign trade in chemicals are to be the subjects of a special investigation just begun by the United States Tariff Commission. The developments that have taken place in the chemical industries since the passage of the tariff act in 1913 are to be studied closely. The scope of the inquiry is set forth by the Tariff Commission as follows:

1—The manufacture within the United States of articles formerly unavailable or obtained exclusively by importation; for example, phosgene.

2—In the case of industries previously established in the United States, the erection of new plants or increase in capacity of existing plants; for example, the increase in capacity of existing plants for making caustic soda and chlorine and the installation of such plants at textile and paper mills.

3—The future of industries or establishments newly created, or in which productive capacity has been greatly increased to meet a direct war demand. How can these plants be utilized when the war demand disappears? For example, the acetone industry.

4—Any general or significant differences in the prevailing method of manufacture in the United States and abroad, such as the relatively small use of the carbureted water-gas process in England compared to its use in the United States.

5—Differences in the organization of the industry in the United States and abroad.

6—The development or invention in the United States or abroad of new or improved processes which are likely to influence the conditions of international competition; for example, the hydrogenation of fatty oils or the flotation process for concentrating ores.

7—Significant changes in the conditions of international competition caused by the recent law-making patents owned by citizens of enemy countries available to American manufacturers; for example, the patents on salvarsan.

8—Industries which have been seriously hampered in their normal operations or in their development by difficulty in securing materials or supplies formerly imported; for example, the lack of potash for fertilizer or glass. If these difficulties have been met by the introduction of substitutes, is it expected that there will be a return to the old materials and methods when foreign supplies again become available, or will the changes be permanent?

9—Developments or changes in other industries which have created a new or greatly increased demand for chemical products; for example, the manufacture of new varieties of glass in the United States.

10—The discovery of new uses of materials, creating a new demand or furnishing a market for materials formerly wasted; for example, the use of aniline as an accelerator in the vulcanization of rubber.

11—Any governmental hindrances in the United States or abroad, either in manufacture or commerce; such as the export duty on nitrate from Chile.

The Commission will publish only general statements or summaries, which will not reveal the operation or plans of individual companies.

The Tariff Commission is preparing for a systematic census of the production of the following coal-tar products: intermediates, dyes, medicinals, flavors, photographic chemicals and synthetic phenolic resins.

Issuance of licenses for the manufacture and sale of salvarsan has been begun by the Federal Trade Commission. It is expected that the price per dose will be lowered to $1.50, as a result of this action.

. . . . . .

Without the necessity of roll call, the House of Representatives on December 15th passed a joint resolution "for the purpose of promoting efficiency, for the utilization of the resources and industries of the United States, for lessening the expenses of the war, and restoring the loss caused by the war by providing for the employment of a discovery or invention called the 'Garabed,' claiming to make possible the utilization of free energy." It required a special rule to get the matter before the House but the Committee on Rules promptly supplied this deficiency. Practically the entire day was taken up in the discussion of cosmic forces and other matters related to the device of Garabed T. K. Giragossian, interspersed with parliamentary wrangles and squabbles over amendments. Despite the fact that Mr. Giragossian refused to show his device or its operation to any member of the Committee on Patents or to any committee that would be appointed by the House, most of the members of that body were dissuaded from voting against the resolution by the idea expressed in this question put by Representative Garrett: "Why is it that gentlemen so much fear to ascertain whether we really have some new blessing for mankind?"

PERSONAL NOTES

Mr. R. S. Banks, instructor in analytical chemistry at Iowa State College, has been appointed a member of the Inspecting Department of the Picatinny Arsenal, Dover, New Jersey.

Mr. L. A. Rumsey, former instructor in organic chemistry at Iowa State College, has been appointed head of the department of chemistry at Denison University, Granville, Ohio.

Mr. A. J. Wuertz, former research chemist of the Experiment Station of the agricultural and biological department of the University of Minnesota, is at present instructor in organic chemistry at Iowa State College.

Mr. William H. Kerr, assistant treasurer of the General Chemical Company, and manager of the Philadelphia offices of the company, has been elected a director to succeed Mr. Edward H. Rising, deceased.

Mr. Frederick Pope, of Moses, Pope and Messer, Inc., consulting engineers of New York, has been commissioned a captain in the Engineer Officers' Reserve Corps, Gas and Flame Division (Thirtieth Engineers).

Mr. A. Gordon Spencer, formerly chief chemist of the Canadian Inspection and Testing Laboratories of Montreal, has severed his connection with that company and is opening an office at 617 Transportation Building, Montreal, Canada, as a consulting chemist and metallurgist.

The United States Bureau of Mines has broadened the scope of its station at Urbana, Ill., to include work in coal and metal mining and the metallurgical industries of the Middle West. The present safety work will be continued and all work will be conducted under a cooperative agreement with the mining department of the University of Illinois. The Bureau staff is under the superintendence of E. A. Holbrook, supervising mining engineer and metallurgist. Other members are W. B. Plank, in charge of mine safety, and F. K. Ovitz, chemist.

Mr. Lester Yoder has been appointed as assistant chemist for the chemical section of the Agricultural Experiment Station at Iowa State College.

Mr. H. B. Underwood has severed his connection with the Buffalo Foundry and Machine Company and has identified himself with the Hewitt Rubber Company, Buffalo, N. Y.

Rensselaer Polytechnic Institute, in March, 1918, will start work on extensive additions to be made to the laboratories of the department of chemistry. Entirely new and complete laboratories will be constructed for quantitative analysis, organic chemistry, and physical chemistry. The food analysis and gas analysis laboratories will be materially enlarged, and new space will be assigned for lecture and recitation rooms. The great increase in the number of students entering for the course of chemical engineering has made these changes imperative.

Dr. J. Stieglitz has appointed the following Committee on the supply of organic chemicals for research during the war: E. Emmet Reid, *Chairman*, Roger Adams, H. L. Fisher, J. W. E. Glattfeld, W. J. Hale.

Mr. James H. Ellis, research associate in physical chemistry at Throop College of Technology, Pasadena, Cal., has become a member of the physics department of the college as instructor in electrical measurements.

Mr. Howard B. Bishop has severed his connection with the General Chemical Co., at Easton, to accept a position with the National Aniline and Chemical Co.

Mr. C. A. Mace has been appointed head of the textile department of Marden, Orth and Hastings Corporation, succeeding Mr. H. Gardner McKerrow. Mr. Mace has been for eight years with the Badische organization at the head of their Chicago offices. He is a graduate of the Massachusetts Institute of Technology.

Mr. R. J. Quinn has left the Wahl-Henius Institute and accepted a position with the Midland Chemical Company.

Dr. J. W. Turrentine is directing the work of the Government's experimental kelp-potash plant at Summerland, near Santa Barbara, Cal. The plant is in operation and is producing crude potash. Apparatus is now being installed which will make possible the production of refined potash and by-products, particularly iodine, for both of which chemicals there is a large demand for industrial and military purposes.

Professor Charles H. LaWall of the Philadelphia Section has been elected president of the American Pharmaceutical Association.

Major S. J. M. Auld, of the British Army, addressed the Northeastern Section of the A. C. S., at Boston, on December 8, on "Gas Warfare."

The United States Civil Service Commission announces an open competitive examination for junior chemist, for both men and women. Until further notice, applications will be received at any time. Salaries range from $1020 to $1800. There is special need of eligibles who are qualified as physical, biological or metallurgical chemists. The Commission also announces an examination for assistant petroleum chemist, for men only, to be held on January 15. Salaries range from $1680 to $1920. For further information apply for Form 1312, Civil Service Commission, Washington, D. C., stating the title of the examination desired.

Mr. Guy R. McDole, Assistant in Soils, in the University of Minnesota, and formerly Research Assistant in Agricultural Chemistry in the University of Nebraska, has enlisted in the Gas and Flame Regiment (Thirtieth Engineers).

Mr. H. Gardner McKerrow, for the last two years associated with the Marden, Orth and Hastings Corporation in the establishment and management of their textile department, is now connected with E. F. Drew and Co., Inc., 50 Broad Street, New York City. Mr. McKerrow will have the management of the textile department, and it is proposed to go into dyestuffs as well as the mill chemicals and industrial oils. Special attention will be given to American dyestuffs. Through the efforts of Mr. McKerrow and others a convention will be held in New York City, January 22 and 23 at the Chemists' Club, at which it is hoped all the manufacturers of American dyestuffs will be represented, for the consideration of a proper means of standardizing American colors. Mr. McKerrow will have associated with him, Mr. T. F. O'Keefe.

Mr. Carl F. Speh, secretary of the Turpentine and Rosin Producers Association, has been appointed on the sub-committee of the National Paint, Oil and Varnish Association to look after legislative matters of interest to naval stores, producers and manufacturers, and distributors of paints, oils and varnish.

Mr. Charles H. McDowel, president of the Armour Fertilizer Company of Chicago, has been called by the government to aid in chemical research work and development.

Dr. R. K. Strong, of the University of Chicago, has been engaged as professor of industrial chemistry at the Oregon Agricultural College.

Twenty-five members of the Southern California Section of the A. C. S. accepted the invitation to the Technical Societies of Los Angeles to inspect the wonderful one hundred inch reflector of the Mount Wilson Solar Observatory, on November 24 and 25. This was the first occasion in its history where the rigid schedule of the Observatory was broken for any reason.

The Michigan Smelting & Refining Co., announces that Charles T. Bragg takes the position of Works Manager of its Detroit plant, January 1, 1918. Mr. Bragg had been Chemical Engineer of The Ohio Brass Co. for six years and was for over four years Technical Director of Berry Bros. of Detroit.

Canada recently appointed Sir Henry Drayton royal commissioner to investigate exportation of Canadian Niagara power and controller of the distribution and production of electrical energy in Ontario.

The University of Illinois will give a Short Course in Ceramic Engineering January 7–19, 1917. The Course will be under the direction of Professor E. W. Washburn, Head of the Department of Ceramic Engineering, and Mr. A. V. Bleininger, Ceramic Chemist of the National Bureau of Standards, assisted by Professors C. W. Parmelee and R. K. Hursh, of Illinois, and a corps of lecturers on special topics. The two-weeks' course is intended to cover in an elementary and practical manner the scientific principles underlying the practice of clay-working. A common school education will suffice for the work of the course and no tuition fees will be charged. The course is open to all who are interested.

Prof. John Charles Clark, of James Millikin University, has been elected to the presidency of the Illinois Academy of Science.

The 276th meeting of the Washington Section of the A. C. S. was held on December 13 at the Cosmos Club. Mr. Atherton Seidell spoke on "Utilization of the Adsorptive Power of Fuller's Earth for Chemical Separations" and Mr. Oswald Schreiner spoke on "Potash Situation in Relation to Food Crops." A special meeting was held at the same place on December 18, at which time Prof. Wilder D. Bancroft of Cornell University spoke on the subject of "Contact Catalysis."

Mr. L. M. Larsen has accepted a position in the research laboratory of Ault and Wiborg of Cincinnati.

On Saturday, December 8, Professor Grignard and Lieut. Engel of the visiting French Commission gave addresses before the Robert Kennedy Duncan Club of the Mellon Institute of Industrial Research at Pittsburgh. Professor Grignard was made the first honorary member of the club. The two distinguished guests were entertained at the University Club at luncheon. After luncheon, Prof. Grignard gave a short informal address in French which was translated in substance by Lieut. Engel.

The 101st regular meeting of the California Section of the A. C. S. was held on December 15, in San Francisco, in conjunction with the annual banquet. Among the after-dinner speakers were Prof. Edmund O'Neill of the University of California, Prof. John M. Stillman of Stanford University, and Dr. Harry East Miller of the International Precipitation Company.

INDUSTRIAL NOTES

To help out in the use of sugar, Italian scientists have developed a process for obtaining a large yield of sugar resembling honey from grapes. This product is very suitable for preserving fruits and marmalades and for use in soda fountain syrups. If this industry attains any magnitude it will affect the trade in half refined tartar which is obtained from grapes, which will in its turn affect the woolen dyers who use this substance as one of the ingredients in the production of olive drab.

The Ideal Laboratories Company has been incorporated under the laws of Delaware with a capital stock of $2,000,000. Incorporators, T. W. Cole, Chicago, Ill.; K. S. Wilson and Marion Luce of Oak Park, Ill.

A shipment of platinum received December 12 at a Pacific Coast port from Russia was the cause of much satisfaction to Government officials. The shipment weighed 21,000 ounces and was valued at more than $2,000,000. It was consigned to the Secretary of Commerce who will supervise its distribution. Because of the internal conditions in Russia it is feared that the shipment will be the last exported from that country for some time to come.

Announcement has been made that the Consolidated Gas Company of New York has reached an agreement with Washington officials to manufacture toluol to help meet the shortage which exists in this war essential. The Government is to pay for the erection of the stills at the Company's plants and the Consolidated Gas Company is to furnish the labor for the actual manufacture of the toluol from its gas. The product is to be furnished the government at the actual cost of its manufacture. It is understood that contracts have already been let for the erection of some of the stills and that work has already been started at the Company's plant in Long Island City.

We learn from the *General Chemical Bulletin* that the discovery of platinum in Alaska has led the Government to assign experts to study the situation there and report whether the discoveries can replenish the platinum supply cut off by the cessation of activity in the Ural Mountain mines.

The T. N. T. plant of the Aetna Chemical Company at Heidelberg, a suburb of Pittsburgh, Pa., was destroyed to the extent of $250,000 by an explosion on December [illegible] causing the death of eight men and seriously injuring many [illegible].

American sulfur production will be augmented by the development of New Mexico deposits, which are claimed to be of high grade and extensive in quantity. To undertake this development the United Sulfur Development Company has been incorporated with $3,000,000 capital by J. J. and M. de Praslin of Lake Charles, La., and J. B. Bailey of Wilmington, Del.

Perchlorate Explosives Company of Poughkeepsie has been formed with a capital stock of $2,100,000. Incorporators: L. Bedell, C. W. H. Arnold, H. B. Vosburgh, Poughkeepsie.

The Amalgamated Dyestuff and Chemical Works of New York has increased its capital stock from $50,000 to $500,000.

Aluminum, antimony, arsenic, bismuth, magnesium, phosphorus and potassium are all found in the state of Queensland, Australia. Platinum is found but in small quantities.

Wyoming Sulfur and Refining Company, dealers in sulfur and chemical products, has been incorporated under the laws of Delaware with a capital stock of $2,000,000.

Exports of cinchona bark and alkaloids and their salts from the United Kingdom have been prohibited to all destinations, according to a cablegram from the American consulate at London.

Advices received from Havana, Cuba, state that planters in Cuba are turning their attention to the growing of castor beans. The shortage of castor beans in this country has turned attention towards the possibilities of bean cultivation in the island of Cuba. Plantings have been made and the reports from the growers are encouraging. Soil and climatic conditions are declared to be entirely adapted to the cultivation of the castor bean, and it seems assured that the new industry will be given a real test on the island.

The salicylic acid plant of E. I. duPont de Nemours and Co., at Newark, Delaware, was burned recently, entailing a loss of approximately $100,000. The fire apparently was the result of an explosion.

The Commonwealth Silica Co., Chicago, Ill., has been incorporated with a capital of $1,500,000, to mine silica, lime and other substances. The incorporators are L. L. and B. F. Cowan and P. Zak.

According to British Imperial Institute reports, a considerable amount of attention has been given in recent years to the recovery of wax from the waste produced in the extraction of sugar from the sugar-cane, and this industry has now been started on a small scale in Natal. Samples of the first consignment of Natal sugar-cane wax shipped to England have been examined at the Institute and have been found to be of good quality, quite equal to that of the first trial samples made and examined. Sugar-cane wax is now becoming better known on the market, and could be used as a substitute for the better-known carnauba wax in the manufacture of gramaphone records, polishes, candles, etc.

In a paper read before the New York Section of the American Chemical Society on November 23, E. D. Boyer called attention to a new use for Portland cement brought about by the war, namely, the construction of ships and barges of concrete. He states that ships of this character have recently been successfully built in Norway, and a 5000-ton ship is at present being constructed in San Francisco, while on November 21, a 250-ton ship was successfully launched at Montreal. The American Concrete Institute and the Portland Cement Association have organized committees who are making a study of the construction of vessels of this type, and these committees have designed a reinforced concrete barge of 2000-ton carrying capacity, with every reason to believe it will be successful.

The Federal Trade Commission has entered order for licenses to three firms to manufacture and sell the product heretofore known as "Salvarsan," "606," "Arsenobenzol," "Arsaminol," patent rights which have been held by German subjects. Hereafter this important drug will be manufactured and sold under the name of "Arsphenamine." The three firms designated are Dermatological Research Laboratories of Philadelphia, Takamine Laboratory, Inc., New York, and Farbwerke Hoechst Company (Herman A. Metz Laboratory), New York. The supply of the drug was heretofore almost exclusively obtained by importation from Germany. The enormous shortage of supply on this important product will immediately be relieved, and the article placed in the hands of the Government, the hospitals and the medical profession at a much lower price.

It is reported that the Spreckles interests of California have purchased extensive deposits of soda salts in southern Oregon and will start development work in the near future.

Further data have been received by the United States Bureau of Foreign and Domestic Commerce on the successful incombustible substitute for celluloid. Announcement of this invention by a professor in one of the Japanese universities was made about a year ago and aroused considerable interest in the United States. The new product has been given the trade name of "Satolite" derived from the name of the inventor, Prof. S. Sato, and a company for its manufacture has been started with a capital of $1,000,000. Satolite is a galolith made of the glucine of soya bean, coagulated by formaline. It is said to be produced much more cheaply than celluloid, and to have several advantages for industrial use not possessed by the latter. The factory is to be built in the Mukojima district in Tokyo, and the actual production will soon begin.

At the annual meeting of the National Academy of Sciences, held at the University of Pennsylvania, Philadelphia, November 20 and 21, Dr. Simon Flexner of the Rockefeller Institute, announced that two American physicians, Doctors Jacobs and Heidelberger, of the Rockefeller Institute, have evolved a new remedy to replace salvarsan. Dr. Flexner stated that it has many advantages over salvarsan, one being its cheapness. It is stated that it is less injurious to the human tissues and more readily manufactured than salvarsan. Like salvarsan it is an arsenic compound.

The cottonseed oil refinery being erected by Swift and Company in Houston Heights, Texas, is near completion. The approximate cost of the plant is about $250,000. The plant as a whole will include three buildings, the power house, packing house, in which the oil is refined and the acidulating building. Three large storage tanks have been built with a capacity of 27,000 barrels of cottonseed oil. This company is also planning the construction of a large fertilizer plant, to cost about $500,000, at Hammond, Ill.

The United States Industrial Chemical Company, which was chartered recently under the laws of Maryland with a capital stock of $24,000,000, is reported to have secured land for the erection of a plant near Curtis Bay to manufacture chemicals, fertilizers and hydrocarbons. It is also reported that the new company will take over the entire plant of the Curtis Bay Chemical Company, subsidiary of the United States Industrial Alcohol Company of New York. The new company's incorporators are Patrick H. Loftus and Francis C. Nickerson of Brooklyn and Stewart M. Seymour of New York. Directors for the first year are George S. Brewster, William R. Coe, Edward W. Harden, William S. Kies, Adrian H. Larkin, Percival J. McIntosh, Horatio S. Rubens, Richard P. Tinsley and Milton C. Whitaker.

Nineteen schools of technology are now maintained by the Japanese government at various sections of the island empire. So far as is possible each school is specialized to meet the general agricultural, mining and industrial needs of that portion of the country in which it is located. At Tokyo and Osaka, dyeing, bleaching and printing, the tanning of leather, industrial designing and the manufacture of oils, soaps, and colors are among the courses offered, and the faculty of the Tokyo school alone numbers eighty-eight, including two foreign instructors.

A training school for the higher technical education of women was recently opened in Lyons, France, the centre of the silk industry in that country. So severe a drain has been made on French manhood of all classes that it was deemed imperative that women should be offered an opportunity in the more important fields. The courses of study offered cover most of the technical courses hitherto confined to men.

A school of industrial chemistry, the first in Italy, is being organized at the University of Pavia.

Restrictions are being placed upon copra exports to France, apparently with a view of assuring a greater supply for the domestic production of edible cocoanut oil.

Platinum production in Colombia is increasing. Prospecting has shown that the metal occurs in the steam gravels and in the high gravels for long distances on the Arato and San Juan River.

A thorough and scientific investigation of the dyestuffs industry in the United States is being undertaken by the United States Tariff Commission for the purpose of ascertaining the need of further tariff protection and also in relation to the production of explosives.

Brazilian manganese is now being imported in large quantities by the United States, owing to the closing of other sources of supply.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

NATIONAL MUSEUM

Mineral Industries of the United States; Interpretation of Fertilizer Situation in the United States. J. E. Pogue. Bulletin 102. 22 pp. Issued October 10, 1917. Paper, 5 cents.

PUBLIC HEALTH SERVICE

Trinitrotoluol. Practical Points in its Safe Handling. J. W. Schereschewsky. Public Health Reports, 32, 1919–26 (November 16).

The Bacteriological Examination of Water. Comparative Studies of Media Used. H. E. Hasseltine. Public Health Reports, 32, 1878–87 (November 9). "The results of this work indicate that if the new Standard Methods (1917) be adhered to in the bacteriological examination of water, time, labor, and material will be unnecessarily expended and misleading results may be obtained."

GEOLOGICAL SURVEY

Chromite in 1916. J. S. Diller. Separate from Mineral Resources of the United States, 1916, Part I. 18 pp. Published October 26. "The greatly increased trade in steel and the consequently larger demand for ferrochrome have stimulated the search for chromite in the United States, as is shown by the fourteenfold increase in production in 1916 as compared with 1915. * * * * The total yield for the United States was 47,035 long tons, valued at $726,243.

"The price of chromite in California on the basis of a content of 40 per cent of chromic oxide ranged in 1916 from $14 a ton f. o. b. at points of shipment early in the season, to $20 toward the end of the year. To this must be added for the eastern buyer a freight rate for carload lots ranging from $10 a ton to Chicago to nearly $15 a ton to the eastern seaboard and making the California 40 per cent ore cost on the eastern seaboard from $29 to $35 a ton. A premium of 50 cents a unit for chromium oxide is usually allowed and a penalty of 50 cents a unit is exacted for chromium oxide under 40 per cent and silica over 6 per cent. At the Atlantic seaboard the ore from the Pacific coast meets the imported ore, which is sold on the basis of a content of 50 per cent of chromic oxide. Prices of imported high-grade ore are reported as ranging in 1916 from $35 to $45 a ton f. o. b. eastern seaports. Low-grade Canadian ore containing 30 to 40 per cent chromic oxide sold for $25 to $30 a ton f. o. b. at the same points. Twenty-five per cent ore sold as low as $18 a ton.

Embargoes were placed on the shipment of chrome ore from some of the principal sources, and it was feared that the supply for the United States would be cut off, but after the producers received a guaranty that the ore would not be reshipped to enemy belligerents the imports greatly increased, compared with 1914, especially those from Rhodesia, New Caledonia, and Canada, though imports from Greece have declined slightly and those from Turkey have entirely ceased.

Silver, Copper, Lead and Zinc in the Central States in 1916. Mines Report J. P. Dunlop and B. S. Butler. Separate from Mineral Resources of the United States, 1916, Part I. 105 pp. Published October 27.

Bauxite and Aluminum in 1916. J. M. Hill. Separate from Mineral Resources of the United States, 1916, Part I. 12 pp. Published November 2. The production of bauxite in the United States in 1916 was 425,100 long tons, having a value at the mines of $2,296,400, an increase over the production in 1915 of 43 per cent in quantity and 52 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1916 was 49,190 long tons, an increase of about 74 per cent, and the Arkansas production of 375,910 long tons showed an increase of approximately 40 per cent.

Apparently the producers of aluminum consumed about 300,000 tons, makers of chemicals about 80,000 tons, and makers of abrasives and refractories about 45,000 tons of bauxite in 1916.

As will be seen by the tables, though the domestic consumption of bauxite in 1916 also increased 43 per cent over the consumption in 1915, domestic deposits were apparently able to supply the whole demand and still leave some bauxite for export. The larger exports were apparently to Canadian aluminum and abrasive makers.

The prices received for bauxite in 1916, as reported by producers, ranged from a low of $4.25 to a high of $6.25 a long ton, the average price for the whole production in 1916 being $5.40 a long ton. During the latter part of the year and early in 1917 higher prices were offered for good grade bauxite from the central Georgia field.

Owing to the freight embargoes placed by various railroads in the last half of 1916 and also to the shortage of cars the producers of bauxite had considerable difficulty in meeting their orders. The exceptionally wet winter was also a handicap to regular production and shipping and, at a few pits in the central Georgia field, work had to be stopped on account of difficult mining or hauling conditions.

"The value of primary aluminum produced in the United States in 1916 was $33,900,000, an increase of 108 per cent over the value of the output in 1915. This increase is, in part, due to the increased price, but is also due in a considerable degree to the greater output of primary aluminum in 1916 than in 1915. It will also be noticed, as shown in the tables, that the value of aluminum produced from scrap in the United States in 1916 increased more than 300 per cent over the value of the production in 1915, owing in part to the greatly increased price in the open market, but also to greater recoveries of aluminum from scrap. The value of the total domestic production of new metal and metal produced from scrap in 1916 was $57,330,200, as compared with $22,082,100 in 1915. The value of imports of aluminum has continued to decline, but the value of exports has increased greatly."

In the United States the quoted prices for primary or "virgin" aluminum ranged from a low of 55 cents a pound in January to a high of 65.12 cents a pound in November, the average for the year being 60.71 cents a pound as compared with 33.08 cents in 1915. These prices are for small lots for immediate delivery, offered in the open market, and may be taken to represent the price received by the single producer of primary aluminum in this country. It is reported, apparently on good authority, that the contract prices of the Aluminum Company of America to regular consumers ranged from 31 cents a pound in 1916, as compared with 20 to 31 cents a pound in 1915. The demand for aluminum was very large during 1916, particularly for war materials of various sorts, and it is highly probable that the demands in the near future will be materially

PRICES OF ALUMINUM, 1912–1916, IN CENTS PER POUND(a)

Year	Average Open Market Price Small Lots	Contract Price
1912	22.01	20–21
1913	23.64	(b)
1914	18.63	(b)
1915	33.98	20–31
1916	60.71	31–37

(a) *Eng. & Min. Jour.* quotations in annual review numbers.
(b) No figures published, but it seems reasonable to believe that contracts were made on approximately the same basis as for 1912.

Nearly 70 per cent of the domestic output of bauxite in 1916 went into aluminum, but manufacturers of aluminum salts used nearly 19 per cent; apparently 8 per cent was consumed in the manufacture of bauxite abrasives; and 3 per cent was used by makers of "high-alumina refractories," sometimes called bauxite brick.

The Palestine Salt Dome, Anderson County, Texas. The Brenham Dome, Washington and Austin Counties, Texas. O. B. HOPKINS. Bulletin 661-*G*, from Contributions to Economic Geology, 1917, Part II. 28 pp. Published October, 1917.

The highly folded, faulted, and eroded condition of the Palestine dome and the general absence of oil and gas as surface seepages and in shallow wells in this area detract from its oil prospects. The tilting and faulting of the rocks probably provided outlets for the escape of oil, and as no evidence of oil exists the conclusion is suggested that no large amount remains here, even if it ever accumulated. It is possible, however, that the soft and dominantly impervious nature of the formations involved in this fold closed up any possible lines of escape for the oil, as its absence at the surface may be interpreted to indicate. The eroded condition of the dome, as shown by the presence of Cretaceous rocks at the surface, and the presence of the salt core within 140 ft. of the surface over a large area are also unfavorable conditions, as they eliminate the possibility that oil may be found on the crest of the dome, which might otherwise be the most favorable area for its occurrence. Oil in commercial quantities has not yet been found in a salt dome so far removed from the coast as this one.

In the Brenham dome, as in most other salt domes, drilling is attended with many uncertainties and should not be undertaken without full knowledge of them. Failure to find oil in commercial quantities in the porous limestone, the "cap rock," and the sands overlying the crest of the dome makes deeper drilling necessary, with its increased costs and risks.

BUREAU OF MINES

Approved Electric Lamps for Miners. H. H. CLARK AND L. C. ILSLEY. Bulletin 131. 47 pp. Paper, 20 cents.

Yearbook of the Bureau of Mines, 1916. V. H. MANNING. Bulletin 141, 165 pp. Paper, 30 cents. This bulletin describes in some detail the more important work done by the Bureau of Mines during 1916 in efforts to increase safety and efficiency in the mineral industries. The purpose and organization of the bureau and a review of its work for each fiscal year are presented in the annual reports of the director. Those reports are necessarily summarized; they cannot give full details of noteworthy experiments nor describe at length new and improved equipment, apparatus, and devices that are being used by the bureau or have been devised by its engineers and chemists. This bulletin gives descriptions of some noteworthy safety devices and discusses in fuller detail than the annual reports the relation of the bureau's work to the general problems of safety and efficiency in the mineral industries and the significance of the results that the bureau has been able to achieve.

The Determination of Moisture in Coke. A. C. FIELDNER AND W. A. SELVIG. Technical Paper 148, 8 pp. Paper, 5 cents. "The experiments described in this paper were undertaken, in the course of fuel investigations made by the Bureau of Mines, with the purpose of ascertaining the most rapid and simple method for determining the moisture in coke with sufficient accuracy for use in specifications for the purchase of coke by the Government, by industrial concerns, or by private individuals.

"Moisture can be determined quickly and with adequate accuracy, ±0.5 per cent, by simply heating to constant weight a large sample of lump coke, in any convenient oven, or on a stove, hot plate, or steam coil at a temperature of 100 to 200° C.

"Because of its simplicity and flexibility this method may be used advantageously at points when coke shipments are sampled."

Effect of Low-Temperature Oxidation on the Hydrogen in Coal and the Change in Weight of Coal on Drying. S. H. KATZ AND H. C. PORTER. Technical Paper 98, 10 pp. Paper, 5 cents. In order to gain information regarding the possible changes of the hydrogen of the coal substance during the alteration of coal by the air, the work described in this paper was undertaken.

"The following conclusions are reached:

"1—There is a lack of agreement between the weight of water evolved by coal and the loss of weight when dried in an inert atmosphere. The excess weight of the coal may be due to absorption of gas.

"2—A study of the vapor tension of water in coal, as indicated by the water removed by a regulated current of dry nitrogen and air used alternately, shows no production of water by the oxidation of coal at ordinary temperatures.

BUREAU OF STANDARDS

Durability of Cement Draintile and Concrete in Alkali Soils (Containing Results of Third Year's Tests). R. J. WIG, G. M. WILLIAMS, A. N. FINN in coöperation with S. H. MCCRORY, Chief of Drainage Investigations of Department of Agriculture, E. C. BEBB, Engineer of U. S. Reclamation Service, and L. R. FERGUSON, Engineer, Portland Cement Association. Technologic Paper 95, 91 pp. Issued November 15.

Gas-Mantle Lighting Conditions in Ten Large Cities in the United States. R. S. MCBRIDE AND C. E. REINICKER. Technologic Paper 99, 35 pp. Published October 29. "From an inspection of about 4500 gas mantle lamps in service in 10 cities a summary of the condition of mantles, glassware, pilot light, and other particulars was made in order to determine to what extent the customer benefited through periodic maintenance service.

"By these observations it is found that a lamp not on regular maintenance is likely to be defective five and one-half times as frequently as a lamp which is regularly maintained. Also it is shown that on the average 1 in 3 of the lamps on regular maintenance was not in good condition, whereas the defects noted in the lamps not so maintained, average more than one for every lamp.

"One satisfactory system of estimating the expenses for maintenance work together with a set of unit costs is presented, based upon the analysis of the operation of 10 gas companies. A suggested table of costs for each type of unit is given."

Determination of Absolute Viscosity by Short-Tube Viscosimeters. W. H. HERSCHEL. Technologic Paper 100, 53 pp. Issued November 9. Paper, 10 cents. "The conclusions from this investigation for short tubes, such as are used in the Engler and the Saybolt Universal viscosimeters, are as follows:

"1—The value of the product of the velocity of flow and diameter of tube, divided by the kinematic viscosity, must not be greater than 800 if the flow is to be viscous rather than turbulent.

"2—Consequently water is not a suitable liquid for use in finding the relation between viscosity and time of discharge, and Ubbelohde's equation and all others based upon it are seriously in error.

"3—A small but positive amount must be added to the measured length of tube to get the effective length.

"4—Boussinesq's value of 1.12 for the coefficient of the kinetic-energy correction would be approximately applicable if the average head could be correctly determined.

"5—If the average head is determined by Meissner's formula, which is the best available, although unsatisfactory and far from accurate, a lower value must be used for the coefficient."

A Method for Testing Current Transformers. F. B. SILSBEE. Scientific Paper 309, 13 pp. Issued November 3. Paper, 5 cents.

Some Electrical Properties of Silver Sulfide. G. W. VINAL. Scientific Paper 310. 9 pp. "Silver sulfide may be prepared in the form of short wires or thin strips like a metal. The wire, which must be drawn hot, was found to conduct electricity like a metal of high specific resistance and approximately zero temperature coefficient. A strip of sulfide rolled at room temperature has a large temperature coefficient and shows both metallic and electrolytic conduction. It has a volt-ampere curve characteristic of a pyroelectric conductor. The strips are sensitive to small alternating currents, which increase the resistance enormously, while small direct currents have the opposite effect. The specific resistance has been measured and experiments made on the electrochemical decomposition."

Axial Aberrations of Lenses. E. D. TILLYER AND H. I. SHULTZ. Scientific Paper 311, 24 pp. Issued November 3. Paper, 5 cents.

COMMERCE REPORTS—OCTOBER, 1917

The **iron and steel** output of Japan is expanding greatly, especially in the shipbuilding, pipe and rail industries. (P. 10)

Among recently reported German discoveries or practice are the following: Formation of a viscous yellow **mineral oil** by treating coal with liquid sulfurous acid; production of **illuminating oil** by heating naphthalene with aluminum chloride; production of **ozokerite** from lignite; increase of 80 per cent in the output of atmospheric **nitrate** plants; use of new **lead and zinc alloys** to replace copper and brass; smelting of copper schists with 0.7 per cent copper and of low-grade lead-sandstone ores; production of **aluminum** from clay; smelting of low-grade **nickel** ores; new methods for regeneration of **rubber;** and increased use of nettles as a **cotton substitute.** (P. 50)

Steps are being taken to increase the production of **candelilla wax** in Mexico. (P. 55)

A new **petroleum refinery** is in operation in Venezuela. (P. 57)

Large areas of **mangrove** are found in the Philippines with 21 varieties, the bark of which contains from 12 to 35 per cent tannin. (P. 118)

Use of nettle fiber for **textiles** is increasing in Denmark. The nettle **"Urtica dioca"** is about 30 in. high. It is dried, stripped, and retted like flax, except that the water must be changed to prevent fermentation of the sugar present. (P. 119)

Production of **salt** from sea water is proposed in New Zealand. (P. 153)

Experiments in Scotland to increase the use of straw have shown that it can be rendered more digestible for **cattle food** by superheating with dilute caustic soda. Its use for paper pulp is also increasing. Experiments on the use of straw as **fertilizer** have shown that it stimulates the growth of "azotobacter," and other nitrogen organisms. This effect is most marked with straw containing 1 part of arsenic per 100,000. (P. 164)

Efforts are being made to locate **petroleum** in Australia, which is now entirely dependent on foreign countries for its oil supply. (P. 168)

Gas is being used extensively in Birmingham, England, as a **substitute for gasoline** in motor vehicles. 250 to 300 cu. ft. of gas are equivalent to 1 gal. of gasoline. No change in the engine is required, and the only objection is the great bulk of the gas containers. (P. 170)

The **vegetable wax** produced in Japan is extracted from the fruit kernels of a native tree, by crushing, steaming and pressing. It is refined by crude methods, which are, however, being improved. It is used for polishes, pomades and soaps, and in dressing leather. (P. 227)

The Malay Peninsula is now the largest **rubber-producing** and exporting country in the world. Exports to the United States are now greater than to any other country. (Pp. 232–6)

Exports of **dyestuffs** from the United States in July amounted to $1,278,709, distributed to over 12 countries. (P. 271)

Additions to the "conservation" list of articles, **export** of which from the United States is practically prohibited, include: **phosphorus, babbitt metal, bichromate, bismuth salts, brass, bronze,** caustic potash, china-wood oil, ores, alloys or compounds of chromium, cobalt, copper, manganese, molybdenum, **nickel,** tin, tungsten, and vanadium; crucibles, industrial diamonds, electrodes, hydrofluoric acid, mercury, emery, graphite, solder, type metal. The complete revised list is published. A complete revised list of articles requiring a license for export is also included. (Pp. 292–9)

A systematic prospecting of the placer deposits in the Ronda Mountains in Spain have shown the presence of **workable platinum** deposits, with extensive deposits of **chromium, nickel and magnetite ores.** The nickel is present as garnierite, with 16–20 per cent nickel, *i. e.*, equal Canadian and New Caledonian deposits (P. 311)

Increased prices for **antimony** have caused the re-opening of mines in Italy. (P. 323)

Exports of **mineral oils** from the United States in 1916–17 were greater than ever before. (P. 354)

A marked improvement is observed in the quality of **dyestuffs** made in England. Many new dyes are available, but there is still a lack of certain dyes, *e. g.*, diamond black, B H direct cotton black, patent blue, and rhodamin 6 G. (P. 360)

Production of **iron and steel** in Canada in 1917 shows a decided increase (P. 405)

Canada has removed the prohibition on the manufacture and sale of **oleomargarine,** which can now be sold under strict regulations (P. 417)

The use of **chromium** in steel except for war purposes has been prohibited in England, thus stopping the manufacture of "stainless" steel cutlery, etc. Chrome steel is being used for naval, ordnance, and airplane parts (P. 42[illegible])

A new **zinc smelter** is being erected in Mexico, to use petroleum for fuel. (P. 430)

SPECIAL SUPPLEMENTS ISSUED IN OCTOBER

BRITISH WEST INDIES—22a BRITISH GUIANA—44a
BRAZIL—40a PHILIPPINE ISLANDS—80a

STATISTICS OF EXPORTS TO THE UNITED STATES

Hongkong—15a	Java—Sup. 40a
Antimony	[illegible]
Chemicals	[illegible]
Earthenware	Diamonds
Hides	[illegible]
Leather	Rubber
Peanut oil	[illegible] wax
Aniseed oil	[illegible] Sup. 22a
Cassia oil	[illegible]
Peanuts	[illegible] extract
Paper	[illegible]
Sugar	[illegible]
Tin	[illegible]

COMMERCE REPORTS, NOVEMBER, 1917

The **mineral exports** of New Zealand include gold, silver, tungsten, ore, coal, and kauri gum. "Kauri-gum oil," obtained by distillation of **peat** found in kauri-gum swamps, is being used with gasoline, as motor fuel. (P. 4[illegible])

Efforts are being made to develop the production of **wintergreen** oil in Assain, India, when the leaves and stems of the "gaultheria" plant yield, upon distillation, about 0.68 per cent oil, as compared with as little as [illegible] per cent in other regions of India. (P. 440)

Plans have been made in France [illegible] of instruction for apprentices in **metallurgical** industries, to be conducted by

the employers; attendance is compulsory, but apprentices are to be paid for the period of instruction. (P. 455)

All the London **milk** dairies have been consolidated into a $20,000,000 corporation in order to effect economies in labor and operation. (P. 456)

Export duties on **manganese ore** from Brazil have been increased from $0.85 to $3.00 per ton. (P. 472)

Experiments are being conducted in Mexico upon the production from **bananas** of **flour, starch, vinegar, alcohol, fiber, paper and cardboard.** (P. 478)

A large **detinning** plant has been erected near Dundee, Scotland. (P. 486)

To avoid exportation of **raw hides and tanning materials** from India, efforts are being made to develop a local tanning industry. (P. 507)

Exports of **wattle bark** and extract for tanning purposes from South Africa, show a marked increase. The trees are cultivated from seed, and are cut down for stripping the bark, after five or six years. (P. 508)

Cultivation of the wild geranium for the production of **geranium oil** is being urged in India. (P. 516)

Wolframite is being mined extensively in South China. (Pp. 522 and 546)

A new law in Uruguay requires a chemical **analysis of all drugs and chemicals** to be imported. Owing to lack of laboratory facilities much delay has arisen. (P. 539)

Mineral exports from Spanish Morocco include **hematite, galena and calamine.** (P. 563)

A large part of the output of **castor oil** in England is now being used as a lubricant for airplane engines. (P. 586)

The **zinc** industry of Russian Poland has been revived, with an output nearly equal to that before the war. (P. 631)

Soap is now being made in Sweden from sewer fat, the oils of beechnuts and horse-chestnuts. (P. 641)

A company has been organized in Sweden for the manufacture of **dyes.** (P. 653)

Among the **mineral products** of Japan are antimony, chromite, copper, gold, iron, lead, manganese, platinum, mercury, silver, tin, tungsten, molybdenum, zinc, asphalt, coal, petroleum, graphite, phosphate rock, pyrite, and sulfur. (P. 668)

Although Italy has rich **zinc** deposits, the output of zinc is limited by the shortage of fuel. (P. 669)

Attempts are being made in Italy to **briquette** rice hulls for use as fuel. (P. 678)

Mineral products of South Africa include gold, diamonds, coal, copper, tin, antimony, asbestos, corundum, and lime. (P. 692)

There has been a great increase in the **vegetable oil** industry in Sao Paulo, Brazil, including cottonseed, castor oil, linseed, peanut, and cashew nut. (P. 710)

New Zealand has offered a bonus for the production of **mercury.** (P. 718)

As a **sugar substitute,** "honey of grapes" is used in Italy. It is obtained from unfermented grape juice by evaporation followed by freezing (removing water and tartaric acid), and by further evaporation under reduced pressure. (P. 756)

A large **blast furnace,** rolling mill, etc., are to be erected in Holland to prepare, from foreign ores, steel for the shipbuilding industry. (P. 771)

The business of the British **dye syndicate** has been very successful thus far. The list of colors has been greatly extended, and the manufacture of intermediates has been increased. Research is being conducted at the Universities of Oxford, Leeds and Liverpool, and a main research laboratory is being erected at Huddersfield. (P. 776)

A non-combustible substitute for **celluloid,** known as "Satolite," has been introduced in Japan. It is made from the glucine of soya bean, coagulated by formaldehyde. (P. 779)

The **mineral products** of Burma include petroleum, salt, and ores of tungsten, lead, silver, tin, gold, zinc, iron, antimony, molybdenum, platinum, and copper. (P. 780)

The methods of making and coloring **glass beads** in Venice are described in great detail. (Pp. 789–98)

The **glycerine** now being recovered in England from waste fat, etc., from the army camps, is sufficient to provide propellant ammunition for 17,000,000 shells per annum. (P. 811)

Owing to decreased demand for natural **indigo,** the production in Madras is considerably below that of last year. (P. 820)

Investigation of **vegetable fibers** in Brazil has shown some suitable for paper, but not for textiles. The latter are in great demand for bagging, etc., owing to scarcity of jute. (P. 831)

SPECIAL SUPPLEMENTS ISSUED IN NOVEMBER

FRANCE—5*a*, *b*, *c*
ITALY—8*a*
NETHERLANDS—9*b*
SPAIN—15*e*
ENGLAND—19*b*
WALES—19*c*
SCOTLAND—19*d*
ECUADOR—43*a*
PERU—46*a*
SPAIN—58*a*
EGYPT—68*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

HANKOW, CHINA—492
Antimony
Soya beans
Camphor
Albumen
Gall nuts
Hemp
Hides
Bean oil
Cottonseed oil
Rape seed oil
Soya bean oil
Nut oil
Sesamum seed
Tallow
Turmeric

MALAGA—580
Fusel oil
Tartar
Thymol
Hides
Juniper oil
Lavender oil
Pennyroyal oil
Origanum oil
Rosemary oil
Thyme oil
Almond oil
Olive oil
Copper ore
Iron ore
Licorice

GLASGOW—598
Acids
Corundum
Creosote
Sodium cyanide
Hides
Magnesite
Paper stock
Ammonium sulfate

MARSEILLES—Sup. 5*c*
Benzoic acid
Citric acid
Belladonna
Cochineal
Glycerine
Gums
Gentian root
Copper matte
Glue
Hides
Nickel matte
Ocher
Copra oil
Olive oil
Palm oil
Paper stock
Graphite
Soap
Tin
Zinc oxide

ITALY—Sup. 8*a*
Hides
Mercury
Fusel oil
Olive oil
Parchment paper
Zinc ore
Citrate of lime
Pumice
Sulfur
Tartar
Artificial silk
Citric acid
Bergamot
Sesame oil
Sumac
Senna
Zinc ore
Glassware

PARIS—Sup. 5*a*
Aluminum
Bones
Carbon
Alizarin
Casein
Hides
Olive oil
Peanut oil
Essential oils
Platinum
Saffron
Zinc ore

HAVRE—Sup. 5*b*
Copper matte
Fertilizer
Optical glass
Hides
Colza oil
Flint pebbles
Prussiate of potash
Rubber

LYON—Sup. 5*b*
Calcium tartrate
Orchil extract
Gum arabic
Tartar
Copper matte
Hides
Enameled iron
Photographic plates
Artificial silk

NETHERLANDS—Sup. 9*b*
Beeswax
Chemicals
Drugs
Dyes
Cocoa butter
Fertilizers
Fibers
Hides
Ink
Leather
Matches
Paper stock
Paraffin
Rubber
Stearine
Formic acid

SPAIN—Sup. 15*e*
Antimony
Argols
Fusel oil
Glycerine
Calcium tartrate
Potash
Hides
Lithopone
Barytes
Paper stock
Mercury
Olive oil
Peanut oil
Soap

SCOTLAND—19*d*
Asphalt
Glassware
Leather
Paper stock
Guano
Hides
Gelatin
Acids
Ammonium sulfate
Bone char
Corundum
Creosote oil
Magnesite
Manganese ore

ENGLAND—Sup. 19*b*
Animal charcoal
Ammonia
Hides
Iron oxide
Alum
Barium carbonate
Carbolic acid
Creosote
Cresol
Fertilizer
Gum copal
Castor oil
Palm oil
Rape oil
Paris white
Ultramarine
Rubber
Bones
Copper
Grease
Ferro manganese
Coconut oil
Whale oil
Paper stock
Ammonium sulfate
Ammonium chloride
Bleaching powder
Cochineal
Cutch
Glycerine
Gum tragasol
Soda ash
Sodium silicate
Leather
Artificial silk
Tin

ECUADOR—Sup. 43*a*
Gold
Hides
Indigo
Kapok
Ivory nuts
Rubber

PERU—Sup. 46*a*
Aluminum
Antimony
Copper matte
Lead
Cochineal
Silver
Guano
Hides
Molybdenum
Mercury
Rubber
Gold
Sugar
Tungsten ores
Vanadium ores
Zinc ores
Kerosene
Naphtha
Crude oil
Cocaine
Potassium sulfate

SIAM—Sup. 58*a*
Gum benzoin
Hides
Stick lac
Tungsten ore

EGYPT—Sup. 68*a*
Beeswax
Gum arabic
Hides
Iron ore
Paper stock
Senna
Ivory nuts

BOOK REVIEWS

Standard Table of Electrochemical Equivalents and Their Derivatives. By CARL HERING AND FREDERICK H. GETMAN. 130 pp. D. Van Nostrand Co., New York, 1917. Price, $2.00 net.

This little book should serve a useful purpose to the electrochemist or any one engaged in electrochemical work. The tables, which are four in number, include electrochemical equivalents by weight, grams per ampere hour in the order of magnitude, electrophysical equivalents by volume and the valences of the elements in their combinations. The principal table is that of the electrochemical equivalents by weight, and is very complete. On eight pages are given the element, symbol, atomic weight, valence, milligrams per coulomb, coulombs per milligram, grams ampere per hour, ampere hours per gram, pounds per 1000 ampere hour, and ampere hours per pound. Calculations are taken up, giving by a well chosen set of examples, the method best adapted for solving such problems as are liable to arise in electrochemical work.

Part II deals with electrolysis, theory of electrolytic dissociations, Faraday law and coulometers, and a section is given to the electronic theory.

An Appendix includes a chapter on valence, chemical reactions and calculations, conversion factors used in electrochemical calculations which is taken from Mr. Hering's "Conversion Tables," and finally a glossary of terms

It will be seen that all of this information is to be found in other books, but it is convenient to have it brought together in one volume, and it is presented in a clear and logical manner that should recommend it as a reference book.

SAMUEL A. TUCKER

A Short Manual of Analytical Chemistry, Qualitative and Quantitative—Inorganic and Organic. By JOHN MUTER, PH.D., F.R.S.E., F.I.C., F.C.S., Analyst to the Metropolitan Asylums Board, Late Editor of *The Analyst*, etc. 6th American Edition, Illustrated. xiii + 237 pp. Edited by J. THOMAS, Sc.D. P. Blakiston's Son & Co., Philadelphia, 1917. Price, $2.00 net.

This manual, which is prepared primarily for the use of pharmacists, has previously passed through ten English and five American editions, indicating its acceptability to the pharmaceutical profession. The notable characteristics of the present edition is the revision of the procedures for the assaying of drugs and the inclusion of the legal standards for drugs, as laid down in the ninth decennial revision of the United States Pharmacopoeia.

It is obvious that any attempt to cover so wide a field within the compass of a short manual must involve extreme brevity of treatment of many topics and procedures. It is also true that many of the procedures for the estimation of inorganic constituents will scarcely appeal to the practicing analyst outside of pharmacy, and it may be deplored that pharmacists are disposed to accept such procedures without adequate criticism. The fact remains, however that the continued popularity of this manual indicates that it satisfies a demand in the field for which it is prepared, and the present edition is doubtless at least as satisfactory as those which have preceded it.

H. P. TALBOT

The Chemical Engineering Catalog—1917 Edition. 517 pp. Illustrated. Obtained by special arrangement with the Publishers, The Chemical Catalog Co., Inc. New York City.

A need was felt, even before the recent new and increased capacities in our chemical industry, on the part of the chemical engineer, superintendent and buyer for a compilation containing the fullest knowledge relative to chemical-technical data, plant equipment and products, and imparting information regarding the source of supply of the manifold needs of laboratory and works. This information, so essential to the successful development of the industry, was not only lacking in coördination but also extremely meager, and the little that was obtainable was scattered in periodicals, pamphlets and individual catalogs. To supply this necessity, a joint supervisory committee was appointed by the American Institute of Chemical Engineers, the American Chemical Society and the New York Section of the Society of Chemical Industry, with the result that the first edition of the Chemical Engineering Catalog was published in 1916 by the Chemical Engineering Catalog Co., Inc. This first edition was of 288 pages of the size of THIS JOURNAL, listed 136 manufactures of chemical plant equipment, products and material, and contained in addition a number of illustrations of apparatus and machinery. If the first edition was an experiment, the edition of 1917 proves the success of the experiment. The 1917 edition comprises 517 pages, 277 being devoted to illustrations, descriptions and uses of a variety of plant equipment. Such rapid strides must have exceeded the expectations of the most optimistic sponsors of the Catalog and the editors of the volume are to be congratulated on their accomplishment. An improvement worthy of note is the division of the book into two sections, one devoted to chemical plant equipment, data of interest to the engineer and superintendent, while the other pertains to materials and supplies peculiar to the province of the buyer.

Although the Catalog has doubled in size since last year, it must be realized that it is not yet complete and represents only part of that completeness contemplated by the editors "to produce such an encyclopedia of trade information that the engineer or buyer will be able to obtain from it the data necessary to enable him to specify or purchase the equipment or material required to take a plant from a mere idea to the point where it is successfully turning out a finished product."

This has not yet been attained, but coöperation on the part of those who unquestionably will benefit by such a work, will assist so materially that it will not be long before the ideal condition will be consummated.

There is ample assurance therefore that the Catalog will then become the inseparable companion of the several classes operative in the Chemical Industry and, moreover, others who are not yet interested will eventually find in it valuable information for their respective fields of activity. With the improvements and advances noted, it is only another convincing index of the progress and achievements of the American Chemical Industry.

GEO. D. ROSENGARTEN

The Leather Specimen Book. [illegible] W. LACROIX, of the Pfister & Vogel Leather Co., Milwaukee, Wis. Price, $7.00.

This book, as the author claims, has been prepared especially for the use of those interested in the manufacture of leather. The description of the general processes employed is of necessity made brief, but at the same time it conveys a good idea of some of the [illegible] through which a hide or skin must pass before it becomes a finished product. The eighty four specimens of [illegible] shown, together with the text accompanying each [illegible] ting. Those engaged in leather manufacture or in allied lines will find this volume both helpful and instructive.

ALLEN ROGERS

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Amidophenol: Le Diamidophenol acide en photographie. G. UNDERBERG. 16mo. 32 pp. Price, 60 cm.

Analysis: Methods in Metallurgical Analysis. C. H. WHITE. 8vo. Price, 10s 6d.

Analysis: A Systematic Course of Qualitative Analysis of Inorganic and Organic Substances. H. W. SCHIMPF. 8vo. 187 pp. Price, $1.50. John Wiley & Sons, New York.

Building Stones and Clays. C. H. RICHARDSON. 8vo 437 pp. Price, $5.50. The University Book Store, Syracuse, N. Y.

Chemicals: Dictionary of Chemicals and Raw Products. G. H. HURST. 2nd Ed. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Chemistry. JAMES KNIGHT. Edited by J. ADAMS. 12mo. 162 pp. Price, $0.75. David McKay, Philadelphia.

Chemistry: Experimental and Applied Chemistry. H. S. DOOLITTLE. 8vo. 189 pp. Price, $1.00. G. Wahr, Ann Arbor, Mich

Chemistry: Laboratory Manual of Elementary Chemistry. H. C. COOPER. 12mo. 247 pp. Price, $1.10. John Wiley & Sons, New York.

Colloid Chemistry: An Introduction to Theoretical and Applied Colloid Chemistry. WOLFGANG OSTWALD. Translated from the German by M. H. FISCHER. 8vo. 232 pp. Price, $2.50. John Wiley & Sons, New York.

The Dyeing of Cotton Fabrics. F. BEECH. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Dyes: A Book of Vegetable Dyes. E. M. MAIRET. 8vo. 125 pp. Price, 5s. D. Pepler, London.

Electric Furnace in the Iron and Steel Industry. W. RODENHAUSER AND OTHERS. 2nd Ed. 8vo. 429 pp. Price, $3.75. John Wiley & Sons, New York.

Electrical Engineering. C V. CHRISTIE. 2nd Ed. 8vo. 546 pp. Price, $4.00. McGraw-Hill Book Co., New York.

Explosives: Industrial Nitrogen Compounds and Explosives. G. MARTIN AND W. BARBOUR. 8vo. 125 pp. Price, 7s. 6d. Crosby Lockwood & Son, London.

Explosives: A Short Account of Explosives. ARTHUR MARSHALL. 8vo. 104 pp. Price, 5s. J. & A. Churchill, London.

Food Adulterants: Detection of the Common Food Adulterants. E. M. BRUCE. 3rd Ed. 88 pp. Price, $1.25. D. Van Nostrand Co., New York.

Gas Engine Troubles and Installation. J. B. RATHBUN. 3rd Ed. 12mo. 448 pp. Price, $1.00. Stanton & Van Vliet Co., Chicago.

Industrial Chemistry: Laboratory Guide of Industrial Chemistry. ALLEN ROGERS. 8vo. 212 pp. Price, $2.00. D. Van Nostrand Co., New York.

Iron and Steel: Non-Technical Chats on Iron and Steel and Their Application to Modern Industry. L. W SPRING. 8vo. 358 pp. Price, $2.50. Frederick A. Stokes Co., New York.

Military Preparedness and the Engineer. E. F. ROBINSON. 16mo 361 pp. Price, $2.00. Clark Book Co., New York.

Ore Mining Methods. W. R. CRANE. 2nd Ed. 8vo. 277 pp. Price, $3.50. John Wiley & Sons, New York.

Pyrometry: Practical Pyrometry. E. S. FERRY AND OTHERS. 12mo. 147 pp. Price, $1.50. John Wiley & Sons, New York.

Resins: The Distillation of Resins. H B. STOCKS. 2nd Ed. 8vo. Price, 10s. 6d. Scott, Greenwood & Son, London.

Science: Experimental General Science. W. N. CLUTE. 12mo 303 pp. Price, $1.00. P. Blakiston's Son & Co., Philadelphia.

Sewage Purification and Disposal. G. B. KERSHAW. 8vo. 340 pp. Price, $3.75. Philadelphia Book Co., Philadelphia, Pa.

Steam: Properties of Steam and Ammonia. G A GOODENOUGH. 2nd Ed. 4to. 126 pp. Price, $1.25. John Wiley & Sons, New York.

Technical Papers: The Composition of Technical Papers. H. A. WATT. 12mo 431 pp. Price, $1.50. McGraw-Hill Book Co., New York

Water Supply Engineering. A. P. FOLWELL. 8vo 485 pp. Price, $3.50 John Wiley & Sons, New York

NEW JOURNAL

Oil and Mining Journal. Semi-monthly. Published by The Oil and Mining Journal Publishing Co., Oklahoma City. Price, $2.00 a year.

RECENT JOURNAL ARTICLES

Acid Open Hearth Process. F. ROGERS. *Blast Furnace and Steel Plant*, Vol 5 (1917), No. 12, pp. 545-549.

Agriculture and National Defense. D F. HOUSTON. *The American Fertilizer*, Vol 47 (1917), No. 11, pp. 21-24

Blast Furnace Gas: A New Blast Furnace Gas-Cleaning Machine. JOHN RUDDIMAN *Metallurgical and Chemical Engineering*, Vol 17 (1917), No. 10, pp. 608–611.

British National Physical Laboratory. I. W. CHUBB. *Industrial Management*, Vol. 57 (1917), No. 3, pp. 420–426.

British Welders and the World War. FRANK MYNOTT. *Journal of Acetylene Welding*, Vol. 1 (1917), No. 6, pp. 254–256.

Caffetannic Acid a Bugaboo. C. W. TRIGG. *Tea and Coffee Trade Journal*, Vol. 33 (1917), No. 5, pp. 437–439.

Cement Floors: Protective Treatment for Cement Floors Subject to Injurious Liquids. W. P ANDERSON. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 667–668.

Coal: Using Coal to the Best Advantage. E. H. HINCKLEY. *Textile World Journal*, Vol. 53 (1917), No. 22, pp. 41–45.

Color: The Physical Basis of Color Technology. M. LUCKIESH. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 631–637.

Cotton: Use of Cotton as a Wool Substitute. *Textile World Journal*, Vol. 53 (1917), No. 23, pp. 25–27.

Crude Oil: A New Method of Burning Crude Oil. W. K. JANSSEN. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 12, pp. 569–570.

Dezincification of Brass Pipe. E. B. STORY. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 653–659.

Engineering Advice in Making Electric Power Contracts. A. L. JOHNSTON, JR. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 366–369.

Ferro-Manganese: Bibliography of the Manufacture of Ferro-Manganese. E. C. BUCK. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, pp. 638–642.

Fertilizer Industry and the Potato Situation. H. G. BELL. *The American Fertilizer*, Vol. 47 (1917), No. 11, pp. 28–31.

Fertilizers—An Interpretation of the Situation in the U. S. J. E. POGUE. *The American Fertilizer*, Vol. 47 (1917), No. 10, pp. 25–35.

Flotation: Status of the Flotation-Patent Litigation. R. C. CANBY. *Engineering and Mining Journal*, Vol. 104 (1917), No. 22, pp. 951–959.

Flotation Tests with Hardwood Oils. R. E. GILMOUR AND C. S. PARSONS. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 763–764.

Fuel: Methods for More Efficiency in Utilizing Our Fuel Resources. H. G. BARNHURST. *General Electric Review*, Vol. 20 (1917), No. 12, pp. 924–931.

Fuel Oil: Practical Details in Burning Fuel Oil under Boilers. H. J. KENNEDY. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 370–383.

Furnace Refining of Copper. LAWRENCE ADDICKS. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 10, pp. 579–584.

Grinding Wheels: Economical Use of Grinding Wheels. W. T. MONTAGUE. *The Iron Trade Review*, Vol. 61 (1917), No. 22, pp. 1153–1159.

Heap-Leaching of Copper-Sulfide Ore. C. DEKALB. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 749–757.

Industrial Power on the Pacific Coast. H. J. KENNEDY. *Industrial Management*, Vol. 54 (1917), No. 2, pp. 214–224.

Industrial Waste—A Tax Paid to Ignorance. W. N. BERKELEY. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 321–322.

Manganese: Utilizing Domestic Manganese Supplies. EDMUND NEWTON. *The Iron Age*, Vol. 100 (1917), No. 22, pp. 1290–1292.

Miami: The Smelting of Ore. T. A. RICKARD. *Mining and Scientific Press*, Vol. 115 (1917), No. 22, pp. 784–796

Mill Pumping Stations. A. W. ALLEN. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 11, 629–631.

Oxide of Zinc. G. E. STONE. *Mining and Scientific Press*, Vol. 115 (1917), No. 21, pp. 759–762.

Peat Production in 1916. J. S. TURP. *The American Fertilizer*, Vol. 47 (1917), No. 11, pp. 35–36.

Photographic Research Laboratory. C. E. K MEES. *The Scientific Monthly*, Vol. 5 (1917), No. 6, pp. 481–496.

Physical Analysis of Refractory Material. COSMO JOHNS. *Blast Furnace and Steel Plant*, Vol. 5 (1917), No. 12, pp. 563–566.

Power Plant: Improving Power-Plant Operation through Instruction. H. A. FISHER. *Industrial Management*, Vol. 54 (1917), No. 3, pp. 393–395.

Pyrite in Northern New York. D. H. NEWLAND. *Engineering and Mining Journal*, Vol. 104 (1917), No. 22, pp. 947–948.

Refractories: Industrial Uses of Refractories. H. C ARNOLD. *The Iron Trade Review*, Vol. 61 (1917), No. 23, pp. 1212–1217.

Rosin Size: The Cooking Process in the Manufacture of Rosin Size. J. A. DECEW. *Pulp and Paper Magazine*, Vol. 15 (1917), No. 46, p. 1072.

Slide Rules: Design of Special Slide-Rules. A. L. JENKINS. *Industrial Management*, Vol. 54 (1917), No. 2, pp. 241–248.

Sulfur: Recovery of Sulfur from Illinois Coals. J. E. POGUE *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 10, pp. 584–585.

Tungsten: New Derivatives of Tungsten. J B HILL. *Chemical News*, Vol. 116 (1917), No. 3225, pp. 235–238.

War Work of the Technical Societies. C. W. RICE *The Iron Trade Review*, Vol. 61 (1917), No. 21, pp. 1100–1102.

Wood: Economic Importance of Wood Preservation. K. C. BARTH. *Engineering and Mining Journal*, Vol. 104 (1917), No. 23, pp. 985–990

MARKET REPORT—DECEMBER, 1917

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON DEC. 20

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	6.00 @	6.05
Alum, ammonia, lump	100 Lbs.	4.00 @	4.50
Aluminum Sulfate, high-grade	Ton	60.00 @	80.00
Ammonium Carbonate, domestic	Lb.	11 @	11¼
Ammonium Chloride, white	Lb.	15 @	17
Aqua Ammonia, 26°, drums	Lb.	18 @	19
Arsenic, white	Lb.	15 @	16
Barium Chloride	Ton	65.00 @	70.00
Barium Nitrate	Lb.	9½ @	11
Barytes, prime white, foreign	Ton	28.00 @	30.00
Bleaching Powder, 35 per cent	100 Lbs.	2.00 @	2.25
Blue Vitriol	Lb.	9⅛ @	9¼
Borax, crystals, in bags	Lb.	7¼ @	8
Boric Acid, powdered crystals	Lb.	12¾ @	14
Brimstone, crude, domestic	Long Ton	nominal	
Bromine, technical, bulk	Lb.	60 @	65
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00 @	23.00
Caustic Soda, 76 per cent	100 Lbs.	6.75 @	7.00
Chalk, light precipitated	Lb.	5½ @	6
China Clay, imported	Ton	18.00 @	30.00
Feldspar	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered	Ton	35.00	
Fuller's Earth, domestic	Ton	8.50 @	15.00
Glauber's Salt, in bbls.	100 Lbs.	1.00 @	1.50
Green Vitriol, bulk	100 Lbs.	1.00 @	1.05
Hydrochloric Acid, commercial, 20°	Lb.	2 @	2½
Hydrochloric Acid, C. P., conc., 22°	Lb.	2½ @	2¾
Iodine, resublimed	Lb.	4.25 @	4.30
Lead Acetate, white crystals	Lb.	17 @	19
Lead Nitrate	Lb.	nominal	
Litharge, American	Lb.	9½ @	10
Lithium Carbonate	Lb.	1.50	
Magnesium Carbonate, U. S. P.	Lb.	18 @	20
Magnesite, "Calcined"	Ton	60.00 @	65.00
Nitric Acid, 40°	Lb.	8¾ @	9
Nitric Acid, 42°	Lb.	9 @	10
Phosphoric Acid, 48/50%	Lb.	7½ @	8
Phosphorus, yellow	Lb.	1.90 @	2.00
Plaster of Paris	Bbl.	1.50 @	1.70
Potassium Bichromate, casks	Lb.	45 @	46
Potassium Bromide, granular	Lb.	1.45 @	1.46
Potassium Carbonate, calcined, 80 @ 85%	Lb.	45 @	55
Potassium Chlorate, crystals, spot	Lb.	42 @	45
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%	Lb.	82 @	84
Potassium Iodine, bulk	Lb.	2.90	
Potassium Nitrate	Lb.	28 @	30
Potassium Permanganate, bulk	Lb.	4.10 @	4.15
Quicksilver, flask	75 Lbs.	115.00 @	120.00
Red Lead, American, dry	Lb.	10 @	10½
Salt Cake, glass makers'	Ton	30.00 @	35.00
Silver Nitrate	Oz.	53 @	56
Soapstone, in bags	Ton	10.00 @	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.90 @	3.00
Sodium Acetate	Lb.	18 @	19
Sodium Bicarbonate, domestic	100 Lbs.	2.50 @	2.60
Sodium Bichromate	Lb.	17 @	18
Sodium Chlorate	Lb.	24½ @	25
Sodium Fluoride, commercial	Lb.	18 @	19
Sodium Hyposulfite	100 Lbs.	1.75 @	2.00
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.60 @	4.75
Sodium Silicate, liquid, 40° Bé	100 Lbs.	1.75 @	2.00
Sodium Sulfide, 60%, fused, in bbls.	Lb.	4½ @	5
Sodium Bisulfite, powdered	Lb.	6¾ @	7
Strontium Nitrate	Lb.	22 @	30
Sulfur, flowers, sublimed	100 Lbs.	4.05 @	4.06
Sulfur, roll	100 Lbs.	3.70 @	4.15
Sulfuric Acid, chamber, 66° Bé	Ton	nominal	
Sulfuric Acid, oleum (fuming)	Ton	60.00 @	65.00
Talc, American white	Ton	15.00 @	18.00
Terra Alba, American, No. 1	100 Lbs.	85 @	90
Tin Bichloride, 50°	100 Lbs.	23.75 @	24.75
Tin Oxide	Lb.	72 @	74
White Lead, American, dry	Lb.	9 @	9½
Zinc Carbonate	Lb.	25 @	30
Zinc Chloride, commercial	Lb.	10½ @	11
Zinc Oxide, American process XX	Lb.	14 @	15

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls.	Lb.	70 @	75
Acetic Acid, 56 per cent, in bbls.	Lb.	11 @	11½
Acetic Acid, glacial, 99½%, in carboys	Lb.	35 @	36
Acetone, drums	Lb.	35 @	36
Alcohol, denatured, 180 proof	Gal.	80 @	82
Alcohol, sugar cane, 188 proof	Gal.	5.05 @	5.25
Alcohol, wood, 95 per cent, refined	Gal.	1.35 @	1.40
Amyl Acetate	Gal.	5.25 @	5.50
Aniline Oil, drums extra	Lb.	26 @	27
Benzoic Acid, ex-toluol	Lb.	3.20 @	3.30
Benzol, Pure	Gal.	43 @	45
Camphor, refined in bulk, bbls.	Lb.	76½ @	77½
Carbolic Acid, U. S. P., crystals, drums	Lb.	53 @	54
Carbon Bisulfide	Lb.	7½ @	8
Carbon Tetrachloride, drums, 100 gals.	Lb.	14 @	16
Chloroform	Lb.	63 @	65
Citric Acid, domestic, crystals	Lb.	75 @	78
Creosote, beechwood	Lb.	1.90 @	2.00
Cresol, U. S. P.	Lb.	18 @	20
Dextrine, corn (carloads, bags)	Lb.	7 @	8
Dextrine, imported potato	Lb.	18 @	20
Ether, U. S. P. 1900	Lb.	27 @	30
Formaldehyde, 40 per cent	Lb.	19 @	20
Glycerine, dynamite, drums included	Lb.	62 @	64
Oxalic Acid in casks	Lb.	45 @	46
Pyrogallic Acid, resublimed, bulk	Lb.	3.15 @	3.25
Salicylic Acid, U. S. P.	Lb.	1.25 @	1.30
Starch, cassava	Lb.	—	
Starch, corn (carloads, bags) pearl	100 Lbs.	6.30 @	6.45
Starch, potato, Japanese	Lb.	10¾ @	11
Starch, rice	Lb.	10 @	12
Starch: sago flour	Lb.	6½ @	7½
Starch, wheat	Lb.	5¾ @	6½
Tannic Acid, commercial	Lb.	50 @	60
Tartaric Acid, crystals	Lb.	78½ @	79

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	54 @	60
Black Mineral Oil, 29 gravity	Gal.	18 @	19
Castor Oil No. 3	Lb.	32 @	33
Ceresin, yellow	Lb.	nominal	
Corn Oil, crude	Lb.	— @	—
Cottonseed Oil, crude, f. o. b. mill	Gal.	1.30 @	1.35
Cottonseed Oil, p. s. y.	Lb.	18.60 @	18.70
Menhaden Oil, crude (southern)	Gal.	— @	—
Neat's-foot Oil, 20°	Gal.	2.50 @	2.60
Paraffin, crude 118 to 120 m. p.	Lb.	10½ @	11
Paraffin Oil, high viscosity	Gal.	35 @	36
Rosin, "F" Grade, 280 lbs.	Bbl.	7.10 @	7.20
Rosin Oil, first run	Gal	35 @	36
Shellac, T. N.	Lb.	59 @	60
Spermaceti, cake	Lb.	25	
Sperm Oil, bleached winter, 38°	Gal.	1.85 @	2.00
Spindle Oil, No 200	Gal.	34 @	35
Stearic Acid, double-pressed	Lb.	24 @	25
Tallow, acidless	Gal.	1.57 @	1.62
Tar Oil, distilled	Gal.	34 @	35
Turpentine, spirits of	Gal.	47 @	48

METALS

Aluminum, No. 1, ingots	Lb.	38 @	40
Antimony, ordinary	Lb.	15 @	15½
Bismuth, N. Y.	Lb.	2.85 @	2.90
Copper, electrolytic	Lb.	23½ @	—
Copper, lake	Lb.	23½ @	—
Lead, N. Y.	Lb.	6¼ @	6½
Nickel, electrolytic	Lb.	55 @	56
Platinum, refined, soft	Oz.	105.00	
Silver	Oz.	85⅞ @	86
Tin, Straits	Lb	nominal	
Tungsten (WO₃)	Per Unit	23.00 @	25.00
Zinc, N. Y.	Lb.	7⅜ @	7¾

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.30 @	7.35
Blood, dried, f. o. b. Chicago	Unit	6.60 @	6.65
Bone, 3 and 50, ground raw	Ton	32.00 @	35.00
Calcium Cyanamid	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian	100 Lbs.	—	
Castor Meal	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works	Unit	6.50 @	10
Phosphate, acid, 16 per cent	Ton	16.00 @	16.50
Phosphate rock, f. o. b. mine		5.50 @	6.50
Florida land pebble, 68 per cent	Ton	2.25 @	2.50
Tennessee, 78–80 per cent	Ton	5.50 @	6.00
Potassium "muriate," basis 80 per cent	Ton	350.00 @	355.00
Pyrites, furnace size, imported	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	6.25 @	10

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | FEBRUARY 1, 1918 | No. 2

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY, M. C. WHITAKER

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

OFFICERS FOR 1918:
Dr. Nichols—Leader in Chemical Industry 92

EDITORIALS:
On with the Investigation 93
Somebody, Please Cut the Tape 94
Platinum Oscillations 95
An Appreciation and a Greeting 95
Chemistry Insignia 95

ORIGINAL PAPERS:
The Extraction of Potash and Other Constituents from Sea Water Bittern. Joel H. Hildebrand 96
The Direct Heat Treatment of Cement Mill Dust to Increase Its Water-Soluble Potash Content. Albert R. Merz 106
Effect of Coal Ash on the Liberation and Nature of Cement Mill Potash. N. S. Potter, Jr., and R. D. Cheesman 109
Toluol Recovery and Standards for Gas Quality. R. S. McBride 111
Catalysts in Vulcanization. D. Spence 115
Vulcanization of Rubber by Selenium. Charles R. Boggs 117
The Pigments of the Tomb of Perneb. Maximilian Toch 118
The Preparation of $N/100$ Permanganate Solutions. J. O. Halverson and Olaf Bergeim 119
The Use of Microörganisms to Determine the Preservative Value of Different Brands of Spices. Freda M. Bachmann 121
Disinfection with Formaldehyde. A Substitute for the Permanganate-Formalin Method. C. G. Storm 123
Effect of Fertilizers on Hydrogen-Ion Concentration in Soils. F. W. Morse 125
The Seeds of the *Echinocystis Oregana*. Milo Reason Daughters 126
Variation in the Ether Extract of Silage. L. D. Haigh 127

LABORATORY AND PLANT:
Some Methods of Analysis for Nebraska Potash Salts and Brines. A. H. McDowell 128
Suggestions on Some Common Precipitations. George H. Brother 129
A New Portable Hydrogen Sulfide Generator. W. Faitoute Munn 130
An Automatic Hydrogen Sulfide Stopcock. Carl H. Classen 131
A Simple and Efficient Filtering Tube. William M. Thornton, Jr. 132

ADDRESSES:
The Automatic Control and Measurement of High Temperatures. Richard P. Brown 133
Airplane Dopes. Gustavus J. Esselen, Jr. 135
The Collaboration of Science and Industry. V. Grignard 137

PERKIN MEDAL AWARD:
Introductory Address. Jerome Alexander 138
Mr. A. J. Rossi and His Work. F. A. J. FitzGerald 138
Presentation Address. William H. Nichols 140
Address of Acceptance. Auguste J. Rossi 141

BRITISH PROGRESS IN DYESTUFF MANUFACTURE:
British Dyes Limited. James Falconer, M. P. 145
Levenstein Limited 149

CURRENT INDUSTRIAL NEWS:
Platinum in Spain; Tungsten in Malaya; Tubular Cycle Components; Magneto Machines for Pocket Torches; Thermit Welding; Refractory Properties of Magnesia Bricks; Prevention of Scale in Boilers; Electric Heat Storage in Boilers; British Board of Trade; Mineral Production of Victoria; Manufacture of Electrodes; Recovery of Potash and Magnesia from Canadian Lake; Fluxes; Waterproof Varnish from Oil; Shellac Derivatives; Cellulose Turpentine; Substitute for Oil in Paint; Dye from Sulfite Lyes; Electric Arc Welding 150

SCIENTIFIC SOCIETIES:
Reduction of Waste; Seventy-Fifth Annual Meeting American Association for the Advancement of Science, Pittsburgh, Pa., December 28, 1917—January 2, 1918; American Metric Association; Annual Meeting Technical Association of the Pulp and Paper Industry, New York City, February 5–7, 1918; New York Section of the Société De Chimie Industrielle 153

NOTES AND CORRESPONDENCE:
Two Letters on the Chemical Control of Ammonia Oxidation; Avoidable Waste in the Production of Sulfuric Acid by the Chamber Process; Bromine Process Decision; United States Tariff Commission Inquiry in Regard to Chemical Industries; Special Chemicals and Apparatus Available through the Chemistry Committee of the National Research Council; As to Platinum; Platinum Resolutions; Fuel for Manufacture of Chemicals; A Study of the Estimation of Fat in Condensed Milk, Etc.—Correction; Composition of Loganberry Juice and Pulp—Correction; Chemists and the Draft 155

WASHINGTON LETTER 160
PERSONAL NOTES 161
INDUSTRIAL NOTES 162
GOVERNMENT PUBLICATIONS 165
BOOK REVIEWS 167
NEW PUBLICATIONS 169
MARKET REPORT 170

OFFICERS FOR 1918

The following officers have been elected by the American Chemical Society for the year 1918:

President: William H. Nichols, General Chemical Company, New York City.

Directors: H. E. Barnard, State Laboratory of Hygiene, Indianapolis, Ind.; and G. D. Rosengarten, Powers-Weightman-Rosengarten Co., Philadelphia, Pa.

Councilors-at-Large: H. E. Howe, A. D. Little, Inc., Cambridge, Mass.; G. A. Hulett, Princeton University, Princeton, N. J.; W. A. Noyes, University of Illinois, Urbana, Ill.; and Allen Rogers, Pratt Institute, Brooklyn, N. Y.

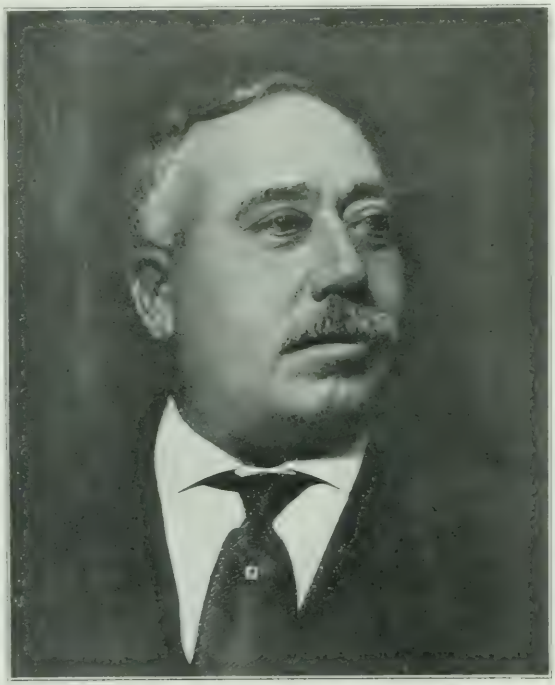
DR. NICHOLS—LEADER IN CHEMICAL INDUSTRY

By C. F. Chandler

Dr. William H. Nichols was one of the small group of New York chemists who, in 1876, originated this by far the largest chemical society in the world. It now has 51 local sections and approximately 11,000 members, and publishes three distinct chemical journals.

Dr. Nichols was born January 9, 1852, in Brooklyn, N. Y. He graduated from the Brooklyn Polytechnic Institute in 1868 and then entered New York University, where he had the good fortune to study chemistry under Dr. John W. Draper, the first President of the American Chemical Society. He received his B.S. in 1870. In 1873 he received his M.S. from the same institution; in 1904, LL.D. from Lafayette and Sc.D. from Columbia. In 1912 he was decorated by the King of Italy with the Order of Commendatore of the Crown of Italy. He was president of the English Society of Chemical Industry 1904–1905 and of the Eighth International Congress of Applied Chemistry held in Washington and New York in 1912.

In 1870, when only eighteen years old, he founded his own chemical business under the title G. H. Nichols and Company, using his father's name because he was not yet of age. Later the business was incorporated as the Nichols Chemical Company.



William H. Nichols, President American Chemical Society

The instincts of the pioneer in Dr. Nichols led to the origin in his plant of many ideas and appliances used in chemical industry to-day, for example, the well-known practice of storing and transporting sulfuric acid in steel.

The manufacture of sulfuric acid from pyrites was first carried out profitably in the Nichols Chemical Works at Laurel Hill. The pyrites used contained some copper and the search for the proper metallurgical treatment of it led to the invention of methods still employed for smelting such ores and also to the devising of a method for analyzing copper by electrolysis, which was the foundation of the industry of the electrolytic refining of copper. These processes for smelting and refining copper ores were so successful that the business grew rapidly to such dimensions that in 1898 it was transferred to a special company, the Nichols Copper Company, of which Dr. Nichols is president. The works, located on Newtown Creek, Brooklyn, constitute one of the most extensive copper plants in the world. In 1899, the chemical branch of the business went into the General Chemical Company.

The superior executive ability of Dr. Nichols shows in the success he has had in such enterprises as the rehabilitating of the Granby Consolidated Mining, Smelting and Power Company, Ltd., [illegible]ing it into one of the best-managed copper companies in the world; the recent organizing of the National Aniline and Chemical Company, Inc., looking to the permanent relief of American textile manufacturers and others; the bringing of a new lease of life to his Alma Mater, the Polytechnic Institute of Brooklyn, which seemed to be on the decline but is to-day a school of engineering of high mark, due largely to the good work of Dr. Nichols.

With all these business activities Dr. Nichols has acted as chairman of the Committee on Chemicals for the government and just recently has been appointed by Secretary Lane chairman of the Committee of Chemists advisory to the Bureau of Mines.

New York City

EDITORIALS

ON WITH THE INVESTIGATION

The massing of German reinforcements from the East on the western front led Winston Churchill, British Minister of Munitions, in an address at the American Luncheon Club recently, to exclaim:

"America! Come and aid us with all your might and speed, for this is a matter for action on the largest scale ever planned. * * We are sure to win the whole of President Wilson's program if we will utilize all our resources fully." Such an appeal, coming from a member of a race strong in self-reliance and bull-dog tenacity, must sink deep into the heart of every American.

That we have lacked speed in many of our preparations has been shown clearly by the investigations of the Senate Committee on Military Affairs. The reports show that the Committee felt fully capable of probing deep into the supply of cannon, machine guns and rifles, but when the subject of ammunition for such arms, and particularly of the basic chemicals needed in its manufacture, was approached, the investigation seemed at once to veer from so technical a subject. This is not difficult to understand, and yet we feel that the Committee can perform further public service if it will extend its investigations to cover thoroughly this field, particularly as to acetic acid for aeroplane dope and toluol for high explosives.

Enormous quantities of acetic acid are needed immediately, and until this is supplied the aviation program will be held up. The present total output of this product is already engaged for the Navy and our Allies. New factories must be built for further output. With the liberty motor completed, with all arrangements made for the supply of spruce wood in abundance, the startling fact remains that, unless action has been taken within the twenty-four hours previous to this writing, not even the method of manufacture of the necessary acetic acid has been decided upon, much less has the erection of any plant begun. In view of the tremendous difficulties of plant construction in these times, it is appalling to think of the delays ahead in this work which even in peace times and under normal conditions would prove an extremely formidable undertaking. It looks as if someone has blundered seriously, especially when we reflect upon the unprecedented speed with which Congress at the outset appropriated $650,000,000 for the aviation service.

The fundamental importance of toluol, the great need for it in the production of high explosives, and the method of its manufacture by stripping gas are well understood at the present time. Appropriations have been available since the adjournment of the previous session of Congress. Nearly six months have elapsed since the conference was held in Washington between representatives of the War Department, the gas producers, and the public service commissions. Yet to-day there are many gas plants with which no final arrangements have been made by the War Department for the erection of scrubbers to strip the gas. That this condition is not due to lack of coöperation by the companies is indicated in a letter to us from Brig.-Gen. William H. Crozier. Under date of October 17, 1917, he states: "We have received a ready response to coöperate with us from every company that we have written to so far." We have been informed by the Ordnance Department that for the present at least negotiations for the installation of apparatus for the recovery of toluol will not be conducted with gas plants whose capacity would be less than 40,000 gallons per year. It would be interesting to learn through a public investigation how far these negotiations have resulted in actual contracts and inauguration of construction work, and what dates such contracts bear. Unfortunately we are not in position to give much detailed information on this point, but we know of one contract which has been shifting forward and backward for months, and is not yet signed. Whether the delay in settling the petty features of the contract is due to the attitude of the manufacturer or to the methods of the War Department it is not for us to judge, but we do know that the construction firm in question would not be at all adverse to an investigation of the reasons for this delay. When all is said, it is not a question of this or that manufacturer; if any such firm delays the prompt execution of government plans, turn aside from him and get a contractor who will start the work promptly. It is toluol that is needed, and not the saving of a few cents per gallon in its production. It would seem that officials of the War Department are still following the leisurely ways of contract making characteristic of peace times, while material which may be of the utmost importance at a critical moment is now being burned, and can never be recovered.

Of course the decision to use mixtures of toluol and ammonium nitrate for high explosives relieves the situation somewhat, nevertheless the ammonia plants are not yet completed. We have upon us the responsibility of supplying not only the needs of our own Army, but of aiding in every way possible those of our Allies. This applies particularly to Italy, fighting so resolutely to-day, its very existence immediately threatened.

If it be held that toluol recovery must not exceed nitration capacity because of lack of storage tanks, will not the War Department contemplate the many cases of seemingly autocratic procedure adopted by government officials during the last few weeks, acts which have been accepted cheerfully by the country because they were war measures? In the light of such procedure the storage question can readily be solved by commandeering some of the many storage tanks scattered throughout the country and now filled with petroleum products. Can anyone doubt the relative value to ourselves and our Allies of a half dozen such storage tanks filled on the one hand with kerosene, or on the other hand with toluol? Then too, is the

War Department certain that the nitration capacity of the country is not in excess of toluol recovery, or that it will not be so by the time the recovery plants are installed? Already the coal shortage has seriously diminished the production of toluol from the by-product coke ovens, until now the chief source of supply.

This country can possess no more valuable reserve than ample quantities of stored toluol. Another Halifax disaster, the bombing of a few munitions stations, the sinking of a few supply ships stored with this material might at any moment make a serious shortage, a shortage which would be criminal with all the lives at stake, if the possibility of such can be avoided. On with the investigation! Senator Chamberlain can perform a distinct service if through his Committee he can speed up matters in the supply of such materials. The country will hereafter crucify with its scorn any manufacturer who now seeks to profiteer at its expense in this its hour of trial. So, too, will the country hold accountable those of its public servants who dilly-dally over minor details in fundamental matters.

SOMEBODY, PLEASE CUT THE TAPE

If the National Retail Merchants' Association should arbitrarily rule that all would-be purchasers of hats must be supplied with the hat most convenient to the reach of the clerk in attendance, without regard to the shape, color or size of the hat, what manner of Easter parade would result from males and females thus adorned! Or suppose the Amalgamated Employment Bureau should decree that seekers of help could secure only "the next on the list," regardless of qualifications. What would eventually result to the regular processes of commercial life if, seeking a stenographer, one should draw a cook! These suggestions are not intended to reflect on the good qualities of the number six hat on the seven and a half head or on the abilities of the domestic in her proper sphere. Wait a minute—these cogitations are not trivial.

Burns was all right when he wrote "A Man's a Man for a' That," but there are all kinds of men and there are all kinds of chemists: analytical and research chemists, organics and inorganics, chemists fresh from the universities and chemists who have been able to add to their university training valuable plant experience. Some have specialized in explosives, others in metal alloys. Some are accurate in analytical work, others excel in planning research. If, however, a government department, bureau or division wishes to increase its chemical force by securing the transfer of a specially qualified chemist from a cantonment to a government laboratory, such coördinate branch of the government service must send out to the camps and simply ask for a chemist. Chemists must not be sought by name. To request a specially qualified man, designating the man you want, is no longer permitted. Such is the ruling of the General Staff of the Army, to which ruling the War Department has strictly adhered for some weeks past. Shades of common-sense America, what an absurd situation! Is this the final outworking of the spirit of the selective draft which President Wilson assured us was to fashion this nation into the most efficient fighting machine, which law, the record of these columns will testify, we have striven steadfastly to uphold? Is Secretary Baker aware of this ruling, a ruling which was not brought into being three thousand miles away, but right in the city of Washington in his own Department?

The results of such procedure are not only disaster to government chemical work but serious demoralization of the staffs of the chemical industries, which are supplying the very sinews of war. This can be illustrated best by two specific cases. A colonel in the Ordnance Department wrote recently to a prominent chemical manufacturing company stating that the Department was desirous of securing the services of a number of chemists and factory foremen for use as inspectors at munitions plants. He specified that they should have had such experience as would enable them to carry out intelligent inspection of explosives manufactured for the government in this emergency. The manufacturer was asked to go over his organization and advise as to any men who might be available and whom he could recommend. That is all right from one point of view. Of course the government must have competent inspectors, and chemical manufacturers are just as patriotic as other men and will gladly sacrifice their staffs if need be. That is the real question, "if need be." There are more than three hundred chemists in cantonments to-day, practically inaccessible for government chemical work because of this remarkable ruling of the General Staff. One of these is a graduate of two leading American universities, in each of which he specialized in chemistry. Furthermore he has had three and a half years of experience in research and in the manufacture of explosives, dyestuffs and pharmaceuticals, and is familiar with the installation and operation of chemical machinery. Yet his daily duties consist of scrubbing floors, shoveling coal or cinders, chopping wood, digging ditches (not trenches) and general work around the stable or kitchen.

We do not seek to arouse sympathy for this young soldier chemist. He is having a good experience and loyally doing his duty as any other young American would; his clear eye and soldierly bearing show, too, that he has made good as a soldier. He makes not the slightest complaint. But we do feel that the government is not getting from him the most efficient service he could perform; and it is a shame for a similarly qualified man to be taken at this time from the industries for government work while such a man could be made available in a few hours were it not for the weird ruling of the General Staff.

Sixteen thousand chemists at the outbreak of the war filed with the Bureau of Mines complete data concerning their training and specialization in order that their services might be promptly and intelligently availed of as need arose. Alas, these cards of voluntary information are now bound tightly together by the red tape of this rule-beyond-understanding promulgated by the General Staff.

Somebody, please cut the tape!

PLATINUM OSCILLATIONS

At the recent meeting of Section C (Chemistry) of the American Association for the Advancement of Science at Pittsburgh the platinum resolution (page 159, this issue), introduced by Mr. George F. Kunz, of Tiffany & Co., New York City, was unanimously passed. To present this matter to the proper authorities a committee was appointed consisting of Dr. W. A. Noyes, Chairman, and Dr. W. F. Hillebrand.

The admirable suggestions contained in the resolution will appeal immediately to every chemist in university or technical laboratories. Unfortunately for the ray of hope held out by this movement, Dr. Hillebrand, of the Bureau of Standards, in declining to serve upon the committee, felt compelled to take this step because of his knowledge that all of this platinum supply is needed immediately by the government, and has indeed already been turned over to the Nitrate Committee for catalyzer purposes in the oxidation of ammonia. There seems, at least for the present, no hope that the use of residues for research on the platinum group of minerals can be undertaken, as the question of government ownership of this material is undetermined.

The accounts of the energy, resourcefulness, and peregrinative ability of Mr. Draper, who safely transported from Russia 21,000 ounces of platinum and platinum ore and delivered it to the Department of Commerce, furnish very interesting reading and command unquestioned appreciation of his achievement. The necessity for such a journey, however, suggests further thought as to the accuracy of judgment of the Secretary of Commerce, who last Spring, evidently while this material was being collected, gave ample assurances to the jewelers of the country that the government had an abundance of platinum, either on hand or available from stocks known to be existing abroad, which statement was heralded very widely by the Jewelers' Committee. We tremble to think of the fix the government might have been in if Mr. Draper had stubbed his toe in going aboard ship and spilled the precious metal into the sea, or had lost his trunk in the mazes of the Union Station baggage room in Washington, or had met with the same delay in express shipments which the average citizen encounters nowadays. Seriously, we have been running very close to the danger line in government supplies of this material for munitions manufacture, while the advertising campaign for platinum jewelry has gone merrily on. Meanwhile, the university and industrial chemist cannot hope for relief from the present high prices of platinum ware from the source contemplated by the resolution of Mr. Kunz.

The communication from Dr. Jas. Lewis Howe, printed in this issue, views the platinum situation solely from the standpoint of "business as usual," an antiquated slogan whose pernicious effect upon war programs has already made itself plainly evident.

Two new methods of attacking the problem of platinum conservation have developed. Individuals and local Sections can use their influence with the local press to persuade them to refuse advertisements of platinum jewelry. The *New York Times* and the *New York World* have adopted such a policy, and it it is a pleasure to state that this has been done on the urgent appeal of Mr. Kunz, who is endeavoring to bring all of the New York newspapers into line.

The second interesting development is the recent organization of the Women's National League for the Conservation of Platinum. May the good work of this new organization prosper in every way. It is for women that this platinum jewelry is designed; it is through women that its use can be most effectually discountenanced. Perhaps through this League the real punch will be put into the platinum conservation movement.

AN APPRECIATION AND A GREETING

The appearance of the January number of the *Journal of the American Chemical Society* marks the retirement of Dr. W. A. Noyes from its editorship and the entrance upon his duties of the newly elected editor, Dr. A. B. Lamb.

After fifteen years of splendid service, Dr. Noyes carries with him on retirement universal grateful appreciation of the devotion he has shown to the upbuilding of that Journal. To its list of contributors he has called all of the research workers in pure chemistry in this country. As a result of his accurate and conscientious editorial work the publication stands to-day as one of the great chemical journals of the world.

In assuming his new task, Dr. Lamb may feel confident of the continuation of that spirit of coöperation which in the past has proved so potent a factor in the success of the Journal. He has, moreover, the solid satisfaction of knowing that not only was he the unanimous choice of the Council, but that such choice was based upon the unanimous report of a committee of our ablest men who canvassed the field with closest scrutiny. The fact that Dr. Lamb begins his editorship while devoting much of his time to government service constitutes an additional reason for loyal support.

CHEMISTRY INSIGNIA

For the first time in the history of the United States an Army group will wear a design typifying chemistry as a recognized branch of war service. Through the courtesy of the manufacturers we are the proud possessors of the first insignia and collar design struck from the dies.



OFFICER ENLISTED MAN

INSIGNIA FOR CHEMICAL SERVICE

From the record of attainments of the first men selected to wear such insignia it can be predicted with certainty that they will be worthily worn.

Good luck to the Chemical Service Section of the National Army!

ORIGINAL PAPERS

THE EXTRACTION OF POTASH AND OTHER CONSTITUENTS FROM SEA WATER BITTERN[1]

By Joel H. Hildebrand

Received December 5, 1917

COMPOSITION OF SEA WATER

The main constituents of sea water, besides sodium chloride, are magnesium sulfate, magnesium chloride and potassium chloride, together with a small quantity of magnesium bromide and calcium salts. During the evaporation of the sea water to secure sodium chloride, the calcium present is almost completely deposited as calcium sulfate, so that calcium salts are practically absent from the mother liquor. By considering the various analyses of sea water we may calculate the relative amounts of the solid salts that might be obtained by evaporation. The salt works around San Francisco Bay, with which we are primarily concerned, produce something over 100,000 tons of sodium chloride per annum; the amounts of the other salts associated with this amount of sodium chloride would be as follows:

	Tons
Sodium chloride (NaCl)	100,000
Potassium chloride (KCl)	2,800
Magnesium chloride ($MgCl_2.6H_2O$)	27,300
Epsom salts ($MgSO_4.7H_2O$)	16,000
Bromine (Br) extracted from the bromides	240

At this time, when the country is suffering from an acute shortage of potassium salts, the amount of potassium chloride indicated above is of considerable importance. During the first half of 1917 the total potash production of the country, calculated on the basis of K_2O, was 14,000 tons, which amount was but 10 per cent of the normal amount used before the war. It is evident that the amount of potash that could be extracted from the bitterns of the salt works on San Francisco Bay alone would add about 10 per cent to the country's present annual production of potash. The amount of salt actually produced in this region is nearly 140,000 tons per annum, so that a liberal allowance for losses in working up the bittern should leave still 3000 tons of potassium chloride. By utilizing the bitterns from other regions on the Pacific Coast, notably San Diego, this amount would be very greatly increased.

The other materials mentioned in the above table also represent very considerable values, although they have less relation to the present national emergency.

After the removal of most of the common salt in the salt ponds, the other salts would be contained in approximately 100,000 tons of bittern, having a volume of approximately 100,000 cubic yards.

The values represented by these materials, and their importance both as a natural resource of California and in supplying the country with potash in the present acute emergency, made the study of this problem seem a proper one to undertake at this time.

[1] This work has been supported by the Council of Defense of the State of California.

SCIENTIFIC BASIS OF METHODS FOR RECOVERY OF THE CONSTITUENTS OF BITTERN

We are very fortunate to possess a vast fund of information upon the solubility relationships of the various salts obtainable from sea water through the classic work of van't Hoff and his co-workers. This work is described in great detail in "Über die Bildungsverhältnisse der ozeanischen Salzablagerungen" (Leipzig Verlagsgesellschaft, 1912). During the progress of the work two smaller volumes were published in 1905 and 1909 by van't Hoff, entitled "Zur Bildung der ozeanischen Salzablagerungen" (Braunschweig, Vieweg).

Inasmuch as very little of this work has been translated into English, and in view of the difficulty of interpreting it in its formidable complexity, it seems desirable to give a general outline of its nature.

The solubility of a single salt in its relation to changes in temperature may be represented by simple diagrams of the type familiar to all trained chemists.

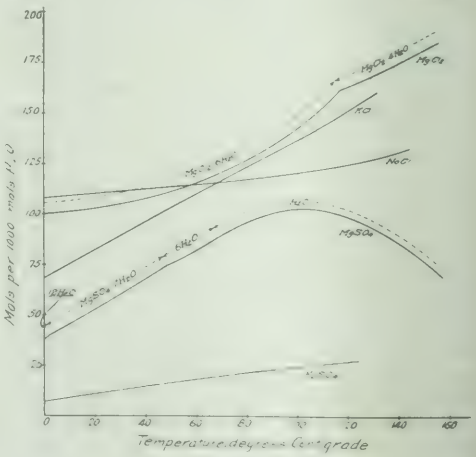


Fig. 1

In Fig. 1 are represented the solubility curves for the main salts with which we have to deal, *viz.*, sodium chloride, potassium chloride, potassium sulfate, magnesium sulfate and magnesium chloride. In this figure solubility is expressed as the number of mols of anhydrous salt per 1000 mols of water. Of course, other units may be used, such as mols or grams of salt in a certain number of grams of water or of solution, or in a certain number of cubic centimeters in solution. If we know the solubility expressed in any of these terms it is possible to calculate it in any other terms, the density of the solution being required where the conversion is between a weight and volume basis.

The laws of dilute solutions may frequently be extended to give an approximate idea of the behavior of concentrated solutions. The solubility of a given

salt is varied by the introduction into the solution of another salt. The effect of the second salt can be predicted qualitatively by remembering that where the salts possess a common ion the solubility of each is usually decreased by the presence of the other. If, however, there is a strong tendency to form a complex salt the solubility of one may be increased by the presence of the other. Again, where there is no common ion the solubility of one is increased by the presence of the other owing to the interaction of the two salts.

There are various ways of representing graphically the solubility relationships of salt pairs. The method adopted by van't Hoff is to represent the amount of each salt in the solution in terms of mols of anhydrous salt per 1000 mols of water, measured along two axes at right angles to each other, as illustrated in Fig. II. Each curve here represents the composition of a solution saturated with one component. The intersections of the curves represent the composition of a solution saturated with both components. A point between these curves and the origin denotes the composition of an unsaturated solution. A point outside of the curves would represent a mixture of a saturated

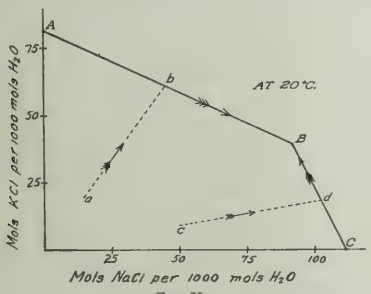


FIG. II

solution with one or both solid salts, depending upon its position. On evaporation of an unsaturated solution the relative amounts of the two salts would remain the same until the solution becomes saturated, so that, for example, a solution having the composition represented by the point *a* in Fig. II would, on evaporation, change in composition as represented by the motion along the line *ab*. As soon as the curve *AB* is reached, representing in this case the composition of a solution saturated with potassium chloride, solid potassium chloride will separate and the solution must become relatively richer in sodium chloride, so that as the evaporation proceeds from *b* the solution will change in composition along the solubility curve towards *B*. Similarly, an unsaturated solution having the composition represented by *c* would, on evaporation, change in composition as represented by movement along the line *cd*. At *d* sodium chloride would begin to crystallize, whereupon the solution would become richer in potassium chloride, its composition changing along the line *dB*. It is evident that the final result in the evaporation of any solution of these two salts would be a saturated solution having the composition represented by *B*, changing into a mixture of the two solid salts.

The effect of temperature may be indicated on a third axis at right angles to the others, giving a solid figure, as represented in perspective in Fig. III.

Where a double salt may be formed, the solubility relationships at a given temperature would be represented by a diagram such as that in Fig. IV. This diagram represents the solubility at 30° of mixtures of sodium sulfate decahydrate, and magnesium sulfate heptahydrate, which form the double salt, astrakanite, $Na_2Mg(SO_4)_2.4H_2O$. The middle portion of the curve seen in this figure represents the composition of solutions saturated with astrakanite. Solid astrakanite, which contains equivalent quantities of the two salts, has a composition lying upon a line bisecting the angle between the two axes. The composition of the solid salt is represented by a point on this line at *E*, expressing the number of mols per 1000 mols of water in the solid salt. The composition of solid sodium sulfate, $Na_2SO_4.10H_2O$, which lies along the line *OA*, is at a distance from the origin corresponding to its water content at *F*. Similarly, solid magnesium sulfate has the composition represented by the point

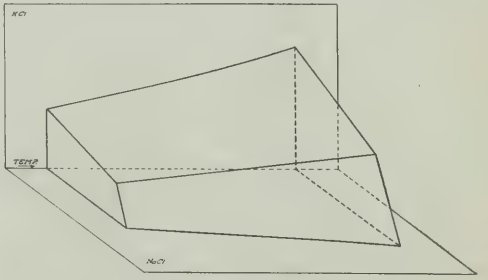


FIG. III

G. When an unsaturated solution containing these salts is evaporated, its composition will, as in the previous case, move along a line away from the origin until one of the curves representing the composition of the saturated solution is reached, when the solution will change in composition along this line in the direction away from the line representing the composition of the solid which is separating. Thus a solution having the composition represented by *a* would, on evaporation, change in composition along the line *ab*, when, on further evaporation, sodium sulfate would separate, and finally, at *B*, both sodium sulfate and the double salt would separate, the solution remaining constant in composition until it had all disappeared. Similarly an unsaturated solution of composition represented by *c* would change in composition in the direction *cdB*, the solids separating being first pure astrakanite and then a mixture of astrakanite and sodium sulfate. The point *B* represents, therefore, the end-point of crystallization for solutions which contain more sodium sulfate than magnesium sulfate.

Fig. V represents the solubility of mixtures of magnesium chloride and potassium chloride, from which

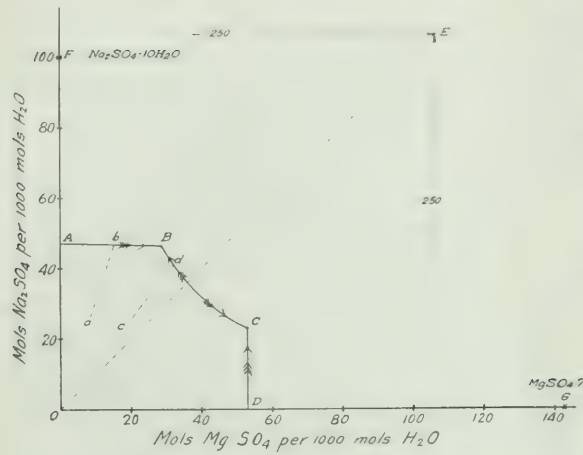


FIG. IV

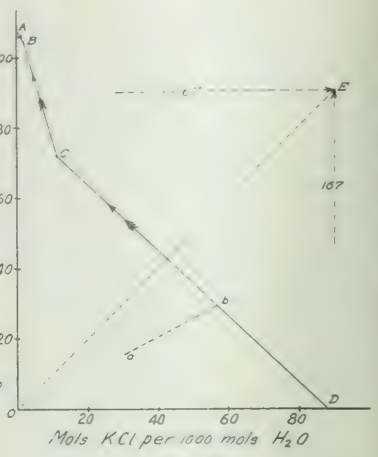


FIG. V

it is possible to crystallize the double salt carnallite, $KMgCl_3.6H_2O$. Unlike the previous instance, however, the line *OE*, somewhere upon which lies the point representing the composition of solid carnallite, does not intersect the curve *BC* which expresses the composition of solutions saturated with carnallite. This fact makes the path of crystallization, during the evaporation of solutions of these two salts, somewhat different from that considered above. A solution having the composition represented by *a* will, on evaporation, change in composition till *b* has been reached, whereupon potassium chloride begins to crystallize out, and the solution, becoming richer in magnesium chloride, will move along *bC*. When the solution has reached the composition represented by *C*, carnallite will begin to separate, but since carnallite contains more potassium chloride than does the saturated solution at *C*, it is evident that while carnallite crystallizes, the solution will tend to move along the line *CB* instead of remaining at *C*. The phase rule, however, requires that while both potassium chloride and carnallite are present, the solution must remain constant in composition at *C*. Therefore, instead of the liquid phase disappearing at this point, as was the case in the former salt pair, it is one of the solid phases, potassium chloride, which will now disappear, being changed over into carnallite. It is not until all of the potassium chloride has been so changed that the solution can move from *C* to *B*. *B* will thus represent an end point of crystallization, while *C* will not. It is evident, therefore, that in order to prepare crystals of carnallite it is necessary to use a solution containing more than the equivalent amount of magnesium chloride, the relative amounts of the two salts being such that, on evaporation, the line *BC* will be intersected slightly above *C*. Similar considerations show us that on treating solid carnallite with water, instead of dissolving as such, it would tend to change into solid potassium chloride and a solution whose composition is that represented by *C*. It is obvious, therefore, that it is not difficult to obtain potassium chloride from carnallite, a point of importance in the treatment of salt bitterns, as will be discussed later. After the removal of the potassium chloride the solution can be evaporated, carnallite separating, while the composition of the solution changes from *C* to *B*. This carnallite can be treated with water, leaving solid potassium chloride, etc.

Solutions containing magnesium and potassium chlorides and sulfates are in equilibrium with solid phases at 25° according to the data in Table 1, and are

TABLE 1
System, KCl–$MgCl_2$–K_2SO_4–$MgSO_4$, at 25°

	Solid Phases	Composition of Solution: Mols of constituents per 1000 mols H_2O			
		K_2Cl_2	$MgCl_2$	$MgSO_4$	K_2SO_4
A	KCl	44	...	..	..
B	$MgCl_2.6H_2O$	..	108	..	..
C	$MgSO_4.7H_2O$	..	...	55	..
D	K_2SO_4	..	..	..	12
E	KCl and $KMgCl_3.6H_2O$	5.5	22.5	..	..
F	$MgCl_2.6H_2O$ and $KMgCl_3.6H_2O$	1	105	..	..
G	$MgCl_2.6H_2O$ and $MgSO_4.6H_2O$	..	104	14	..
H	$MgSO_4.7H_2O$ and $MgSO_4.6H_2O$	..	73	15	..
I(*a*)	$MgSO_4.7H_2O$ and $K_2Mg_2SO_4.6H_2O$	..	...	58.5	5.5
K	K_2SO_4 and $K_2Mg_2SO_4.6H_2O$	..	...	22	16
L	K_2SO_4 and KCl	42	..	..	1.5
M	KCl, K_2SO_4 and $K_2Mg_2SO_4.6H_2O$	35	21	11	..
N	KCl, $MgSO_4.7H_2O$ and $K_2Mg_2SO_4.6H_2O$	9	55	16	..
P	KCl, $MgSO_4.7H_2O$ and $MgSO_4.6H_2O$	8	62	15	..
Q	KCl, $MgSO_4.6H_2O$ and $KMgCl_3.6H_2O$	4.5	70	13.5	..
R	$MgCl_2.6H_2O$, $KMgCl_3.6H_2O$ and $MgSO_4.6H_2O$	2	90	12	..

(*a*) The composition of the solution at this point is given by different figures in van't Hoff's earlier and later works. The latter are doubtless incorrect, as the former agree with those of H. [illegible] van Klooster, *J. Phys. Chem.*, **21** (1917), 513.

represented by van't Hoff along four axes, as in Fig. VI, each pair of axes representing solutions containing a common ion. The boundary lines correspond to solutions saturated with the two constituents represented by the enclosing axes. Where salt pairs containing no common ion are present it is impossible to represent the composition by a point in the plane of this figure. A mixture of [illegible] quantities of potassium sulfate and magnesium chloride would evidently lie at the origin *O* and would be indistinguishable from pure water by its position in the plane. In order to make this distinction it is necessary to intro-

duce a vertical axis representing the sum of the constituents of the solution. Again, since equivalent quantities of potassium sulfate and magnesium chloride in solution may be represented equally well as equivalent amounts of magnesium sulfate and potassium chloride, by plotting along the potassium chloride axis not mols of potassium chloride, but double mols, namely, K_2Cl_2, it is possible to construct a solid model expressing the composition of solutions containing any amounts of these ions. Such a model, a perspective drawing of which is seen in Fig. VII, may be constructed by inserting needles at the intersections of the lines in the plane figure, the heights of the needles being equal to the total number of mols of dissolved salt in the solution at this point, always remembering to consider the mol of potassium chloride to be K_2Cl_2. The tops of these needles may be connected by threads which mark off surface within which a saturated solution is in equilibrium with a single salt. Along the threads

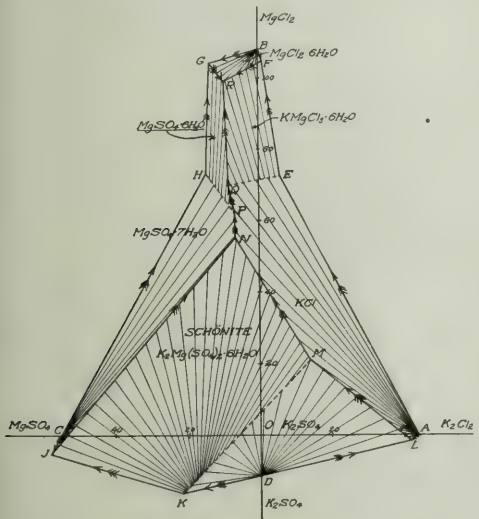


FIG. VI

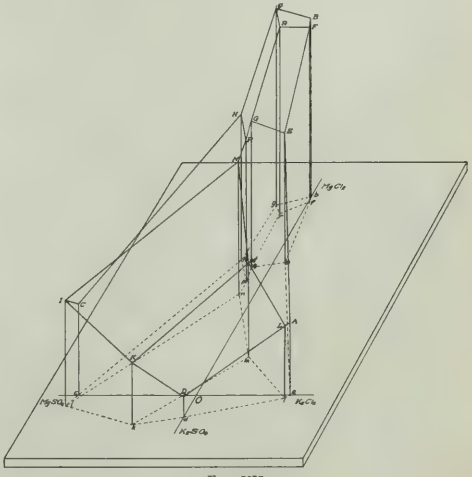


FIG. VII

separating two fields the solution is saturated with two salts, while at the intersections three salts are present. The composition of unsaturated solutions is represented by points within the model. For example, a solution containing 2 mols of K_2Cl_2, 8 mols of $MgSO_4$ and 10 mols of $MgCl_2$ will be represented by a point found by counting 2 divisions along the potassium chloride axis, 8 divisions to the left in the direction of magnesium sulfate, which would then be 6 divisions to the left of the magnesium chloride axis, 10 divisions along the magnesium chloride axis, and then upwards 20 divisions, representing the total number of mols. This solution could also be represented as containing 6 mols of magnesium sulfate, 12 mols of magnesium chloride, and 2 mols of potassium sulfate, which would give the same locus to the point. On the removal of water from this solution all of the solid constituents will increase in the same proportion, so that the solution would move along the line in space away from the origin O until one of the fields is reached representing the separation of a solid salt. Further evaporation would then result in a change in composition of the solution equivalent to the removal of a saturated solution of the solid which is separated, since both this solid and water are being removed simultaneously. The composition of the solution would thus move along one of the faces of the model until one of the boundary lines has been reached, when a second salt would begin to separate along with the first. The solution would then change in composition as represented by motion along this line. By drawing lines on these surfaces it is possible to represent in the projection of the solid model such crystallization paths, so that the projection may be used in many cases instead of the solid model.

It is possible to calculate in this way the amounts of the various solid salts and the amount of water which have separated from any solution when a certain point on a crystallization path has been reached. Thus, in the case of the solution considered above, the diagonal which joins the origin with the point representing the composition of this solution will be found to intersect the schönite face, showing that this would be the first salt to separate on evaporation. As evaporation proceeds the crystallization path would meet the boundary line of this face with the magnesium sulfate face, after which these two salts would separate together. Suppose, for example, we wish to calculate the actual amounts of these two salts separating and the amount of water that must be removed when the point N has just been reached, at which potassium chloride just begins to separate. The solution at N has the following composition: $1000H_2O + 9K_2Cl_2 + 16MgSO_4 + 55MgCl_2$. The amount of this solution we may represent as an unknown quantity by p, the amount of schönite separating we may represent by q, the magnesium sulfate by r, and the amount

of water removed by s. We may then represent what has become of the original solution during evaporation by means of the following equation:

$$1000H_2O + 8MgSO_4 + 10MgCl_2 + 2K_2Cl_2 = p\,1000H_2O + 16MgSO_4 + 55MgCl_2 + 9K_2Cl_2) + q(K_2Mg(SO_4)_2.6H_2O) + r(MgSO_4.7H_2O) + sH_2O$$

By equating coefficients of the various substances present, it is possible to set up the following equations:

Coefficients of H_2O: $1000 = 1000p + 6q + 7r + s$
Coefficients of Mg: $18 = 7tp + q + r$
Coefficients of K_2: $2 = 9p + q$
Coefficients of Cl_2: $12 = 64p$

The solution of these equations gives the following values:

$$p = 0.188;\ q = 0.31;\ r = 4.38;\ s = 779$$

These values of q, r and s represent the amounts of the respective substances which have separated by evaporating the original solution and p represents the amount of solution left. If, instead of taking the

TABLE 2
System, NaCl–KCl–$MgCl_2$–$MgSO_4$–Na_2SO_4, at 25°

Saturation with NaCl and	Mols per 1000 Mols H_2O				
	Na_2Cl_2	K_2Cl_2	$MgCl_2$	$MgSO_4$	Na_2SO_4
O	55.5	...	...	...	...
A $MgCl_2.6H_2O$	2.5	...	103	...	...
B KCl	44.5	19.5	...	...	...
C Na_2SO_4	51	...	...	...	12.5
D $MgCl_2.6H_2O$, Carnallite	1	0.5	103.5	...	...
E KCl, Carnallite	2	5.5	70.5	...	...
F KCl, Glaserite	44	20	...	...	4.5
G Na_2SO_4, Glaserite	44	10.5	...	...	14.5
H Na_2SO_4, Astrakanite	46	...	...	16.5	3
I $MgSO_4.7H_2O$, Astrakanite	26	...	7	34	...
J $MgSO_4.7H_2O$, $MgSO_4.6H_2O$	4	...	67.5	12	...
K $MgSO_4.6H_2O$, Kieserite	2.5	...	79	9.5	...
L Kieserite, $MgCl_2.6H_2O$	1	...	102	5	...
M KCl, Glaserite, Schönite	23	14	21.5	14	...
N KCl, Schönite, Leonite	19.5	14.5	25.5	14.5	...
P KCl, Leonite, Kainite	9.5	9.5	47	14.5	...
Q KCl, Kainite, Carnallite	2.5	6	68	5	...
R Carnallite, Kainite, Kieserite	0.5	1	85.5	8	...
S Na_2SO_4, Glaserite, Astrakanite	26	8	16	...	22
T Glaserite, Astrakanite, Schönite	27.5	10.5	16.5	18.5	...
U Leonite, Astrakanite, Schönite	22	10.5	23	19	...
V Leonite, Astrakanite, $MgSO_4.7H_2O$	10.5	7.5	42	19	...
W Leonite, Kainite, $MgSO_4.7H_2O$	9	7.5	45	19.5	...
X $MgSO_4.6H_2O$, Kainite, $MgSO_4.7H_2O$	3.5	4	65.5	13	...
Y $MgSO_4.6H_2O$, Kainite, Kieserite	1.5	2	77	10	...
Z Carnallite, $MgCl_2.6H_2O$, Kieserite	0	0.5	100	5	...

No.	Field	Formula	Mineralogical Designation
1	ALZD	$MgCl_2.6H_2O$	Bischofite
2	BFPRQE	KCl	Sylvite
3	CGSH	Na_2SO_4	Thenardite
4	DZRQE	$KMgCl_2.6H_2O$	Carnallite
5	FMTSG	(1.33K 0.67Na)SO_4	Glaserite
6	SHIVUT	$Na_2Mg(SO_4)_2.4H_2O$	Astrakanite
7	VIJXW	$MgSO_4.7H_2O$	Epsom salts
8	IXYK	$MgSO_4.6H_2O$	Not found
9	KYRZL	$MgSO_4.H_2O$	Kieserite
10	TUNM	$K_2Mg(SO_4)_2.6H_2O$	Schönite
11	NUVWP	Mg(1.52K 0.48Na)$(SO_4)_2.4H_2O$	Leonite
12	PWXYRQ	$MgSO_4.KCl.3H_2O$	Kainite

amount of the original solution represented by 1000 mols of water, a different amount is taken, proportionate amounts of the solids and water are obtained from the solution on evaporation to the same point. When we come to consider the evaporation of sea water, we have in addition to the above components large amounts of sodium salts. Since during evaporation sodium chloride is always present, it is possible to represent saturated solutions such as are obtained on evaporating sea water by solid models similar to the one considered above. By introducing sodium chloride as another component no new degrees of freedom are introduced, provided it is stipulated that solid sodium chloride shall always be present. Van't Hoff and his co-workers have determined the solubility relationships at 25° and 83°. Fig. VIII represents the results for 25° contained in Table 2; results for 83° are found in Table 3 and Fig. IX. The amount of sodium chloride present is not considered in the projection, but is counted in the total number of dissolved mols which would be represented in a solid model. Sodium sulfate may be expressed in terms of the other salts present, since $Na_2SO_4 = Na_2Cl_2 + MgSO_4 - MgCl_2$, or, $= Na_2Cl_2 + K_2SO_4 - K_2Cl_2$. Thus point C, Table 2, is represented in Fig. VIII by counting $12^1/_2$ divisions to the left of the origin and $12^1/_2$ divisions along the K_2SO_4 axis. Its position in a space model would be $63^1/_2$ divisions vertically above the point so obtained. Such a model may be constructed in a way similar to that previously described.

The composition of sea water which has been evaporated until it is saturated with sodium chloride is as follows, expressed in mols of each constituent:

TABLE 3
System, NaCl–KCl–$MgCl_2$–$MgSO_4$–Na_2SO_4, at 83°

Saturation with NaCl and	Mols per 1000 Mols H_2O				
	Na_2Cl_2	K_2Cl_2	$MgCl_2$	$MgSO_4$	Na_2SO_4
O	59	...	...	..	..
A $MgCl_2.6H_2O$	1	...	121	..	..
B KCl	39	37	...	..	..
C Na_2SO_4	56.5	...	...	..	8
D $MgCl_2.6H_2O$, Carnallite	1	2	117	..	..
E KCl, Carnallite	1.5	10	92	..	..
F KCl, Glaserite	39.5	39	...	..	4.5
G Na_2SO_4, Glaserite	43.5	21	...	..	11.5
H Na_2SO_4, Vanthoffite	51	..	4.5	10.5	..
I Vanthoffite, Loeweite	35	..	22	12.5	..
K Loeweite, Kieserite	12.5	..	61.5	5.5	..
L Kieserite, $MgCl_2.6H_2O$	1	..	120	1	..
F KCl, Glaserite, Langbeinite	29.5	33.5	13	10	..
Q KCl, Carnallite, Kieserite	2	12	86.5	5	..
R KCl, Langbeinite, Kieserite	11	15	76	5	..
S Glaserite, Na_2SO_4, Vanthoffite	43	22.5	...	7.5	5.5
V Loeweite, Glaserite, Vanthoffite	34.5	26.5	8.5	17.5	..
W Loeweite, Glaserite, Langbeinite	30	24.5	12	16.5	..
Y Loeweite, Kieserite, Langbeinite	16	10.5	42	14	..
Z Carnallite, $MgCl_2.6H_2O$, Kieserite	1	2	116	1	..

No.	Field	Formula	Mineralogical Designation
1	ALZD	$MgCl_2.6H_2O$	Bischofite
2	BFPRQE	KCl	Sylvite
3	CGSH	Na_2SO_4	Thenardite
4	DZQE	$KMgCl_2.6H_2O$	Carnallite
5	FPWVSG	(K, Na)SO_4	Glaserite
6	HSVI	$MgNa_2(SO_4)_2$	Vanthoffite
7	IVWYK	$MgSNa_4(SO_4)_4.5H_2O$	Loeweite
8	KYRQZL	$MgSO_4.H_2O$	Kieserite
9	WPRY	MgK_2SO_4	Langbeinite

$1000H_2O$, $47Na_2Cl_2$, $1.03K_2Cl_2$, $7.36MgCl_2$, $3.57MgSO_4$

By the use of a solid model it is possible to determine that this solution, on further evaporation, would intersect the surface at the point a, where Epsom salts would begin to separate. The composition of the solution at this point is approximately $1000H_2O$, $11Na_2Cl_2$, $6K_2Cl_2$, $20MgSO_4$, $41MgCl_2$. Further evaporation would lead to the boundary between this field and the kainite field WX, after which these two salts would separate together. It is possible to calculate as before the amounts of each substance removed from the solution when the latter has the composition indicated, say, by X. Suppose that 10,000 g. of the original solution are used. The number of grams corresponding to the number of mols of each substance in the original solution is 24,790, so that 10,000 g. of solution would contain, instead of the previous number of mols of each constituent, only 0.404 of these quantities, namely, $404H_2O$, $19Na_2Cl_2$, $2.42K_2Cl_2$, $3MgCl_2$ and $1.44MgSO_4$. On evaporation this solution would yield p mols of the solution saturated at X, containing its constituents in the proportions indicated in Table 2, together with $qMgSO_4.7H_2O$ + rNa_2Cl_2 + $sKCl$.-

$MgSO_4.3H_2O + tH_2O$. We can, therefore, write the following equation:

$$404H_2O + 19Na_2Cl_2 + 0.42K_2Cl_2 + 3MgCl_2 + 1.44MgSO_4 = p(1000H_2O + 3.5Na_2Cl_2 + 4K_2Cl_2 + 65.5MgCl_2 + 13MgSO_4) + qMgSO_4.7H_2O + rNa_2Cl_2 + sKCl.MgSO_4.3H_2O + tH_2O$$

By equating corresponding coefficients and solving the resulting equations, we obtain the following values:

$p = 0.0458$; $q = 0.37$; $r = 18.9$; $s = 0.47$; $t = 354$

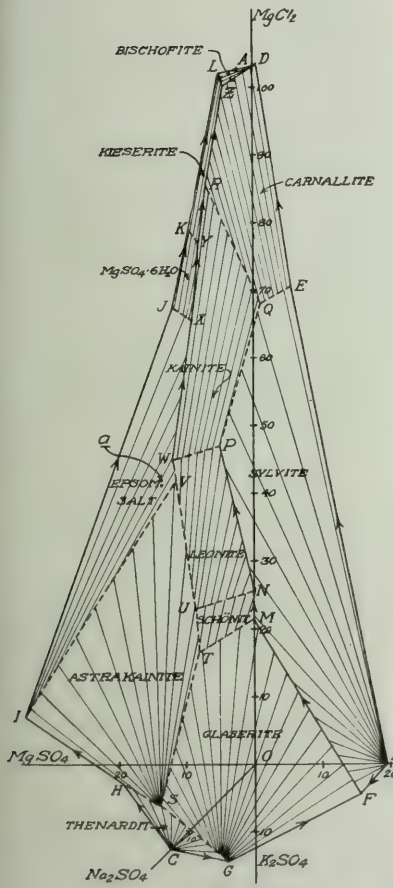


FIG. VIII

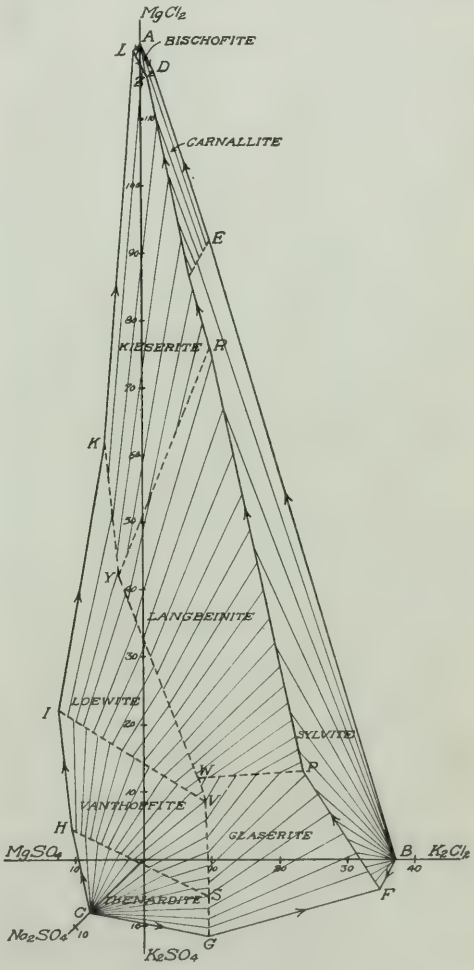


FIG. IX

Hence we conclude that 354 mols of water have been evaporated, and 0.37 mol of Epsom salts, 18.9 mols of Na_2Cl_2 and 0.47 mol of kainite are in the solid portion. Similar calculations may be made to determine what will happen during all sorts of changes. For example, instead of removing water, a certain salt may be added to a solution saturated with other salts, and by the aid of geometric and algebraic considerations it will be possible to determine what will take place.

It is evident from the position of point a in the diagram for 25° that only a small amount of Epsom salts will have been crystallized by evaporation of the mother liquor from sea water before kainite will begin to separate. It is true that kainite shows a great tendency to supersaturation, and unless suitable nuclei are present this field might not be present, which will allow the evaporation and separation of Epsom salts to continue somewhat further until the potassium chloride field is reached. The conditions obtaining in solar evaporation are, however, very favorable to the crystallization of such a substance because of the presence of many impurities. In order to get a good separation of the potassium salts from the magnesium

salts in the bittern of sea water it is not desirable to carry on the evaporation so as to separate more than a small amount of Epsom salts at 25°. On comparing Figs. VIII and IX it will be seen that at the higher temperatures it is possible to continue the evaporation much farther before any salt containing potassium will crystallize from the hot solution. At this temperature and in the presence of the magnesium chloride which exerts a dehydrating effect, instead of Epsom salts crystallizing, kieserite, $MgSO_4.H_2O$, is obtained. The fact that the solubility of magnesium sulfate tends to decrease at higher temperatures, while the solubilities of potassium chloride and magnesium chloride, and hence, carnallite, increase, causes the kieserite field at 83° to become large at the expense of the fields of potassium chloride and carnallite. It is evident, therefore, that most of the sulfate present in the solution could be removed as kieserite by evaporating the bittern at higher temperatures until the carnallite boundary is approached. During this evaporation, the solids which separate would be sodium chloride and kieserite. By removing these from the hot solution they could be obtained relatively uncontaminated with potassium. If, now, the mother liquor from these crystals is cooled, the growth of the carnallite field as lower temperatures are reached indicates that this salt would separate as the solution cools, while the mother liquor from the carnallite would consist largely of a solution of magnesium chloride. These considerations seem to indicate the possibility of a satisfactory process for the separation of the bittern into three main constituents: magnesium sulfate, carnallite, and a solution of magnesium chloride. There would remain the necessity, first, of separating magnesium sulfate from the sodium chloride accompanying it, second, of treating the carnallite for the recovery of potassium chloride, according to the principles discussed earlier, and, third, the evaporation and cooling of the magnesium chloride liquor to obtain $MgCl_2.6H_2O$.

EVAPORATION EXPERIMENTS

The process outlined above, on the basis of the equilibrium diagrams, was first tested on a laboratory scale by evaporating weighed quantities of bittern. In one set of experiments the evaporation was carried on at the boiling point of the solution. Crops of crystals were removed from the solution from time to time by centrifuging the liquid through a muslin bag. The density of the solution was read by the aid of a hydrometer made of pyrex glass, the small coefficient of expansion of which made its readings nearly correct in spite of changes of temperature. The boiling point was read with a thermometer graduated to one-tenth of a degree. The amount of water, when each reading of density and boiling point was made, was determined by weighing the vessel containing the hot solution. It will be seen from the results, plotted in Fig. X, that the density and boiling point rise gradually until water has been removed amounting to about 50 per cent of the weight of the original bittern. The density and boiling point from here on increase more rapidly with the further removal of water. This more rapid increase is caused by encountering the boundary of the carnallite field shown in Fig. IX, and the subsequent separation of carnallite. The crystals which are deposited from the solution after this point is reached contain a considerable amount of potassium in the form of carnallite. A calculation of the amount of water which should be removed in order to reach the carnallite boundary at 83° gave a figure corresponding very closely with that indicated by the above curve.

The original mother liquor at 25° is saturated both with sodium chloride and magnesium sulfate, but since the solubility of sodium chloride does not materially change with the temperature, whereas that of magnesium sulfate does increase during the first part of the evaporation, the solution is saturated with sodium chloride but not with magnesium sulfate, hence the first crystals to separate consist largely of sodium chloride, which was found to be the case with the aid both of the microscope and of a chemical analysis. It is possible, therefore, to remove an additional amount of sodium chloride from the magnesium sulfate by filtering the hot solution by the aid of the centrifuge during the early stages of the evaporation. This procedure simplifies the further purification of the

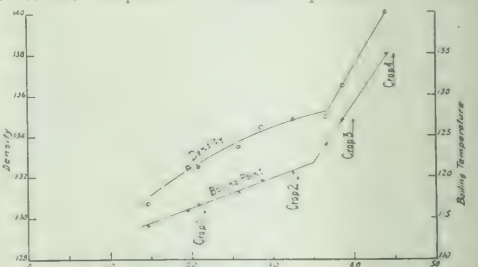


FIG. X—WATER EVAPORATED IN PER CENT OF BITTERN TAKEN

magnesium sulfate which separates as evaporation proceeds. Table 4 gives the results of the analysis of the crystals removed from the solution by the aid of the centrifuge at the stages of evaporation indicated in Fig. X.

TABLE 4

	Crop 1	Crop 2	Crop 3	Crop 4	Crop from cooled mother liquor from 4	Crop from final evaporation
$MgSO_4$	18.1	24.6	30.1	34.1	1.3	3.5
$MgCl_2$	12.0	12.3	21.8	27.9	39.2	38.2
KCl	4.8	6.3	4.4	17.1	3.6	1.1
NaCl	20.3	20.3	13.3	17.0	1.3	
H_2O	52.8	36.4	40.5	4.9	54.7	57.5

The centrifuge employed was not very efficient, and some cooling took place during the process, so that the respective crops are contaminated with the salts that should remain in the mother liquor. It is evident from the results of this analysis, together with the course of the density and boiling point curves, that the process contemplated furnishes the desired separation. In a second experiment, based upon the results of the first, the solution was evaporated until the density had reached a value of 1.35 at the boiling point of the solution, 121°. The crystals separating up to this point were removed and the mother liquor

allowed to cool. The crystals separating on cooling should be carnallite, and it will be seen from the analysis of these crystals in Table 5 that their composition approximates closely to that of carnallite. The mother liquor from the carnallite consists principally of a solution of magnesium chloride, as is confirmed by its analysis. The potassium content of the first two fractions may be attributed to the cooling in the centrifuge inevitable in working on such a small scale. As is to be expected, the proportion of $MgSO_4.H_2O$ to NaCl is greater in the second crop of crystals than in the first.

TABLE 5—COMPOSITION OF MATERIAL OBTAINED AT VARIOUS STAGES IN PER CENT

	B. p. 116°	Removed at b. p. 121°, d. 1.35	Removed from cooled liquor	Theoretical for carnallite	Final mother liquor
K	3.1	5.7	10.0	14.1	0.4
Cl	23.5	19.1	36.6	38.4	23.4
SO_4	16.9	32.2	trace	0.0	2.7
Mg	3.9	9.2	7.6	8.7	7.9

The curve given in Fig. XI was obtained by an evaporation in which no crystals were removed, thus avoiding the inevitable losses occurring through attempts to remove crystals from the hot solution. The break in the boiling-point curve in Fig. XI is at a higher temperature than that in Fig. X. This is doubtless due to the use of different samples of bittern in the two experiments, so that the carnallite field is encountered at different points in the two cases. It may be noticed that the break is more pronounced in the case where it occurs at the lower temperature which is just what would be expected on the basis of the solubility diagram in Fig. IX. The composition of the two samples of bittern used in the above experiments is given in Table 6. The sodium content is not given.

TABLE 6

	Bittern used in getting curves in Fig. X	in Fig. XI
K	1.48	1.76
Cl	15.82	18.22
SO_4	5.81	3.88
Mg	5.38	6.32

OUTLINE OF PROPOSED PROCESS

1. EVAPORATION OF THE BITTERN—The bitterns from various sources will vary somewhat depending on the temperature of the liquid in the last salt pond, and whether or not any Epsom salts are allowed to separate. There is, in fact, no reason apparent why a crop of Epsom salts should not be removed by cooling, either artificially or by storage till winter, before the subsequent process of separation is applied. The process of solar evaporation should not, however, be carried far enough to cause any potassium salts to crystallize, as it is probably not desirable to separate the potassium content into two portions. The variations in the composition of the bittern caused by any of the above factors would not cause any serious difficulty, as during the later evaporation the separation of NaCl and $MgSO_4.H_2O$, kieserite, would take place in such proportion as to make the resulting liquid converge towards a fairly uniform composition.

It is more important, under present conditions, to recover all of the potassium salts, and hence to prevent their contaminating the NaCl and kieserite fraction, than it is to recover all of the Epsom salts, or to obtain pure magnesium chloride from the final liquor. Such contamination would result, if the evaporation were continued as far as the carnallite boundary, for some cooling during the separation of the kieserite from the mother liquor is inevitable, and if the solution is saturated with carnallite before this separation begins, some of it will crystallize along with the kieserite. On the other hand, if the evaporation is not continued so far, a little of the sulfate will remain in the solution, and will probably pass through the succeeding operations and come down with the magnesium chloride at the final stage of the process. Since very pure magnesium chloride will probably not be desired, the presence of this sulfate can do no harm.

Instead, therefore, of continuing the evaporation as far as the break in the boiling-point curves, as in Figs. X and XI, it will doubtless be better to evaporate till the boiling point is about 120° C. This will result in the recovery of practically all of the carnallite and still allow leeway for variations in the bitterns used.

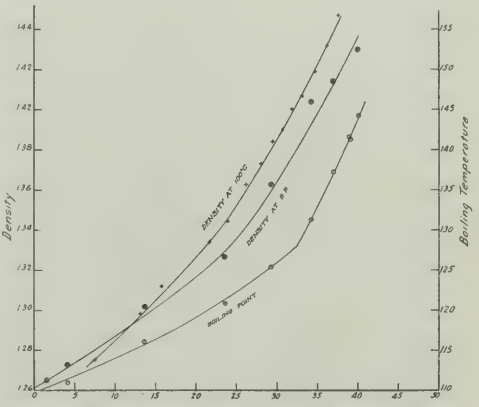


FIG. XI—WATER EVAPORATED IN PER CENT OF BITTERN TAKEN

The best type of evaporator for this operation will doubtless be of the film type, where a given part of the liquid is not boiling for a very long time. There is a tendency for magnesium chloride to hydrolyze, giving magnesium hydroxide and hydrochloric acid, which escapes with the steam. If the liquid is evaporated in a kettle it is boiling for such a length of time that a considerable amount of magnesium hydroxide is formed. If, on the other hand, the liquid is allowed to flow over a heated surface, the evaporation taking place very quickly, there is little time for this hydrolysis to take place. This liquid may then be kept in a settling tank without further loss of hydrochloric acid, even near the boiling temperature, provided actual boiling does not take place.

In principle, then, the process indicated is as follows: Evaporate until the boiling point of the liquid is raised to about 120° C. and the density is approximately 1.35. The liquid running off from the evaporator should be caught in a steam-jacketed tank

where it is allowed to settle. The clear liquor is allowed to run off to a cooling tank, in which the carnallite will separate. The sludge of NaCl and kieserite is run into centrifuges, previously heated, where it is separated from the adhering mother liquor, which is run into the cooling tank mentioned above. The separation of the NaCl from the material remaining in the centrifuges and the recovery of Epsom salts will be discussed later.

2. THE RECOVERY OF THE CARNALLITE—The liquor containing the carnallite may be cooled by the fresh bittern going to the evaporator, in order to utilize the heat content of the latter. After it has been thoroughly cooled, the carnallite which has separated is removed and freed from its mother liquor by centrifuging. The recovery of the potassium chloride from this carnallite will be discussed later.

3. THE RECOVERY OF BROMINE AND MAGNESIUM CHLORIDE—The mother liquor from the carnallite contains a very little potassium, a little sulfate, a considerable amount of colloidal organic matter, the bromine content of the sea water, and a large amount of magnesium chloride. The liquid must be evaporated further in order to recover $MgCl_2.6H_2O$. During this evaporation, however, the temperature rises considerably, unless vacuum evaporation is employed, charring the organic matter, and strongly darkening the magnesium chloride which separates on cooling. To destroy this organic matter, therefore, as well as to recover the bromine, preliminary treatment with chlorine is desirable. The details of this treatment are now the subject of investigation in this laboratory. We can only say at the present time that there seems to be good prospect of success.

The disposal of the large quantities of magnesium chloride that would be obtained from these bitterns presents an economic problem. The possible outlets seem to be as follows: magnesium oxychloride cement, magnesium oxide and hydrochloric acid, and metallic magnesium. The use of magnesium oxychloride cements might be greatly increased by skilful advertising, hydrochloric acid might be substituted for sulfuric acid, for certain purposes, and there seems to be good reason to anticipate a large production of magnesium in the future.

4. THE SEPARATION OF SODIUM CHLORIDE AND MAGNESIUM SULFATE—The separation of the sodium chloride and the kieserite obtained in the first part of the process is complicated by the possibility of forming astrakanite, $Na_2Mg(SO_4)_2.4H_2O$, at ordinary temperatures and of loeweite, $Na_4Mg_2(SO_4)_4.5H_2O$, or vanthoffite, $Na_6Mg(SO_4)_4$, at higher temperatures. In order to put the separation of the magnesium from the sodium salts on an exact basis it is desirable to have a knowledge of the solubility relationships of the chlorides and sulfates of these two metals. It has been found possible, by using data given by van't Hoff, Seidell[1] and Roozeboom,[2] to construct the equilibrium diagram for all but two points which are unimportant for the present purpose. The data used are given in Table 7, and are represented graphically in Fig. XII, giving a diagram similar to that in Fig. VI, where potassium chloride is considered instead of sodium chloride. The two undetermined points have been added more or less at random, for the sake of completing the fields, and are denoted by interrogation marks on the figure.

Now the material obtained from the first stage of our process contains $MgSO_4$ and NaCl in nearly equivalent amounts, and hence, if dissolved in water, would be represented by a point lying nearly vertically above the origin, at a distance increasing as the solution is evaporated. It might, therefore, cut the surface of the solid model in the astrakanite face, which would prevent the separation of the sodium from the magnesium. A little magnesium chloride, however, would, if added, raise the solution away from the astrakanite

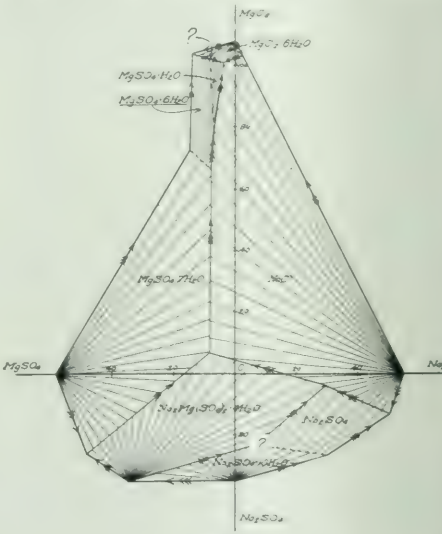


FIG. XII

field, so that we would have only NaCl and $MgSO_4.7H_2O$ to deal with.

The solubilities of these two salts are affected so differently by the temperature that we may anticipate their separation by first cooling, removing Epsom salts, then evaporating partly at higher temperatures, removing sodium chloride, then cooling again, etc. The portion of the equilibrium diagram that can be constructed for 83° from van't Hoff's data shows that at that temperature loeweite and vanthoffite intrude themselves between the magnesium sulfate and sodium chloride fields, even when a considerable amount of magnesium chloride is added, so that it may not be advisable to evaporate the solution for the removal of sodium chloride at too high a temperature. The great tendency of these double salts towards supersaturation might allow the evaporation to proceed without their formation.

[1] *Am. Chem. J.*, **27** (1902), 52; see also Schreinemakers and Baat, *Z. physik. Chem.*, **67** (1909), 533.

[2] *Z. physik. Chem.*, **2** (1888), 518.

TABLE 7

System, $NaCl$–$MgCl_2$–$MgSO_4$–Na_2SO_4, at 25°

Solid phases	Na_2Cl_2	$MgCl_2$	$MgSO_4$	Na_2SO_4
Na_2Cl_2	55.5	...	..	..
$Na_2SO_4.10H_2O$	..	...	..	35.5
$MgSO_4.7H_2O$	..	..	58	..
$MgCl_2.6H_2O$	..	108	..	..
$MgCl_2.6H_2O$; Na_2Cl_2	2.5	103	..	..
Na_2Cl_2; Na_2SO_4	51	...	..	12.5
Na_2SO_4; $Na_2SO_4.10H_2O$(*)	30	...	..	27
$Na_2SO_4.10H_2O$; $Na_2Mg(SO_4)_2.4H_2O$	..	...	35	35
$MgSO_4.7H_2O$; $Na_2Mg(SO_4)_2.4H_2O$	..	...	48	26
$MgSO_4.7H_2O$; $MgSO_4.6H_2O$	..	73	15	..
$MgSO_4.6H_2O$; $MgSO_4.H_2O$	Not determined			
$MgSO_4.6H_2O$; $MgCl_2.6H_2O$	..	104	14	..
Na_2Cl_2; Na_2SO_4; $Na_2Mg(SO_4)_2.4H_2O$	46	...	16.5	3
Na_2SO_4; $Na_2SO_4.10H_2O$; $Na_2Mg(SO_4)_2.4H_2O$	Not determined			
Na_2Cl_2; $MgSO_4.7H_2O$; $Na_2Mg(SO_4)_2.4H_2O$	26	7	34	..
Na_2Cl_2; $MgSO_4.7H_2O$; $MgSO_4.6H_2O$	4	67.5	12	..
Na_2Cl_2; $MgSO_4.6H_2O$; $MgSO_4.H_2O$	2.5	71	9.5	..
Na_2Cl_2; $MgSO_4.H_2O$; $MgCl_2.6H_2O$	1	102	5	..

(*) From the experimental work of Professor W. C. Blasdale, which is still in progress in this laboratory, this point may be considerably in error.

In order to have the desired data it is very important that the equilibria here involved should be determined for temperatures both lower and higher than 25°. Work on the solubilities at 0° is now in progress in this laboratory and will be published as soon as possible. It is planned, also, to include potassium salts in this work, so that a diagram for 0° similar to that in Fig. VIII can be constructed, and which might suggest a modification of the first treatment of the bittern.

5. THE RECOVERY OF POTASSIUM CHLORIDE FROM CARNALLITE—The recovery of potassium chloride from the carnallite was discussed earlier in connection with Fig. V. We may ask whether hot or cold water should be used for this purpose. A reference to the tables shows that the proportion of potassium chloride to magnesium chloride in the solution at equilibrium with potassium chloride and carnallite is much less at 25° than at 83°. This makes it obvious that a much smaller proportion of potassium chloride goes into solution at the lower temperature. The composition of the solution in equilibrium with potassium chloride and carnallite at 25° is as follows: $1000H_2O + 5.5K_2Cl_2 + 72.5MgCl_2$. From this it is possible to calculate the amount of water to be used in extracting the magnesium chloride from the carnallite at this temperature. If 1 mol of carnallite is used we can write the following equation:

$$KMgCl_3.6H_2O + xH_2O = yK_2Cl_2 + z(1000H_2O + 5.5K_2Cl_2 + 72.5MgCl_2)$$

From this we find $x = 7.8$; $y = 0.425$; $z = 0.0138$. That is, 1 mol, or 277.5 g. of carnallite, requires 7.8 mols, or 140.4 g. of water, or, the weight of water required is approximately half the weight of the carnallite. At the lower temperatures that would naturally be used somewhat more water would be required, but relatively less KCl would be dissolved.

The liquor used in extracting the carnallite may then be partly evaporated and cooled, whereupon another crop of carnallite crystals will be obtained. To obtain the maximum amount of carnallite but no magnesium chloride the solution should be evaporated to such an extent that on cooling with separation of carnallite its composition will correspond to point *B* in Fig. V, which is $1000H_2O + 105MgCl_2 + K_2Cl_2$. The amount of evaporation necessary is calculated from the following equation:

$$1000H_2O + 72.5MgCl_2 + 5.5K_2Cl_2 = xH_2O + yKMgCl_3.6H_2O + z(1000H_2O + 105MgCl_2 + K_2Cl_2)$$

This gives $x = 340$; $y = 9.8$; $z = 0.6$; hence 25720 g. of solution should lose 6120 g. of water, giving 2720 g. of carnallite on cooling; or, 1 ton of solution should lose 0.238 ton of water, and deposit 0.107 ton of carnallite.

It will probably not pay, here or in stage 2 of the process, to recover the small amount of potassium chloride remaining in the mother liquor from the carnallite.

Condensed summary of the above process:

Evaporate bittern till boiling point becomes about 120°, and density (hot) 1.35. Separate solid and liquid while hot (settling tank and centrifuge).

A. Solid. NaCl and $MgSO_4.H_2O$. Dissolve out NaCl with cold water (containing some $MgCl_2$?); dissolve residue in hot water and cool with ice machine, getting $MgSO_4.7H_2O$.

B. Liquid. Cool.

I. Solid carnallite. Extract with minimum amount cold water, leaving

1. Solid KCl.
2. Solution. Evaporate partly, cool.
   a. Solid carnallite, add to I.
   b. Solution of $MgCl_2$, add to II.

II. Solution, mainly $MgCl_2$. Bleach with Cl_2 and remove Br_2. Evaporate, cool, recover solid $MgCl_2.6H_2O$.

The above process is being tested in this laboratory on a semi-commercial scale under the direction of Professor Merle Randall, and will be described in a later publication. It may be mentioned, however, that an excellent separation of actual bittern has been obtained into one lot of material consisting of kieserite and sodium chloride, another consisting of carnallite of a high degree of purity and whiteness, and a mother liquor consisting of magnesium chloride solution containing but very small amounts of sulfate and of potassium. For example, using 150 lbs. of bittern, and evaporating till the boiling point was 118°, the three fractions of material obtained had the following composition:

	NaCl, Kieserite Fraction	Carnallite Fraction Found	Carnallite Fraction Theoretical	Mother Liquor
K	1.6	11.0	14.1	Trace
Cl	21.1	37.4	38.4	23.4
SO_4	22.2	0.4	0.0	1.25
Mg	10.0	8.1	8.7	...

The writer wishes, in conclusion, to express great appreciation for the cordial coöperation of the Oliver Salt Company, which has given information and has furnished samples of material and bittern.

Generous credit should be given to Messrs. A. H. Foster, W. D. Coughlan, Carl Iddings and W. D. Ramage for much of the experimental work herein described, and to Mr. Iddings for drawing the illustrations. Professor W. C. Bray has given considerable time to the final criticism of the manuscript and the checking of the figures necessitated by the absence of the author from Berkeley due to his acceptance of a commission in the army.

Since concluding the above work there has appeared in *Chemical Abstracts*, Vol. 11 (1917), 2719, a brief outline of a process by T. Nishimura, *J. Chem. Ind. Tokyo*, Vol. 20 (1917), 587, for extracting potassium from bittern which, apart from certain serious errors in translation, seems to be fundamentally similar to that herein described, and which we may welcome, therefore, as additional evidence of the feasibility of working up these bitterns instead of allowing them to be largely wasted, as at present.

BERKELEY, CAL.

THE DIRECT HEAT TREATMENT OF CEMENT MILL DUST TO INCREASE ITS WATER-SOLUBLE POTASH CONTENT

By Albert R. Merz

Received November 9, 1917

When a potash-containing silicate mixed with lime is ignited at temperatures above 1000°, the lime displaces more or less potash which is volatilized. This fact suggests a possible procedure for the immediate commercial production of potash from potash silicates. Since, however, commercial grades of any insoluble potash silicate in quantity contain comparatively small percentages of potash no process for recovering potash from such material can offer much promise of profitable application unless there is also produced some other product of value in addition to the potash. Fortunately, and by strange coincidence, the two manufacturing industries of this country which have the largest outputs are industries wherein raw materials which contain potash silicates are heated with limestone to temperatures so high that the potash is more or less displaced and volatilized. These two industries, *viz.*, the blast-furnace and Portland cement industries, are already firmly established and for them the problem becomes merely one of the successful recovery of the volatilized potash as a by-product. It may be stated that the chief potential source of potash in this country is the raw material which is or may be used in these industries.

Some potash is contained in all cement materials. In a recent publication by this Bureau[1] it was shown that in the raw mix as fed into the kiln the potash varies from 0.20 to 1.16 per cent in the various cement mills of the United States and Canada, and that the percentage of this potash driven from the kilns in the different plants varies from 24.5 to 95.9. From the results of the analysis of samples of raw mix and of cement from 102 plants it has been calculated that the potash escaping from the kilns of these plants ranges from 0.35 to 5.14 lbs. per barrel of cement produced with an average for the plants of this country of 1.93 lbs. On the basis of an average production of 90,000,000 bbls., the total potash escaping from the cement plants of this country, as at present operated, amounts to about 87,000 tons annually. The profitable recovery of this potash is not dependent upon successful collection alone, but it must be obtained in a form so concentrated as to be merchantable and at a cost sufficiently low to permit of a profit under normal market conditions. Three factors determine such profitable recovery and must be considered in any attempt advantageously to obtain potash as a by-product in the cement industry: liberation of the potash, recombination and collection.

A full discussion of the various conditions which affect the liberation of potash from the raw mix in the kiln and of the methods which have been devised to increase the percentage of potash volatilized is to be found in the publication already mentioned. Similarly the methods of collection of the potash that escapes from the kilns have received ample treatment in this bulletin. The work presented here deals with a method for making water-soluble the "recombined" potash of cement dust.

The recovery of the potash which escapes from the kilns of cement mills was first made by the Riverside Portland Cement Co., at Riverside, Cal., using the Cottrell process of electrical precipitation. The cement dust recovered at this plant was found to contain upward of 90 per cent of its potash in the water-soluble form. A sample of precipitator dust secured from this mill was analyzed by the author and found to give a total potash content of 10.7 per cent, and a water-soluble potash content of 9.8 per cent. The water-soluble potash of this particular dust was 92 per cent of the total potash present in the dust. It was natural to expect that the dust which would be recovered by a similar method at other plants would have a water-soluble potash content approximating the same percentage of the total potash present. It was found, however, when the Cottrell process was installed at the mill of the Security Cement and Lime Company, at Hagerstown, Md., that the dust collected contained a considerable portion of its potash content in a form which was not readily soluble in water. A sample of dust obtained from this plant was found to contain 11.4 per cent total potash, whereas the water-soluble potash content was but 6.8 per cent. Instead of the anticipated 90 per cent or over, this particular sample of dust contained but 60 per cent of its potash in water-soluble form. It has been found at another plant, the Alpha Portland Cement Company at Cementon, N. Y., where installation of the Cottrell process for the recovery of dust has been made, that the water-soluble potash in the dust recovered constitutes a considerably lower proportion of the total potash present than at the Security plant. A sample of the dust recovered at this mill was found by the author to contain 7.0 per cent total potash and only 2.9 per cent water-soluble potash This sample of dust, therefore, had but 41 per cent of its potash present in the water-soluble form.

The term "water-soluble potash" as used above refers to that potash which is obtained in solution by the procedure given in the "Methods of the Association of Official Agricultural Chemists," in accordance with which 10 g. of the sample are boiled with 300 cc. of water for 30 min. and the volume subsequently brought to 500 cc. As it is customary in the fertilizer trade to make payment for none other than this potash it becomes a matter of vital importance to the cement manufacturer who recovers his dust for sale to the fertilizer trade on the basis of its water-soluble potash content to ascertain the cause of the failure to secure the maximum amount of his potash in this form, to devise methods, if possible, to obtain most of the potash in his dust directly as water-soluble potash, to adopt some procedure which will profitably increase the water-soluble potash of his dust as at present obtained or, finally, to endeavor to secure from the fertilizer trade credit for that available potash of his dust which is but slowly water-soluble and for which at present he receives no compensation.

[1] W. H. Ross, A. R. Merz and C. R. Wagner, U. S. Department of Agriculture, *Bull.* 573.

As stated in a previous publication,[1] the potassium compounds occurring in cement dust may be divided into three groups: (1) those which are readily water-soluble; (2) those which are slowly soluble; and (3) those which are insoluble.

The insoluble potash represents the combinations occurring in the original silicates of the raw mix carried over mechanically in the dust before being subjected to a temperature sufficiently high to bring about decomposition. The form of combination which is slowly soluble in water has been attributed to the recombination of the volatilized potash with the finely divided incandescent particles of siliceous coal ash carried over in the dust[2] and it is claimed[3] to be proportional to the amount of coal ash present in the gases from the kiln. Where oil or gas is used for fuel this combination of the potash occurs in comparatively small amount but, where coal is used for burning, the extent to which the potash occurs in this 'recombined" form may be considerable. Of the three cement p'ants mentioned above, the Riverside Portland Cement Company uses oil for fuel while the Security Cement and Lime Company and the Alpha Portland Cement Company use coal in their operation. The insoluble potash is assumed to be that portion of the total potash which remains undissolved after the dust is boiled in a 5 per cent solution of hydrochloric acid. The difference between the total potash and the sum of the water-soluble and insoluble portions is taken as the slowly soluble or recombined potash. It has been shown by Nestell and Anderson[4] that continued extraction of cement dust with boiling water for 10 hrs. is sufficient to dissolve practically all this slowly soluble potash.

Various methods have been tried to prevent the recombination of potash and it is reported by J. J. Porter,[4] of the Security Cement and Lime Company, that the use of salt has been found beneficial in this connection.

In a publication by W. H. Ross[5] it was shown that when feldspar and lime are digested with water under a steam pressure of 10 to 5 atmospheres about 90 per cent of the potash in the feldspar passes into solution. In cement dust as it escapes from the kilns, the slowly soluble and insoluble potash are already associated with a considerable percentage of free lime and consequently he concluded that the greater part of the constituents might be recovered in water-soluble form by digesting the dust with steam under pressure. Experimental work has shown this to be the case and the results obtained by this procedure will be published separately.

Since ignition of a potash-containing silicate in the presence of lime liberates potash and since the cement dust, as has already been stated, contains a considerable proportion of free lime, it occurred to the author that the recombined potash might be rendered water-soluble by simple ignition of the dust. A preliminary experiment was carried out in which a sample of the above-mentioned treater dust from the Security Cement and Lime Company was ignited with an equal weight of calcium carbonate in a J. Lawrence Smith crucible at about 1000° for a period of 40 minutes. The water-soluble potash was found to have been increased by this treatment from 6.8 to 10.4 per cent on the basis of the original sample. In other words, the water-soluble potash had been increased from 60 per cent to 91 per cent of the total potash content. The addition of calcium carbonate served, however, to considerably lower the percentage of water-soluble potash in the resultant product so that the latter contained 7.1 per cent of water-soluble potash. It is possible that a procedure somewhat similar to this on a large scale should prove profitable to the cement manufacturer who at present receives nothing for his recombined potash, for although he has not appreciably increased the percentage of water-soluble potash in the material he sells, he has increased the quantity of his product over 40 per cent.

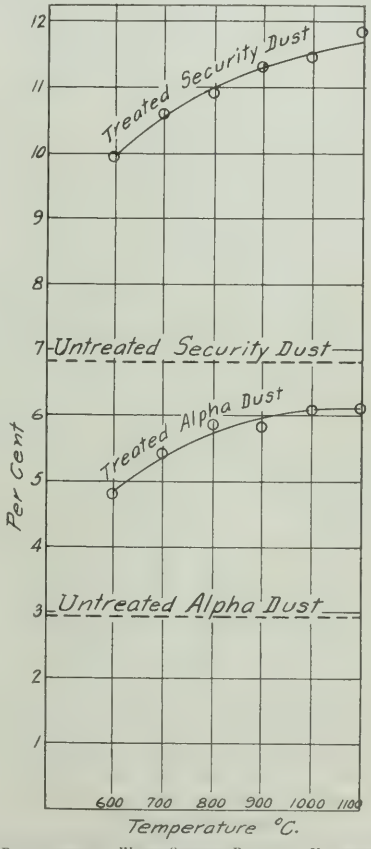


FIG. 1—PERCENTAGES OF WATER-SOLUBLE POTASH IN UNTREATED AND TREATED DUSTS

[1] W. H. Ross and A. R. Merz, THIS JOURNAL, 9 (1917), 1035.
[2] R. J. Nestell and E. Anderson, *Ibid.*, 9 (1917), 646.
[3] J. J. Porter, paper presented at the meeting of the Portland Cement Association, Chicago, September, 1917.
[4] *Loc. cit.*
[5] THIS JOURNAL, 9 (1917), 467.

Similar experiments were carried out without the addition of calcium carbonate, using the same dust and also the dust from the Alpha Portland Cement Company already referred to. The results obtained were unexpected—with the former dust there was a decided increase of the water-soluble potash of the original sample, whereas with the latter there was an actual decrease. Table I gives the percentages of total potash in the dusts before treatment and the percentages of water-soluble potash before and after treatment at about 1000° in a closed crucible all expressed on the basis of the original sample.

TABLE I

	Cement Dust from Security Cement and Lime Co. Original Dust Per cent	Alpha Portland Cement Company Original Dust Per cent
Total potash, K_2O	11.4	7.0
Water-soluble potash before treatment	6.8	2.9
Water-soluble potash after treatment	9.4	2.1

From Table I it may be seen that ignition of the Security dust in this manner has caused an increase of water soluble potash from 60 to 82 per cent of the total potash in the un-ignited dust, while an identical procedure with the Alpha dust has brought about an actual decrease of water-soluble potash from 41 to 30 per cent. The method of ignition which was carried out as in the J. Lawrence Smith method precluded the loss of this potash by volatilization and the only conclusion to be drawn was that a further "recombination" of water-soluble potash takes place in the dust.

controlled by use of a thermocouple pyrometer and a rheostat in the circuit of the electrically heated muffle, and it was decided to make ignitions of the two cement dusts through a range of temperatures to ascertain the influence of differences of temperature of ignition on the conversion of "recombined" potash into water-soluble potash or on the further recombination of water-soluble potash. As interest was centered on the behavior of the Alpha dust an initial experiment was run with this dust subjected for 40 min. to a temperature of 600°. This experiment showed that instead of a diminution of water-soluble potash as obtained previously there was an increase thereof when the carbonaceous matter was removed by combustion. It is questionable that the recombination of potash can be attributed solely to the siliceous ash of the coal in the light of the above results. The writer hesitates to ascribe this effect to the carbon, however, because the Alpha dust also contains sulfides in some quantity, a fact forcibly presented when the dust was treated with hydrochloric acid. These sulfides no doubt also undergo change when the dust is ignited in an oxidizing atmosphere and it may be that they have an influence on the recombination of potash in the absence of air.

Table II contains the results of this series of experiments with the two dusts.

The readings of the pyrometer are probably not exact indications of the actual temperatures obtaining

TABLE II—EFFECTS OF IGNITION FOR 40 MINUTES IN AN OPEN DISH ON PRECIPITATOR DUST EXPRESSED IN PERCENTAGES

	Security Dust							Alpha Dust						
	Untreated	Temperature of Ignition						Untreated	Temperature of Ignition					
On Basis of Original Dust	Dust	600°	700°	800°	900°	1000°	1100°	Dust	600°	700°	800°	900°	1000°	1100°
Loss in weight	...	5.69	6.05	6.40	6.64	7.32	8.70	..	12.91	13.21	13.48	14.55	15.52	17.84
Total potash, K_2O	11.40	11.37	11.42	11.42	11.27	11.19	10.99	7.02	6.98	6.97	7.00	6.48	5.97	5.38
Water-soluble potash	6.79	9.36	9.95	10.18	10.55	10.62	10.82	2.93	4.16	4.69	5.06	4.96	5.15	5.01
On Basis of Product														
Total potash	11.40	12.06	12.15	12.20	12.07	12.07	12.04	7.02	8.02	8.03	8.09	7.58	7.07	6.55
Water-soluble potash	6.79	9.93	10.59	10.88	11.30	11.46	11.85	2.93	4.78	5.40	5.85	5.81	6.10	6.10

TABLE III—WATER-SOLUBLE POTASH IN IGNITED CEMENT DUSTS EXPRESSED IN PERCENTAGES OF TOTAL POTASH CONTENT

	Security Dust							Alpha Dust						
	Untreated	Temperature of Ignition						Untreated	Temperature of Ignition					
	Dust	600°	700°	800°	900°	1000°	1100°	Dust	600°	700°	800°	900°	1000°	1100°
On basis of total potash in original dust	60	82	87	89	93	93	95	42	58	67	72	71	73	71
On basis of total potash in ignited dust	..	82	87	89	94	95	98	..	60	67	72	71	86	93

A glance at the dusts in their original condition before ignition would be sufficient to enable anyone to distinguish between them. The Security dust is ash-gray in color while the Alpha dust is black, evidently containing unburnt carbonaceous matter. A sample of the latter dust was boiled with concentrated hydrochloric acid for 30 minutes, filtered on an alundum plate and a carbon determination was made on the residue. The carbon was found to form 9.26 per cent of the dust. Assuming the dust lost from the kiln to be 4 per cent of the raw mix, and 600 lbs. of raw mix as necessary to yield a barrel of cement, then the loss of carbon per barrel of cement produced amounts to 2.2 lbs. The view that this carbonaceous matter may have an influence on the behavior of the cement dust suggested the ignition of a sample of Alpha dust in an open dish placed in a muffle so that the carbonaceous matter might be burned up, combustion of this material not occurring to any great extent in the closed J. Lawrence Smith crucible. The temperature at which such ignition occurred could be approximately

in the dishes. In the first place, it was evident that all parts of the muffle were not at a uniformly high temperature and, again, the temperatures locally produced by the combustion of the carbon in the Alpha cement dust may have been considerably in excess of the recorded temperatures. In consequence of this carbon content the manner of distribution of the sample in the dish may also have had an influence on the local temperatures of the samples. These same conditions, however, would obtain in large scale operations.

Table III shows that the ignition at temperatures of 600° or over in an oxidizing atmosphere of treater dust from cement mills results in a liberation of the recombined potash of the dust and that the released potash (at 900°) amounts to 33 per cent of the total potash of the original dust in the one case and 40 per cent in the other. In view of this fact it is considered possible that a procedure similar to this may find successful application on a manufacturing scale. The use of a kiln using oil or gas as a fuel is to be considered necessary for such operations, or if coal is used some arrange-

ment whereby heat is supplied without contact of the fuel with the dust to be treated.

In case the dust is to be sold directly to the fertilizer trade such a process would have the advantage of yielding a product with its water-soluble potash more concentrated than in the original dust, for not only is the recombined potash liberated by this procedure but the total weight of the material is diminished. This diminution of weight may be attributed to loss of water, of carbon dioxide, and of any carbonaceous matter in the dust. If, however, the preparation of potash salts is aimed at, it is possible that for dusts behaving like the Alpha dust digestion under steam pressure, as mentioned above, would be the preferable method of treatment since in the latter method there is no volatilization of potash and the yield of water-soluble potash on the basis of the total original potash is consequently greater. This volatilization apparently commences at about 900°. As stated before, the temperatures of the Alpha dust very likely were considerably above those indicated by the pyrometer and relatively greater volatilization of potash in this dust at a given temperature may be easily explained on this assumption.

To ascertain the effect of time of heating on the two dusts, samples were ignited at 1000° for 20, 40 and 60 minutes. The results obtained are shown in Table IV.

TABLE IV—THE EFFECT ON WATER-SOLUBLE AND TOTAL POTASH CONTENT OF VARIATIONS IN DURATION OF IGNITION. TEMPERATURE 1000°

	Security Dust			Alpha Dust		
	20 min.	40 min.	60 min.	20 min.	40 min.	60 min.
ON BASIS OF ORIGINAL DUST						
Loss in weight	7.06	7.32	7.37	15.15	15.52	15.80
Total potash	11.33	11.19	11.06	6.12	5.97	5.89
Water-soluble potash	10.60	10.62	10.58	5.02	5.15	4.89
ON BASIS OF PRODUCT						
Total potash	12.19	12.07	11.94	7.21	7.07	7.00
Water-soluble potash	11.41	11.46	11.42	5.92	6.10	5.81

It is apparent from inspection of this table that for the periods considered ignition of the dust for a longer period than 20 minutes has no decided effect on the ratio of water-soluble to total potash in the material.

SUMMARY

I—Dusts from cement mills using coal as fuel have considerable proportions of their potash content in a form not readily water-soluble.

II—Ignition of such dusts in an oxidizing atmosphere at temperatures of 600–1100° converts the "recombined" potash into a readily water-soluble form.

III—For the periods considered (20 to 60 minutes) time of ignition apparently has little effect on the water-soluble potash content of the resultant product.

DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS, WASHINGTON, D. C.

EFFECT OF COAL ASH ON THE LIBERATION AND NATURE OF CEMENT MILL POTASH

By N. S. Potter, Jr., and R. D. Cheesman

Received December 6, 1917

In all articles thus far published relating to potash as a by-product in the manufacture of cement, no consideration has been given to the potash content of the coal used in burning and its attendant effects. It is the purpose of this paper to point out the effect the coal ash has upon the liberation of potash in the kilns and upon the nature of the so-called "treater dust" collected.

The potash collected from the kiln stack gases where coal is used for burning appears in practically two forms, water-soluble potash and the insoluble or slowly soluble potash. The insoluble potash has been attributed to two causes: the potash in the unburned or partly calcined raw material carried over mechanically in the gases and to a recombination of the volatilized potash with the finely divided ash particles of the coal.

R. J. Nestell and E. Anderson in their paper, "The Nature of Cement Mill Potash,"[1] state that "the most important differences in the potash material from coal-fired and oil-fired kilns, as shown by the analyses given, lie in the relative amounts of soluble and insoluble K_2O, and in the wide variation in potash concentration in the lighter fractions of dust obtained from kilns using these two different forms of fuel. In the dust from the oil-fired and coal-fired kilns previously referred to, where in the first case the per cent of insoluble K_2O was 0.56 and in the second case 4.55 per cent, it seems safe to assume that the amount of mechanically carried-over raw material was practically the same, consequently the difference noted in the amount of siliceous material shown cannot be due to a greater amount of calcined raw mix in one case. The only other source of siliceous material is the ash from the coal used as fuel. Since this ash, coming as it does from finely powdered coal, must be in a state of extremely fine subdivisions, approaching that of a true fume, it is reasonable to suppose that part of this ash would be collected among the lighter portions of dust. Since approximately 9 lbs. of coal ash are introduced into the kiln per barrel of clinker burned, if only one-half this amount is carried out with the gases, it would still be sufficient to effect appreciably the composition of the collected dust, as the amount of dust caught per barrel of clinker produced is only about 20 lbs. Consequently it is probable that the considerable amount of insoluble potash shown to be present in the dust from the coal-fired kilns is in reality due to a combination of the volatilized potash with the finely divided incandescent particles of siliceous coal ash."

Wm. H. Ross, in his paper on "The Extraction of Potash from Silicate Rocks—II,"[2] also states that "the slowly soluble combination is explained on the ground that during the burning of the cement part of the volatilized potash undergoes a recombination with the silicates in the dust."

The following is taken from an article on "The Recovery of Water-Soluble Potash as a By-product in the Cement Industry:"[3] "The insoluble potash represents the combinations occurring in the original silicates of the raw mix which is carried over mechanically in the dust before being subjected to a sufficiently high temperature to bring about decomposition. The form of combination which is slowly soluble in water is supposed to be due to a recombination of the volatilized potash with the silicates in the dust. In

[1] THIS JOURNAL, 9 (1917), 646.
[2] *Ibid.*, 9 (1917), 467.
[3] *Ibid.*, 9 (1917), 1035.

some plants where coal is used for burning, the extent to which the potash occurs in the "recombined" form may be considerable, while in certain other plants where oil is used for fuel this combination of the potash is present in comparatively small amount." Thus it is evident that the potash content of the coal ash has been quite neglected.

Analyses of the ash from the coal burned in the kiln, Table I, bring out the fact that the potash content of the ash is considerable and to such an extent that it must be taken seriously into consideration in figuring liberation and potash balances. The samples taken for analyses represent a week's composite of the daily averages of coal going into the kiln. Being compelled to buy coal upon the open market due to the coal situation, it was impossible to differentiate the sources relative to the mines furnishing the coal. Work along the line of determining the potash content of the ash of coal from different mines throughout the country is now in progress and the results obtained will be published in due time.

TABLE I—K_2O CONTENT OF KILN COAL ASH

SAMPLE	Per cent K_2O
Week ending Oct. 29, 1917	5.32
Week ending Nov. 3, 1917	4.84
Week ending Nov. 12, 1917	4.85
Week ending Nov. 17, 1917	4.75

The average potash content figures close to 5 per cent. As the coal consumption at the different cement plants throughout the country varies greatly, ranging from 80 lbs. coal per barrel to 250 lbs., it is apparent that the potash entering with the coal is considerable. Assuming the ash content to average 10 per cent and using the above figures, it is evident that the potash introduced by the coal lies between 0.4 lb. and 1.25 lbs. per barrel of clinker. Due to the very finely divided state of these ash particles and the velocity of the gases in the kiln, but a very small percentage of the ash is deposited in the kilns, nearly all passing out with the gases. The per cent being deposited in the kiln is undoubtedly higher in mills using the wet process where the ash particles have a tendency to cling to the wet slurry. In order to observe this effect of the ash upon the nature of the materials in the kiln, samples of the material were taken at intervals of 10 ft. throughout the length of the kiln. The effect upon the K_2O content of the materials is shown graphically in Fig. 1.

Curve I takes into consideration the actual K_2O as determined by analyses assuming the original material (slurry) to be previously calcined.

Curve II shows the actual K_2O in these different samples.

Curve III attempts to show the K_2O content of the samples as it would be on the basis of K_2O content of slurry entering the kiln and taking into consideration the actual loss attained at the different intervals as shown by chemical analyses, disregarding any additions of K_2O from other sources.

Curve IV shows the K_2O content at the different intervals calculated on the assumption that the material had been previously calcined and no volatilization of K_2O in the kiln or addition of K_2O from other sources

Comparing Curves II and III it is clearly shown that the K_2O content of the slurry is effected appreciably from some other source. This source is either the K_2O in the ash from the coal or the K_2O as fume in the gases. Due to the very physical nature of the K_2O from these two causes it is safe to assume that the K_2O in the ash is the principal contaminator.

The appreciable rise in the K_2O content of the slurry at 115 ft. as shown in Curve II is probably only a local condition due to the peculiar construction in our kilns at this point. [illegible] ft. in length

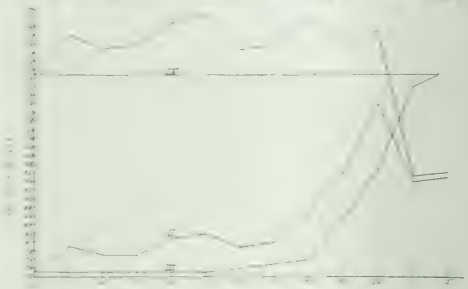


FIG. 1—DISTANCE FROM FEED END OF KILN

I Actual K_2O supposing no loss of volatiles

II Actual K_2O in sample

III Theoretical K_2O supposing no contamination from ash on volatilization of K_2O

IV Theoretical K_2O figured to no loss on moisture basis, non volatilization of K_2O and no additions from ash

are attached to the interior wall of the kiln. These are spaced at intervals of 3 ft. and lie parallel to the axis of the kiln. The kiln in rotating lifts the slurry at this point to approximately the top of the kiln where it drops back through the gases to the floor of the kiln. This very readily acts as a filter causing considerable of the fine dust particles to deposit with the wet slurry.

TABLE II—CHEMICAL ANALYSES

Distance from Front of Kiln								Loss on Ignition
Ft.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	S	
5	22.68	3.89	6.29	61.75	3.51	1.16	0.05	2.25
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.06	4.90
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.07	12.05
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.17	19.11
45	16.22	3.22	3.96	42.70	2.65	1.05	0.04	32.10
55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.52	37.15
65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.52	37.40
75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.58	38.36
85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.40	38.77
95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.22	38.80
105	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.50	39.05
115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.43	39.01
125	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.39	38.96
Ash	[illegible]	[illegible]	[illegible]	[illegible]				

The ash deposit with the slurry is further demonstrated by chemical analyses.

Table II shows the chemical analyses of the different samples as taken throughout the kiln and also the ash analyses of the coal going to [illegible]

As the velocity of the kiln gases is quite high these ash particles will be exposed to the intense heat of the firing zone of the kiln for a very [illegible] possibly not more than a few seconds. Further, the very nature of combustion here, [illegible] precludes the possibility of a very high temperature being attained by the ash particles. Such being the case there should be practically no volatilization of the potash in the ashes from the coal in the kiln.

TABLE III—SOLUBILITY TESTS ON COAL ASH FOR K_2O
Sample Heated to Glow over Meker Burner for 1 Hour
Total K_2O in Ash, 4.47 Per cent

How Treated	Sol. K_2O Per cent H_2O in Sample
Washed on filter paper	0.10
½ hour boil	0.16
1 hour boil	0.23
2 hours boil	0.23
4 hours boil	0.23
7 hours boil	0.25
10 hours boil	0.28
15 hours boil	0.28
24 hours boil	0.25

Samples of kiln coal ash containing 4.47 per cent K_2O were heated to a glow for approximately one hour over the Meker burner. This showed no volatilization. Two gram samples of this ash were then boiled vigorously for different periods up to 24 hrs. to determine whether this could be made water-soluble upon boiling. Table III shows that after 1 hour's boiling there is no increase in water-soluble K_2O. This water-soluble is so small as to be negligible. While this does not reproduce the kiln condition exactly it is quite evident that at the temperature attained by the ash in passing through the kiln and for the period to which it is subjected to this temperature, no potash of the ash will be volatilized.

Assuming that 90 per cent of this ash in a dry process plant and 75 per cent in a wet plant passes up the flue with the gases the effect of the insoluble K_2O in the ashes will affect the nature of the treater dust very appreciably.

Due to observations made while assisting in the research work at the Security Cement & Lime Company and to data showing potash balances at different plants at hand, but which we are not at liberty to publish at this time, it is quite evident that the insoluble potash content of the dust collected from the kiln gases is of two sources, that which passes over with the raw material, or partially calcined dust, and that which passes over with the ash from the coal used in burning.

CONCLUSIONS

I—K_2O content of coal ash is considerable.

II—K_2O content of coal ash must not be disregarded in calculating the liberation in kilns.

III—K_2O content of coal ash appears in "treater dust" as insoluble K_2O.

IV—Taking into consideration the K_2O content of ash and the K_2O in raw mix carried over mechanically there is apparently no "recombination" of the volatilized K_2O with the siliceous ash particles.

MICHIGAN PORTLAND CEMENT COMPANY
CHELSEA, MICHIGAN

TOLUOL RECOVERY AND STANDARDS FOR GAS QUALITY[1]

By R. S. McBride

Received December 29, 1917

The removal of benzol and toluol from gas necessarily reduces the heating value and candle-power of the gas; the amount of reduction depends upon the quantity of these constituents originally in the gas, the thoroughness of washing, and the general character of the gas with respect to other heating and lighting constituents. In this paper it is intended, *first*, to present a summary of the more important conditions of operation which determine the probable effect of toluol recovery upon the quality of the gas supplied; *second*, to illustrate the method of estimating the probable effect in any particular case; and *third*, to summarize certain general recommendations as to changes in standards that must be made in order that recovery of toluol can be carried out effectively in a large number of localities. In this memorandum, changes of standards are considered only from the standpoint of toluol recovery. No consideration is given to any other factors which might properly in many cases make desirable a change of standards. Such matters would depend upon a number of factors, not within the scope of the present discussions.

[1] Published with permission of the Director, Bureau of Standards.

SUMMARY OF PRESENT STANDARDS OF GAS QUALITY AND GAS COMPANY OPERATING CONDITIONS

Both the heating value and the candle-power of gas are used in this country as a measure of the quality of the product supplied. Usually only one of these two characteristics is prescribed by ordinance or administrative ruling, but in some cases both are fixed. In cases where such standards have not been adopted and the quality of the gas supplied is determined by the local gas company, it is of interest to know what quality of gas is being supplied. This information is presented below; for convenience of consideration the companies are classified according to the standard in force. Data are included for all American gas companies making 500,000,000 cu. ft. or more of coal, water, or oil gas per year and for such other companies as have been recommended to the Ordnance Department for consideration by the Sub-Committee on Coal-Tar By-Products.

I—Gas companies in the following cities are expected to supply gas in compliance with the candle-power requirement as follows:

(a) Requirements of 20 candles or higher:

New York City (including the New York Consolidated System, the Brooklyn Union Gas Company, and the King's County Lighting Company), 22 c.-p. (Permission has recently been given to change to a heating value of 650 B. t. u. at the same price or to any lower heating-value standard if a proportionate reduction in price of gas is made.)

Philadelphia, Pa., 22 c.-p., fixed by a franchise contract with the city.

Des Moines, Iowa, 22 c.-p.

Sioux City, Iowa, 21 c.-p.

Omaha, Neb., 23 c.-p. measured at the gas works, or 21.2 c.-p. measured at the city testing station, and 600 B. t. u. heating value.

Charleston, S. C., 20 c.-p. and 600 B. t. u.

East St. Louis, Ill., 20 c.-p. (an old city ordinance requirement) and 565 B. t. u.

Northern Illinois cities supplied by Public Service Company of Northern Illinois, 22 c.-p. (ordinance) and 565 B. t. u. (state standard).

(b) Requirements of 18 candles:

Detroit, Mich., 18 c.-p. and 600 B. t. u.

Lansing, Mich., 18 c.-p. and 600 B. t. u. *net* heating value.

Los Angeles, Cal., 18 c.-p. and 600 B. t. u. (most of the gas

supply of this city is natural gas which is not limited by these requirements).

(*c*) *Requirements of 16 candles:*

All cities of Massachusetts, 16 c.-p. (fixed by State statute but subject to some waiver for purposes of investigation by the State Board of Gas and Electric Light Commissioners. This Board has very recently recommended to the State legislature a standard of 528 B. t. u.). The following Massachusetts cities are of interest in this connection: Boston, Brockton, Cambridge, Fall River, Haverhill, Lawrence, Lowell, Lynn, Malden, New Bedford, Pittsfield, Springfield, Worcester.

Nashville, Tenn., 16 c.-p. and 600 B. t. u.
Jackson, Mich., 16 c.-p. (20 c.-p. for water gas) and 600 B. t. u.
Grand Rapids, Mich., 16 c.-p. and 600 B. t. u.
Peoria, Ill., 16 c.-p. and 565 B. t. u.

(*d*) *Requirements of candle-power less than 16:*

Minneapolis, Minn., 15 c.-p. and 600 B. t. u.
Birmingham, Ala., 15 c.-p. and 575 B. t. u.
St. Paul, Minn., 14 c.-p. and 600 B. t. u.

II—Gas companies in the following localities supply gas in compliance with heating-value requirements as follows:

(*a*) *Total heating value, 600 B. t. u.:*

St. Louis, Mo. (This is a municipal requirement; the State requirement is 570 B. t. u.)

Baltimore, Md.	Tacoma, Wash
Indianapolis, Ind.	Milwaukee, Wis.
Hammond, Ind.	Madison, Wis.
Peru, Ind.	Atlantic City, N. J.
South Bend, Ind.	Elizabeth, N. J.
Cedar Rapids, Iowa.	Jersey City, N. J.
Washington, D. C.	Newark, N. J.
Wilmington, Del.	Paterson, N. J.
Seattle, Wash.	Trenton, N. J.

(*b*) *Total heating values, 585 and below:*

Denver, Colo., 575	San Diego, 550
Bridgeport, Conn., 575	Allentown, Pa., 570
Hartford, Conn., 575	Chester, Pa., 570
New Haven, Conn., 575	Reading, Pa., 570
Waterbury, Conn., 575	Wilkes-Barre, Pa., 570
Portland, Ore., 570	Manchester, N. H., 565
Ardmore, Pa., 570	Chicago, Ill., 565
San Francisco, Cal., 550	Oakland, Cal., 550

Cities of New York State, 585. (Of these cities the following are of interest in this connection: Albany, Binghamton, Buffalo, Poughkeepsie, Rochester, Schenectady, Syracuse, Troy, Utica.)

III—The gas companies in the following cities have no requirements limiting the candle-power or heating value of the gas which they supply but are reported to be supplying gas of candle-power and heating value as given below:

New Orleans, La., 22 c.-p. and 600 B. t. u.
Jacksonville, Fla., 20 c.-p. and 580 B. t. u.
Atlanta, Ga., 19 c.-p. and 600 B. t. u.
Richmond, Va., 18 c.-p. and 590 B. t. u.
Pawtucket, R. I., 17 c.-p. and 600 B. t. u.
Providence, R. I., 17 c.-p. and 600 B. t. u.
Salt Lake City, Utah, 17 c.-p. and 600 B. t. u.
Houston, Tex., 17 c.-p. and 585 B. t. u.
Mobile, Ala., 15 c.-p. and 600 B. t. u.
Portland, Me., 15 c.-p. and 570 B. t. u.
Savannah, Ga., 575 B. t. u.
Battle Creek, Mich., quality not reported.
San Antonio, Tex., quality not reported.

METHOD OF ESTIMATING INFLUENCE OF TOLUOL RECOVERY UPON GAS QUALITY

As previously stated the quantity of toluol or benzol in the gas initially is a large factor in determining the quality of the gas both before and after removal of the toluol, since the conditions which make for the presence of large quantities of these aromatic hydrocarbons are the conditions prevailing during the production of high-candle-power and high-heating-value gases. In general the quantity of toluol and other light oils present in water gas depends upon the amount of gas oil used in the production of this gas. Approximately 10 per cent of the volume of gas oil used can be recovered as crude light oil and of this amount from $1/8$ to $1/6$ can be recovered as pure toluol. Coal gas made by any of the usual horizontal retort processes, which are the only processes of coal-gas manufacture requiring particular consideration in this report, usually contains about one-fourth to one-third of a gallon of light oil per 1000 cu. ft., depending upon the character and treatment of the coal and the quality of the gas. From one-eighth to one-tenth of this light oil is recoverable as pure toluol.

For each one-tenth gallon of light oil removed per 1000 cu. ft. of gas the total heating value is reduced by approximately 10 to 14 B. t. u. per cu. ft. and the candle-power by $2^1/_2$ to 3 candles. However, restoring part of the light oil removed, for example, enriching with the benzol fraction, may in some measure compensate for the loss in heating value and candle-power brought about by the initial washing. In fact, if a sufficient amount of additional benzol is available the candle-power and heating value can be restored substantially to the original values. (The increase in quality is about the same per unit of volume of benzol returned as was the loss on removal of the light oil.) However, this practice would not generally be practicable since it demands the purchase of benzol or other enriching constituents to take the place of those constituents which are permanently removed from the gas. In estimating the loss of candle-power and heating value, the figures here presented are probably slightly higher than would correspond to the change in quality of gas at the customers since in distributing unwashed gas there is usually considerable loss due to condensation.

From these two generalizations and a knowledge of the initial candle-power and heating value of the gas it is readily possible to estimate approximately the influence upon the quality of the gas of recovering different amounts of toluol or of toluol and benzol. Such estimates are, of course, not exact, but they furnish an excellent guide for readjustment of standards in any case where this is necessary or for approximating the quantity of materials which can be obtained by washing the gas. The following examples will make clear the application of the data:

(1) Assume water gas made from 4 gallons of oil per 1000 cu. ft., having an open-flame candle-power of 20 and a heating value of 625 B. t. u. About 0.4 gallon of light oils per 1000 cu. ft. could be recovered from such gas with practically complete wash-

ing. If none of the benzol was returned to the gas the result would be a gas of about 575 B. t. u. and 10 candle-power. If the light oil were distilled and the benzol fraction were returned to the gas the loss in heating value and candle-power would be, perhaps, one-half as great, and the result a gas of about 600 B. t. u. and 15 candles. In order to restore the heating value and candle-power to substantially their original figures it would be necessary to add benzol to the extent of approximately 0.2 gallon per 1000 cu. ft. of gas manufactured. From the 0.4 gallon of light oil originally obtained, some 0.07 to 0.08 gallon of toluol would probably be obtainable on refining.

(2) Assume carburetted water gas with 3 gallons of gas oil per 1000 cu. ft. and assume a very high oil-efficiency so that the candle-power was 18 and the heating value 570 B. t. u. From this gas about 0.3 gallon of light oil, equivalent to, perhaps, 0.05 to 0.06 gallon toluol, would be obtained per 1000 cu. ft. with commercially complete washing. The result of this washing would be a gas approximately 530 B. t. u. and 9 to 10 candles, which would be restored to 550 B. t. u. and about 12 candles if re-enriched with the benzol portion of the light oil.

(3) A mixture of coal gas and water gas in about equal proportion may be assumed made from water gas for which $3^1/_2$ gallons of gas oil were used to give 18 candles and 600 B. t. u. and coal gas of 580 B. t. u. and 15 candles. Such mixed gas would yield, perhaps, 0.3 gallon light oil per 1000 cu. ft. and the average candle-power would be reduced by washing from $16^1/_2$ to 8 or 9 candles and the heating value from 590 B. t. u. to about 550 B. t. u. Restoration of the benzol fraction would give a product of about 12 candles and 570 B. t. u.

(4) A coal gas made from ordinary grade of gas coal to yield 10,000 cu. ft. of gas per ton is assumed to produce gas of about 14 candles in the open flame and of 585 B. t. u. From this approximately 0.3 gallon of light oil per 1000 cu. ft. of gas could be recovered; and from it 0.025 to 0.03 gallon of toluol per 1000 cu. ft. would be available. The gas after washing would have approximately 8 candles and 550 B. t. u. which would be increased to, perhaps, 12 candles and 570 B. t. u. if the benzol fraction were restored.

In any of the above cases the net loss in heating value and candle-power might readily be reduced if some of the other constituents of the light oils, such as the solvent naphtha fraction, were also restored to the gas; or the loss in heating value and candle-power could be made less by operating the washing equipment in such a way as to accomplish only a partial removal of the light oils. In the latter case if removal of only 75 per cent of the quantity of light oil readily obtainable were considered satisfactory this would make the losses in heating value and candle-power of only about $^3/_4$ as great as above indicated, but, of course it would also somewhat reduce the yield of toluol.

It is probable that complete washing of the gas with restoration of the benzol in most cases will be considered advisable since the need for toluol is considerable and very little sacrifice of toluol yield can be allowed. But the demand for benzol is not so great and the restoration of the benzol to the gas might give results at first more satisfactory to the gas users than would the sale of this benzol with the slight reduction in total costs for the gas which might possibly be accomplished thereby. Especially might the restoration of benzol be necessary where a high candle-power standard has been in force, since otherwise the loss in candle-power would be rather greater than would be desirable at one time. In any computation, therefore, it is probably best to assume, unless other basis is known to be correct, that commercially complete washing of the gas would be necessary and that the benzol fraction of the light oil amounting to approximately one-half the total volume of light oil removed, will be restored to the gas.

RECOMMENDATIONS REGARDING STANDARDS FOR GAS QUALITY

From the estimates in the preceding section it is evident that much greater difficulty is met in complying with a candle-power requirement after removal of toluol or light oil than is encountered if a heating-value standard is to be complied with. Because of this fact it seems desirable that in any case where toluol is to be removed the candle-power standard be altogether eliminated or be made sufficiently low so that it will not interfere seriously with the proposed operations. Many other factors independent of toluol recovery make evident the desirability of eliminating candle-power requirements and substituting heating-value requirements as the primary basis of gas measurement. Therefore, the war is only an added influence tending to hasten an end otherwise desirable.

In all cases where the candle-power has previously been below 18 it would seem that the elimination of the candle-power requirement altogether would be reasonable; although in any event it is expected that the company would supply a gas of at least 8 or 10 candles, which would be sufficient to care for the need of those customers who must use some portion of the gas for open-flame lighting. In cases where 18 or 20 candles or higher have been maintained regularly in the past, it might be undesirable to have the candle-power go below 12 to 14, unless open-flame lights were generally eliminated and a readjustment of the appliances of all customers were made wherever the change in quality might make this necessary. For all companies which have been complying with requirements of 18 candle-power or higher, an understanding might be reached as to the maintenance of at least 12 to 14 candles for such a period as might be necessary to accomplish a general adjustment to the new conditions.

When coal gas is supplied either alone or mixed with very small percentages of water gas it is impracticable to make a very rich gas since the character of the coals available in most instances would preclude economic operation if a higher standard, either of heating value or of candle-power, must be maintained. For cities where only coal gas is supplied the standard could scarcely be higher than about 570 B. t. u. if practically complete toluol recovery is expected. Higher heating-

value standards than this would probably have to be modified for such gas supplied.

If water gas is manufactured either alone or as a major constituent of the supply it is entirely practicable to make a gas of reasonably high heating value and candle-power initially and have after removal of the toluol a heating value of 585 to 600 B. t. u. In each case it would be a question as to which procedure was the more economical; that is, whether it would be better to make the same quality of gas as had previously been supplied and supply the customer with a somewhat lower product than formerly after the toluol had been removed from the gas, or to make the gas initially somewhat richer than before by the use of slightly more gas oil per 1000 cu. ft. so that the product after washing would have substantially the same heating value as had previously been supplied. If the quality previously supplied was rather high, approaching the maximum of the range of quality permissible for efficient operation, then any increase in the initial quality would obviously be undesirable; but otherwise an initial increase in quality with subsequent washing down to the original might be the best practice. Since the quantity of toluol available is largely dependent upon the initial richness of the gas which has been washed there is considerable advantage from the standpoint of the Government in having the richest practicable gas made initially; but, of course, in any case the limits of economical operation must be clearly recognized, and conservation of oil might also be an important factor.

As a summary of these points the following suggestions are offered as desirable adjustments to facilitate the recovery of toluol:

I—Eliminate all candle power requirements now in force except for the cities where 18 candles or higher has been supplied, in which localities reach an understanding that at least 12 candles will be maintained for a period, say a year, during which time readjustments of appliances and substitution of mantle lamps would be accomplished to such an extent as to justify complete elimination of candle-power regulations.

II—For plants making coal gas (or practically only coal gas) let the heating-value standard be from 550 to 570 B. t. u.

III—For plants making water gas, either alone or as a major constituent, let the heating-value standard be 570 to 600 B. t. u. monthly average total heating value, the adjustment being made between these limits according to the economic conditions of operation.

In order to show the number of companies that would be affected by these several recommendations the following tabulation of the companies above listed is prepared. This tabulation does not take account of any unusual local conditions which might affect some of the cases materially. The kind of gas manufactured is also indicated: W, water gas; C, coal gas; O, oil gas; M, mixed coal and water gas; B, by-product coke oven gas; and N, natural gas.

1—Localities in which no change of standard will probably be needed and no serious change in the quality of gas supplied will probably result:

Chester, Pa.	W+B	Schenectady, N. Y.	M
Reading, Pa.	W	Troy, N. Y.	W
Wilkes Barre, Pa.	W	Utica, N. Y.	W
Ardmore, Pa.	W	Poughkeepsie, N. Y.	W
Allentown, Pa.	W	Syracuse, N. Y.	M
Portland, Ore.	O	Binghamton, N. Y.	W
Manchester, N. H.	M	Rochester, N. Y.	M
Hartford, Conn.	M	Chicago, Ill.	W+B+N
Bridgeport, Conn.	W	San Diego, Cal.	W+O
New Haven, Conn.	M	San Francisco, Cal.	O
Waterbury, Conn.	W	Oakland, Cal.	O
Denver, Colo.	M	Houston, Texas	W
San Antonio, Texas	W	Pawtucket, R. I.	M
Savannah, Ga.	W	Providence, R. I.	M
Jacksonville, Fla.	M	Battle Creek, Mich.	M
Richmond, Va.	M	Portland, Me.	M
Atlanta, Ga.	M	Salt Lake City, Utah	M
New Orleans, La.	W	Mobile, Ala.	M
Albany, N. Y.	W		

2—Localities in which a candle-power standard may have to be abandoned, but with no serious change in the heating value of the gas supplied:

Lynn, Mass.	M	Fall River, Mass.	M
Boston, Mass.	M	Haverhill, Mass.	W
Brockton, Mass.	M	Springfield, Mass.	M
Lawrence, Mass.	M	Malden, Mass.	M
Lowell, Mass.	M	Birmingham, Ala.	M
New Bedford, Mass.	M	Waterloo, Iowa.	W
Pittsfield, Mass.	M	Peoria, Ill.	M
Worcester, Mass.	M	Nashville, Tenn.	M
East St. Louis, Ill.	W+N	Cambridge, Mass.	M

3—Localities in which slight change in heating-value regulations may, perhaps, be required, but in no case probably more than equivalent to 5 per cent of the present value. (The six cities marked (*) have candle-power standards which should be eliminated also.)

Indianapolis, Ind.	B+W	Buffalo, N. Y.	M
Tacoma, Wash.	C+O	Milwaukee, Wis.	M
Seattle, Wash.	B+M	Madison, Wis.	W
Trenton, N. J.	B+M	Cedar Rapids, Iowa.	M
Paterson, N. J.	W	St. Louis, Mo.	M+B
Newark, N. J.	M	Baltimore, Md.	W+B
Jersey City, N. J.	W	Hammond, Ind.	M
Elizabeth, N. J.	W	South Bend, Ind.	M
Atlantic City, N. J.	W	Peru, Ind.	M
Washington, D. C.	M	Wilmington, Del.	W
*St. Paul, Minn.	W	*Grand Rapids, Mich.	M
*Minneapolis, Minn.	M	*Jackson, Mich.	M
*Detroit, Mich.	M+B	*Los Angeles, Cal.	O+N

4—Localities in which high candle power regulations should be changed or eliminated in order to permit operation on a heating-value basis; the reduction in heating value of the gas delivered would probably be a considerable percentage of the present value. (In the case of Lansing and Omaha a lower heating value than now in force would also be necessary.)

New York City	M	Charleston, S. C.	W
Omaha, Neb.	W	Des Moines, Iowa	W
Lansing, Mich.	M	Sioux City, Iowa	W
Philadelphia, Pa.	M		

Northern Illinois cities supplied by Public Service Company of Northern Illinois, M.

BUREAU OF STANDARDS
WASHINGTON, D. C.

CATALYSTS IN VULCANIZATION[1]

By D. Spence

When the Chairman of this Section wrote me asking if I would read a paper on "Vulcanizing Catalysts," to me one of the most fascinating subjects of rubber chemistry, it was with regret I advised him that I would be unable to do so on account of lack of time to prepare a paper. In the meantime, however, I have found an article prepared by me in 1911, but never published, which, together with a few notes prepared on my trip to Boston yesterday, with your permission I will read, as they should clear up some of the points raised in this discussion, and at the same time serve to show the extent to which the investigation of this subject had been carried by some of us prior to 1911, and our knowledge of this subject in America at that date.

This subject is one which is of particular interest to me, as it has been, I may say, my main field of investigation for the past eight to ten years. During that period many interesting discoveries have been made, more than one hundred widely different vulcanizing catalysts have been prepared, investigated and put on record, and results of scientific as well as of technical importance have been obtained.

By some of our good friends and allies across the water, jealous of their claims to discoveries along this line, I have been recently criticized, for not placing on public record by patent or otherwise, the results of these past years of investigation, but I am confident that by the time they have carried their studies a little further, they will appreciate the difficulties involved in the problem, and my reasons for comparative silence. These remarks will, I hope, serve to answer some of their criticism and, at the same time, outline the history of this subject as far as I am concerned.

In the first place, I would point out that, as a matter of fact, discreet mention will be found in some of my earliest published work on vulcanization, of this basic principle, the importance of which our European friends, as well as enemies, have to-day begun to realize. Thus in an article dealing with the theory of vulcanization[2] and in particular with Axelrod's theory of a varying velocity of reaction with the degree of polymerization of the rubber, I took occasion to point out that *"what Weber, Axelrod, Ostwald and all investigators had overlooked was the fact that the vulcanization of rubber with sulfur, as we know it, is essentially a catalytic reaction."* Even earlier; however, and in the controversy between Ostwald and myself in 1910–11, over the chemical *vs.* adsorption theories of vulcanization, which some of you probably remember, it was the knowledge of the true nature of the reaction, overlooked by Ostwald, which led me to take the stand I did. In the *Kolloid Zeitschrift*, Vol. 13, pp. 270, 271, will be found further reference to this subject, together with figures and curves showing the influence of varying amounts of a powerful catalyst on the rate of vulcanization, as determined by the amount of combined sulfur. That this basic discovery was not made the subject of a patent as Peachey has suggested,[1] may appear remarkable at first thought, but its very breadth rendered patent protection well-nigh impossible and disadvantageous to seek. The number of substances which can be used in this connection with more or less success is legion, so that patents such as those which have been granted recently, can be readily overcome, and are of no intrinsic value in any case. By the methods of organic chemistry, all manner of substances can be, and have been prepared, which will be found to accelerate vulcanization, and to bring about the physical result to a greater or lesser extent; simple organic substances widely different in constitution, such as aniline oil, piperidine, diazobenzene, etc., metallo-organic compounds such as alkyl derivatives of lead, and the salts of the fatty acids or of aniline oil, with the alkali metals; then there is the great group of substances which by decomposition, natural or induced during vulcanization, produce some very active and efficient catalysts to which class the thioureas belong. Each of these various classes contains several dozen different representatives, which I have already investigated, and there are doubtless hundreds still to be tested, so that I am sure you will agree with me that the task of adequately protecting an invention of the scope of this one is hard, to say the least, and of doubtful value if attempted. It has certainly not been accomplished so far. In 1911, in an effort to cover by patent the results of past years of research in this line, I set down a description of some of the discoveries made by that time, together with four claims, from which, with your permission, I will read the following extracts. The article is entitled "Improvements in and Relating to the Vulcanization of India Rubber" and is dated August, 1911. I was surprised, on referring to it again the other day, to find how fully it deals with the subject.

Since the publication of the classical researches of C. O. Weber into the nature of the vulcanization process, this process has been generally regarded as a simple addition of sulfur or sulfur chloride to the rubber hydrocarbon and the practical vulcanization of the rubber of commerce by sulfur has been handled from the standpoint of a *simple chemical reaction*, as generally understood, between the rubber and the sulfur at the vulcanization temperature. In view of certain difficulties experienced from the earliest of times even to the present day in accepting the simple chemical theory of vulcanization[2] it is therefore the more surprising that what we believe to be the key to successful vulcanization has not been discovered or made known as far as published work shows. The conception of a simple chemical reaction between the rubber and the sulfur at the vulcanization temperature has long been felt to fail to account for certain practical results obtained in vulcanization and only as recently as last year the physico-chemical or adsorption theory of vulcanization was put forward by an eminent authority on the chemistry of rubber on the ground alone that it helped to explain the practical facts of vulcanization better than the simple chemical theory of Weber.

I have cited these facts in order to show that from the earliest days of the industry to the present time what we believe to be the keynote to the vulcanization process as determined by our investigation has never once been sounded * * * * *.

[1] Read before the Rubber Section, at the 55th Meeting of the American Chemical Society, Boston, September 13, 1917.

[2] *Kolloid-Z.*, **11** (1912), 275.

[1] *J. Soc. Chem. Ind.*, **36** (1917), 321.

[2] Ostwald, *Kolloid-Z.*, **6** (1910), 136.

For the better understanding of the facts leading up to and bearing on the present invention, it is necessary to refer to the following discoveries made by us:

That the vulcanization of pure rubber (by which is meant the rubber of commerce divested of those impurities usually associated with it in greater or lesser amount) by sulfur is an exceedingly slow reaction. The amount of sulfur which enters into combination with the rubber in a given time is relatively small, and even the best of the products obtained have very poor physical properties, usually deteriorate rapidly and are of little or no industrial value. It has been universally reported that this inferiority of so purified rubber is due to the quality of the rubber *per se* or to changes in the rubber *per se* brought about by the purification process. That this is not correct we have established by experiments in which, by returning to the purified rubber, certain of the so-called impurities removed in the first case, and investigated by us, or by adding to the rubber certain substances having an analogous action in vulcanization, the velocity of vulcanization of the original rubber and the superior physical properties of the vulcanized product were restored.

For example, it is known that by dissolving Para rubber in solvents and precipitating the rubber from its solution by acetone or by simple extraction of the rubber by acetone, the vulcanizing capacity of the rubber is greatly reduced, and products with very poor physical properties are obtained. We have discovered, however, that by returning to the rubber certain of the so-called impurities removed in purification, the original vulcanizing characteristics of this rubber are restored.

We have discovered in fact that:

I—The superior qualities of certain raw rubbers with respect to vulcanization are not necessarily due to any superiority in the quality of the rubber itself, but are determined far more by the existence in these rubbers of commerce of certain substances, hitherto regarded as impurities, which are not present in like degree or at all in the other rubbers. These so-called impurities are soluble in acetone and can be extracted in this way. When they are added to rubbers with inferior vulcanizing properties, products which vulcanize rapidly and with superior physical properties are obtained.

II—The acetone extract from Para rubber contains, in addition to the resinous impurities generally held to constitute the acetone extract, *organic substances*, nitrogenous and feebly basic in character, having all the reactions and characteristics of an organic alkaloid.[1] We have found, furthermore, that it is these organic nitrogenous substances present in one form or another in Para rubber that impart to this rubber its characteristic vulcanizing properties and are capable of bringing about substantial improvements in vulcanization when added to other so-called low-grade rubbers. These substances which occur in Para and in some other rubbers to a less extent we shall call henceforth the "active principle" of raw India rubber. To what extent this active principle occurs in Para we have not yet been able to determine, but from calculations made there is probably less than 1/10 of 1 per cent.

III—The function of this active principle in effecting more rapid and better vulcanization of rubber by sulfur is complex but essentially that of a catalyst (as generally understood) accelerating as it does enormously the rate of reaction between the rubber and the sulfur. This has been established by us beyond doubt by comparative curves of the combined sulfur of, purified rubber, vulcanized with sulfur only, (*a*) in absence of, (*b*) in presence of the active principle of India rubber, (*c*) in presence of substances having analogous properties.

IV—Organic substances having analogous reactions and properties can be used as catalysts to replace the "active principle" of Para rubber in the vulcanization of India rubber by sulfur. Thus by adding 1 per cent of the well-known alkaloid quinine to a mixture consisting of 100 parts purified rubber with 8 parts of sulfur, the reaction between the rubber and sulfur is so hastened that the time required using 40 lbs. steam pressure to effect proper vulcanization is reduced from 4 to 5 hrs. when no quinine is present to 25 min. when quinine is present. The physical properties of the product obtained are likewise improved enormously by the use of this substance as catalyst.

V—The number of organic substances which can be used to replace the "active principle" existing in higher-grade rubbers is unlimited; derivatives of these and metallo-organic bodies may be likewise employed and although the substances which may be employed may differ widely in chemical composition, they all have the common property of behaving as catalysts in vulcanization, hastening the velocity of reaction by carrying over the sulfur to the rubber at the temperature of vulcanization. We have found, furthermore, that the power which these substances possess as catalysts in vulcanization varies with their constitution and with the nature and arrangement of their reactive groups. We have discovered that it is possible, by suitably modifying the structure of the substance or its reactive groups by the well-known methods of organic chemistry or by suitably modifying the amount of the substance or substances used in vulcanization, to obtain any desired effect. Thus whereas we have found para-phenetidine to be a very powerful catalyst in vulcanization, ortho-phenetidine is but feebly so and the somewhat weak catalytic action of para-amido-phenol is wonderfully increased by converting it into the corresponding amido-phenetol. Similarly diphenylthiourea is but feebly active compared with the corresponding tetramethyldiaminodiphenylthiourea.

As examples of organic substances having the power to act directly as catalysts in the vulcanization of India rubber by sulfur, we may mention aniline, para-phenetidine, piperidine, and quinine.

As examples of derivatives of organic substances with inorganic radicles and metallo-organic substances acting catalytically in the vulcanization of India rubber by sulfur, we may mention the alkyl derivatives of lead and mercury and the salts of oleic acid with sodium or lead.

As the third class of catalyst in vulcanization we have discovered, furthermore, certain substances which are inactive in themselves, but which at the temperature of vulcanization, it may be alone or it may be in the presence of other substances, break down into a substance or substances having the properties of powerful catalysts. As an example of a substance of this kind, we may mention sulfocarbanilide or diphenylthiourea.

What we claim to have discovered is the basic principle of vulcanization of India rubber by sulfur, that the vulcanization of India rubber by sulfur is not a simple chemical reaction as is to-day assumed, but owes its whole success industrially to its catalytic nature.

We are aware of the well-known action of litharge in the vulcanization of India rubber by sulfur. This inorganic substance has been used from the earliest times in large quantities in rubber compounds up to 40 per cent and is known to hasten vulcanization. Further we are aware of the use of magnesium oxide as an accelerator in vulcanization and of the work of Weber and of Henriques in this connection. Henriques, as the result of investigations into the [illegible] *ments* (the ash) of different rubbers, came to the conclusion that it is the presence of compounds of the alkaline earths (*inorganic elements*, in other words) in quick-curing rubbers, that [illegible] the case with which these rubbers vulcanize. This statement as far as the literature shows is still generally accepted as correct, and gave rise,

[1] At the time this was written these nitrogenous bodies had not been definitely identified; only their behavior towards the well-known tests for alkaloids had been noted.

we believe, to the use of magnesium oxide as an accelerator in the vulcanization of rubber by sulfur. We have come to an entirely different conclusion, however, and, although we do not deny the specific results to be obtained by the use of both litharge and magnesium oxide in the vulcanization of India rubber by sulfur, we lay no claim here to the use of any of these inorganic ingredients in vulcanization. We claim, furthermore, that the results obtained by the use of any of these inorganic accelerators in the vulcanization of rubber by sulfur are substantially different from those obtained by the methods of our invention; both these inorganic substances have to be used in large amount to produce any marked result and neither of these inorganic accelerators gives the physical properties to the vulcanized rubber possessed by the products of our invention, which is best illustrated by comparative results and by the fact that the addition of the products of our invention to compounds already containing these inorganic substances causes a still very pronounced improvement in the results of vulcanization."

I will omit the claims at this present time. The article also gives six examples which I have omitted, and defines in full the conditions under which the process may be carried out, and the pros and cons of various classes of reagents. Thus it points out, among other things, that some agents are solids, difficult to handle; others yield colored products on vulcanization (nitrosodimethylaniline, for example); others on account of their poisonous character or odor would not be suitable for practical purposes; nor will the methods of application constitute a novelty in connection with discoveries along this line as the description sets forth in detail.

If our friends across the Atlantic should still doubt our claims to priority of discovery of this fundamental principle of vulcanization let them test the validity of their patents. They will find that the records which I have just cited are a mere indication of the volumes of evidence and facts which can be established to dispose of any claim on their part to novelty of invention as far as America is concerned. As far as the specific claim to the use of *p*-nitrosodimethylaniline is concerned, let me assure Mr. Peachey that when he is ready, I am prepared to demonstrate through several different sources that this material was tried out both scientifically and industrially in this country so long ago as 1910, and was long since abandoned on account of the serious disadvantages to its extensive use. I recall indeed having used it in one instance in the preparation of rubber stoppers for laboratory use, but with unfortunate results. It is a substance which I should not think of employing industrially now, as there are so many objections to its use.

In conclusion, a good reagent must intensify not merely the chemical process of vulcanization, but also the physical; it should toughen the rubber, whether raw or vulcanized; and should render it immune to deterioration. All this has been achieved in America, giving a rubber superior to that from any natural source. A "noble" rubber, similar to the "noble" alloys, is an accomplished fact.

NORWALK TIRE AND RUBBER CO., INC.
NORWALK, CONNECTICUT

VULCANIZATION OF RUBBER BY SELENIUM

By CHARLES R. BOGGS

Received October 31, 1917

Vulcanized rubber has been manufactured for some years, but there has really been no essential change from the general methods of vulcanization as originally specified by the inventors. The two original methods, which are still in use, are the vulcanization with sulfur by heat and that by sulfur chloride in the cold. Variations in the processes have been introduced and innumerable mixtures made with other materials, but no rubber article of practical importance has been put on the market which has essentially deviated from the two original processes.

There have been made, however, many slight variations in compounding rubber mixtures which have produced vulcanized rubber products that are characterized by properties which fit them to special work better than any previously known compounds. It was with this idea that we thought rubber vulcanized with selenium might give a product of especial adaptability to some of the many uses of rubber. At the time that we first tried to vulcanize rubber with selenium, 1913, we thought that we were the first, although it is evident that anyone with a knowledge of chemistry would expect selenium to act similarly to sulfur. We have since noticed that Pearson in his book, "Crude Rubber and Compounding Ingredients," mentions two methods, one by heating rubber with equal parts of selenium and the other by dropping liquid selenium into a CS_2 solution of rubber at 300° F. under pressure. It is evident that these methods had nothing to recommend them and I believe could never have been developed because of the unsatisfactory product.

Selenium is a metal in the same group of the periodic table as oxygen, sulfur and tellurium, is much more metallic than sulfur and has a higher melting point (217° C.), sufficiently high to discourage one from attempting to use it as a vulcanizer for rubber which is not capable of withstanding such a temperature. Its atomic weight is 79.2. It occurs in two crystalline and one amorphous form and forms a complex molecule when cold, Se_8 being very similar to sulfur. A short table of its properties follows:

	Crystal	Specific Gravity	Solubility	Melting Point
Black or gray crystalline	Octahedral		Insoluble in CS_2	217°
	Hexagonal	4.80		
Red crystalline	Monoclinic	4.46–4.51	Soluble in CS_2	175°
Red amorphous	.....	4.26–4.28	1 soluble (and 1 insoluble) in CS_2	Softens at 102°

All modifications go over to the black crystalline form when heated at 100 to 150° C. The black crystalline powder can be obtained on the market in small quantities, but it should be procurable in fair amounts if there were a commercial demand for it. Black selenium has the further peculiar property of being an electric conductor under the influence of light although the other forms are insulators. It might, therefore, cause rubber which has been vulcanized with it to show some slightly unusual electrical characteristics.

Our first attempts were with selenium in the form of black powder used in a standard 5 per cent Para compound in the equivalent proportion that sulfur would be used. By heating at about 150° C. for a couple of hours a partial vulcanization resulted. The physical tests showed a normal elongation, but a tensile strength of only about 50 per cent of the similar sulfur compound. The point to be noted is that partial vulcanization was obtained, although the temperature was well below the melting point of Se. Increase in the time did not improve the product. All of these first samples have aged well and after nearly four years give the same elongation and tensile-strength values of about 70 per cent of the original.

Doubling the amount of selenium and using an organic accelerator, which we were then using with sulfur, did not improve the product but did make the samples go to pieces with age, a normal characteristic of overvulcanized and under-vulcanized rubber. A peculiar point about this compound was that when it was removed from the press hot it expanded 25 per cent of its volume. Its volume became normal when cold. This high coefficient of expansion indicated lack of vulcanization.

Using amorphous selenium and an organic accelerator we were able to increase the tensile strength some without sacrificing the elongation. Some other accelerators were tried without much success. The amorphous selenium should go over the metallic form at the temperature used.

The most promising compound we then had was put on wire and has been tested regularly for the last three years and the remarkable point is that it has not deteriorated appreciably in that time. This compound was below normal in its tensile strength. The difficulty seemed to be that the long heating at the relatively high temperature used to effect vulcanization caused too great a depolymerization of the rubber.

By trial we have now found accelerators which enable us to satisfactorily vulcanize rubber with selenium when heated at the ordinary vulcanizing temperature of 275° F. (135° C.) for only about twice the time required with sulfur. The product gives the normal tensile strength (1100 to 1200 lbs.) and elongation (12 to 10 in. or 12 in.) of the same compound with sulfur. It is somewhat soft. This compound shows no deterioration under the short life test of 4 days' heating in air at 72° C.

Electrical tests have been carried out on wire insulated with this compound and the insulation resistance and dielectric strength are somewhat low. Special determinations as dielectric loss, etc., have not yet been determined.

Chemical analysis as applied to ordinary sulfur compounds does not apply to these compounds vulcanized with selenium, as the black selenium is practically insoluble in acetone and consequently the uncombined Se is not separated by extraction with acetone. Also it is only very slightly soluble in $CHCl_3$ and CS_2. The acetone extract contains only the resins from the rubber (provided oils, waxes, etc., are not added). The $CHCl_3$ extract contains some Se and a small amount of unvulcanized rubber as with soft vulcanized rubber when cured with sulfur. A determination of rubber by the tetrabromide method gave 31.7 per cent rubber plus resins, etc., in a compound to which 31.7 per cent rubber had been added. This would indicate that no correction should be made for combined Se, *i. e.*, that the selenium was either not chemically combined or more likely that it was so weakly combined that it was displaced by Br. It is possible that a complete chemical study of the vulcanization of rubber with selenium may throw some additional light on the theory of vulcanization. Also it may help in the study of the nature of the catalytic effect of accelerators as the vulcanization occurs so far below the melting point of the Se.

The product as we now have it has not yet shown any unusual electrical properties, but the indications are that its deterioration with age is much less than with sulfur compounds. It can be brominized and oxidized but the natural oxidation seems to have been slowed up. As the deterioration of rubber goods is the one disadvantage of rubber, especially in those lines of work where permanency is desired, it may be that the use of selenium may partially remove this disadvantage.

RUBBER LABORATORY OF THE
SIMPLEX WIRE & CABLE COMPANY
BOSTON, MASSACHUSETTS

THE PIGMENTS OF THE TOMB OF PERNEB[1]

BY M. AMMERMAN TAUB

In 1913 Mr. Edward S. Harkness presented to the Metropolitan Museum of Art of New York City, the Tomb of Perneb, which originally stood in the cemetery of the ancient Memphis. Mr. Harkness acquired this tomb from the Egyptian Government and Dr. Albert M. Lythgoe removed the tomb from Sakkara and re-erected it in the main hall of the Metropolitan Museum of Art.

The tomb was built approximately 2650 B. C. and in it was buried an Egyptian Dignitary named Perneb, who held high office under the king at Memphis. The tomb contains many figures in relief, particularly the side wall in the main chamber, on which the carvings are very profuse. The figures are all colored with various pigments.

The pigments used on the Tomb of Perneb are red, yellow, blue, green, gray and black. There is a popular belief that the red used by the Egyptians was red ochre. This is not correct, as ochre is yellow naturally, and only turns red when it is burned or calcined. Ochres all normally contain between 10 and 20 per cent of oxide of iron, whereas the reds of the Egyptians contain more than 50 per cent of oxide of iron, and from their very color it is certain that the red of the ancients was hematite. This is never a very bright

[1] Paper presented at the meeting of the New York Section of the Society of Chemical Industry, October 10, 1917.

[2] It is a great pleasure for me to acknowledge the assistance that I have received from Dr. Albert M. Lythgoe. Through whose courtesy I was given the pieces of limestone and the colored specimens which were taken from the Tomb of Perneb.

red, but is always one which we associate with brick color.

YELLOW—All the yellows used were the native ochre, which is clay stained with iron rust.

BLUE—The Egyptian blues are very beautiful and range from a light sky-blue to a dark ultramarine. An examination with a microscope of the dark Egyptian blue shows it to be powdered glass or porcelain. This material has been known as "frith" and has of itself no hiding or obscuring power, nor does it seem to have been put on with a binder. This powdered glass has been rubbed into the surface and allowed to set with the Nile clay or the Nile mud, which, on account of its slightly alkaline nature, is cementitious of itself and has both setting and binding power. The appearance of this blue glass, which in modern times is called "smalt," appears blue just the same as snowflakes appear white, because the light is broken up on its crystalline structure, yet a single snowflake is as transparent as pure glass.

GREENISH BLUE is azurite, a hydrated carbonate of copper.

GREEN is malachite, azurite and clay.

BLACK is carbon black composed of charred wood or burnt wood or charred bones.

GRAY is limestone mixed with charcoal or carbon.

Mr. Lythgoe found two paint pots which had evidently been thrown out by the workmen and an examination of these shows the pigment to be hematite mixed with limestone and clay.

It is remarkable that in all investigations of historic materials, many of the tools and implements used have been either forgotten or in many cases not found. I have, in times gone by, paid a great deal of attention to the pigments used by the old masters, beginning with the primitive painters of Italy and going through the history of the Flemish materials down to the English masters, and while I have had abundant matter I have had hardly any historic data concerning the implements used, such as brushes and palette knives. There are practically no brushes left to show us how the wonderful technique of the older painters has been carried out. The same may be said of the musical instruments. The bows used by the early violinists of Italy are not well known and their history, method of manufacture and composition are very largely shrouded in mystery.

There is a brush in the Metropolitan Museum of Art, from one of the excavations of the Palace of Amenhotep III at Thebes, that dates from the XVIIIth dynasty. This brush is similar in size and shape to a medium-sized sash tool used by the house painters of the present day. The bristles are not hair, but evidently of a vegetable stalk similar to bamboo, which has been beaten until the longitudinal fibers have separated. It is bound around with a twine of fiber a good deal like hemp, just the same as a modern round paint brush is bound either with wire or cord.

There has been little or no work done on Egyptian pigments, with the exception of the chapter by Dr. Russell, called "Egyptian Colors," in the book "Medum" by Flinders Petrie, compiled in 1892. Dr. Russell was in error, however, when he stated that the splendid rich blue was a silicate of copper, for the samples that were submitted to me proved to be cobalt, and upon investigation I found that A. W. Hoffman demonstrated that the blue frits of the time of Rameses III were painted with cobalt.

Nearly everyone has made the popular error of assuming that the Egyptians used the white of egg as a binder for their pigments. I cannot find any trace of any albuminous binder in the pigments submitted to me, but they do show some evidence of the use of glue or gelatine. It is well known that the Egyptians manufactured very excellent grades of glue either by boiling parchment or bones and hides of animals. They were excellent cabinet makers and used glue very largely in joining pieces of wood. In the great museum at Cairo there are to-day many samples of furniture glued together with Egyptian glue, which are still in excellent condition. It is, however, more than likely that little or no binder was used when the pigments were applied on the various tombs, even to those built about 1500 years later, like the Temple of Karnak. We all know that the climate of Egypt is exceedingly dry and therefore no rain can wash off or disintegrate a cold water paint made by means of pigment and glue. The Nile clay and Nile mud largely used in building are slightly alkaline and in many respects similar to the adobe mud in New Mexico and Arizona. This mud contains a small percentage of free lime, and any earthy substance which contains free lime will in time act like a weak cement and become firmly bound. It is therefore my opinion that many of the decorations made by the Egyptians were made without any binder other than the lime naturally found in the soil, and in a few cases glue was used. I also judge, from the nature of the implements used, that the pigments were rubbed into the surface and they in time became part of the surface.

I do not refer to the splendid decorative work in the wooden sarcophagi when I say little or no binder was used, for in these coffins and on the outside of the linen wrappings there are some really wonderful decorative paintings in which binders were used. The portraits outside of the mummy wrappings in the second century were done with wax and resins and are excellent works of art, although these paintings have nothing to do with the pigments of the Tomb of Perneb.

320 FIFTH AVENUE
NEW YORK CITY

THE PREPARATION OF $N/100$ PERMANGANATE SOLUTIONS

By J. O. HALVERSON AND OLAF BERGEIM

Received August 17, 1917

The preparation, standardization and conditions of use in volumetric analysis of N and $N/10$ solutions of potassium permanganate have been studied with some care.[1] Unfortunately, however, certain of the precautions which have thus been shown to be neces-

[1] See Gooch's "Methods in Chemical Analysis," 1st Ed., New York.

sary for accurate work have been commonly neglected in the literature, even in handbooks of general and applied analytical chemistry. As a result of this and of the widening application of permanganate titration methods, especially in biochemistry, certain methods based on this principle have been recently suggested which possess unnecessary inaccuracies. Common errors are the use of too much sulfuric acid in titrations and a lack of appreciation of the great sensitivity of permanganate solutions to traces of organic matter. In the determination of very small amounts of substance, as, for example, in the estimation of calcium as oxalate in small portions of biological fluids[1] where permanganate solutions approximately $N/100$ must be used, the elimination of these sources of error is a necessity.

Where a standard permanganate weaker than $N/10$ was desired it has been customary to make this shortly before using by dilution of a stronger permanganate solution,[2] in spite of the fact that ordinary distilled water contains appreciable amounts of organic matter which can be removed only with great difficulty. For instance, we have found that water redistilled from both acid and alkaline permanganate may still cause an appreciable deterioration (as much as 2 or 3 per cent) when used in diluting permanganate from $N/10$ to $N/100$. This was true even where the weak solution was used at once. If allowed to stand for any length of time, or if less carefully distilled water was used, the permanganate was almost entirely decomposed, this process being hastened by the catalytic action of the oxides of manganese which were formed.

To avoid the inconvenience as well as inaccuracy of dilution we have endeavored to prepare permanent $N/100$ solutions. The principle used is not new, but the technique as we have adapted it and some data pertaining to the keeping qualities of dilute permanganates and of oxalic acid solutions used as standards may be of interest.

PREPARATION OF $N/100$ POTASSIUM PERMANGANATE

Dissolve 0.40 g. pure potassium permanganate crystals in one liter of redistilled water in a thoroughly clean Florence flask which has been rinsed with the same water. Digest at or near the boiling point for 36 hrs. A funnel covered with a watch-glass may be used as a reflux condenser. Cool and allow to stand over night. Without disturbing the sediment of manganese oxides, filter with gentle suction through a 3-in. Büchner funnel lined with ignited asbestos. Both funnel and filter flask should be rinsed with redistilled water. Transfer the permanganate solution to a glass-stoppered bottle free from traces of organic matter. The solution should be kept in the dark when not in use. If the asbestos becomes clogged with oxides these may be dissolved out with hot concentrated hydrochloric acid, followed by washing with redistilled water without disturbance of the pad.

After standing two or three days this permanganate solution may be conveniently standardized against $N/50$ oxalic acid (0.1261 g. pure crystals to 100 cc.) or sodium oxalate of similar strength. To 10 cc. of the oxalic acid solution add 10 cc. of 10 per cent sulfuric acid which has been treated with just sufficient permanganate solution to give it a faint pink color. Place in a water bath at 65° C. for a few minutes. Then titrate at once to a definite pink color which persists for at least a minute. Correct for the blank obtained by titrating 10 cc. of the sulfuric acid and the same volume of water to the same end-point.

If kept in a dark place, the oxalic acid solution used in standardization does not lose appreciably in strength in from ten days to two weeks. Ordinarily the permanganate solutions after they have stood several days will not vary over 0.1 per cent per week (see Table I). On account of the sensitivity of the reagent it is, nevertheless, desirable to check it up rather frequently. This also serves as a control on technique.

TABLE I.—PERMANENCY OF PERMANGANATE SOLUTIONS, ETC.

No.	Solution	Age of Solution	Cc. Permanganate Required for Definite Volume Oxalic Acid
1.	$N/100$ Potassium Permanganate....	10 days	20.14
		25 days	20.20
		148 days	20.62
		185 days	20.65
		386 days	21.05
2.	$N/75$ Potassium Permanganate ..	2 days	11.88
		5 days	12.04
		15 days	12.15
2.	Separate Bottle.....	2 days	11.81
		223 days	11.99
3.	$N/50$ Potassium Permanganate	1 day	8.14
		6 days	8.17
		19 days	8.25
		47 days	8.31
		68 days	8.45
		125 days	8.50
		180 days	8.55
4.	$N/80$ Potassium Permanganate (by direct dilution of $N/10$).....	Theoretical	13.70
		15 minutes	14.20
5.	$N/100$ Potassium Permanganate (by direct dilution of $N/10$).....	Theoretical	17.50
		15 minutes	17.83
6.	Same as Sol. 5	Theoretical	17.50
		15 minutes	17.81
7.	Same as Sol. 5	Theoretical	17.43
		15 minutes	17.69
		1 day	17.77
		2 days	18.18
8.	Oxalic acid 0.1101 g./100 cc. (0.0175 normal).....	1 hour	20.62
		18 days	20.58
		22 days	20.47
		72 days	18.06
9.	Oxalic acid, 0.1101 g./100 cc.....	1 hour	20.54
		11 days	20.62
		14 days	20.62
10.	Oxalic acid, 0.1101 g./100 cc.....	1 hour	8.34
		6 days	8.32
		10 days	8.30
		14 days	8.23
		19 days	8.27

The solutions on which the above data were obtained were kept away from the light except while in use. Solutions 1 and 3 were used almost every day. They were kept at room temperature throughout one summer and in the case of Solution 1 two summers. In the dilution tests redistilled water was used.

CONCLUSIONS

The preparation of weak permanganate solutions by direct dilution is inaccurate and inconvenient. By means of the procedure outlined in this paper $N/100$ potassium permanganate solutions may be prepared which will retain their strength and usefulness for an indefinite period.

DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY OF
JEFFERSON MEDICAL COLLEGE
PHILADELPHIA, PA.

[1] Halverson and Bergeim, *J. Biol. Chem.*, **24** (1916), 22; **29** (1917), 337; Halverson, Mohler and Bergeim, *J. Am. Med. Assn.*, **68** (1917), 1309.

[2] See Michaelis, *Biochem. Z.*, **59** (1914), 166, and Ellinger, *Z. physiol. Chem.*, **38** (1903), 192, for example.

THE USE OF MICROÖRGANISMS TO DETERMINE THE PRESERVATIVE VALUE OF DIFFERENT BRANDS OF SPICES[1]

By Freda M. Bachmann

Received July 25, 1917

In a former paper[2] the sensitiveness to spices of several microörganisms was discussed. In my work at that time I used only one brand of spice. Further studies with spices from different sources gave results widely divergent and indicate that the sensitiveness of one or more microörganisms to a spice may be a criterion of its preservative value.

ORGANISMS

The organisms used for this study were various species of bacteria, yeasts and molds. The bacteria were *Bacillus subtilis*, *Bacillus coli*, *Bacillus prodigiosus*, and *Sarcina lutea*. Five yeasts were used, one of which was isolated from the commercial yeast foam, another from Fleischmann's compressed yeast. The other three were old laboratory cultures of *Saccharomyces cerevisiae*, *Saccharomyces ellipsoideus*, and *Saccharomyces anomalus*. Professor E. M. Gilbert has very kindly examined cultures of the molds and finds them to be *Aspergillus niger* van Tieghem, *Penicillium glaucum* Link, *Rhizopus nigricans* Ehrenb., and an *Alternaria* which is probably *Alternaria tenuis* Nees.

METHOD

The methods used for determining the preservative value of various brands of spices were the same as those used in my former studies.[3] The medium was sterile, nutrient agar containing a definite amount of spice. The bacteria and yeasts were grown in test-tubes, the bacteria on beef broth agar and the yeasts on wort agar. For the molds a shallow watch-glass of $1^1/_2$ in. diameter was placed inside a Petri dish and then both were sterilized in the oven. Thaxter's potato hard agar, consisting of potato broth with 3 per cent agar and 2 per cent glucose, when sterile was poured into the Petri dish and the same kind of medium containing a definite amount of spice was poured into the watch-glass. When the agar in each was thoroughly hardened it was inoculated with a suspension of mold spores in water by means of a platinum loop. This double plate shows the growth on the spiced agar and also the effect of the volatilized substances on growth of the organism on non-spiced agar. Unless the amount of spice used is so great that the growth of the organism on both the spiced and non-spiced agar is completely inhibited, the agar without spice outside the watch-glass serves as a control plate to prove the viability of the spores used for inoculation. This double plate method is not recommended as ideal because there is some slight variation in results which may be due to the way in which the cover of the Petri dish fits the lower part. If the edge of the lower part of the dish is uneven, more of the volatile substance will escape and permit a better growth of the organism. Unless the plates are kept in a damp chamber, this unevenness may also allow considerable evaporation and the resulting drying of the agar may inhibit growth. It is desirable that the Petri dishes to be used should be carefully examined to have the covers fit well. With this precaution observed, the amount of variation in the sensitiveness toward spice of the organisms used for this study has been considered negligible.

In the study of several brands of spice the molds were grown in the double plates described above and also on spiced agar in test-tubes. The following tabulated results of mold growth are all from Petri dish cultures. It is seldom that the minimum dilution of a spice which permits growth is the same in a Petri dish and in a test-tube. The minimum dilution is usually somewhat less in a Petri dish. This is doubtless to be accounted for in the more shallow layer and the greater surface area of spiced agar in the Petri dish which results in a more rapid loss of volatile substances.

For the results given in this paper only the ground spices were used. Spices of different brands were obtained from various sources.

In the following table are given the results obtained after inoculating potato agar containing various amounts of cloves with suspension of mold spores in water. The different brands of cloves are given as A, B, C, D, and E. The results are from cultures on agar in Petri dishes as described above. In my former paper attention was called to the difference in sensitiveness to spice of the mycelial filaments and the spores of molds. This phenomenon has been frequently observed in the Petri dish cultures. There is often no growth on the spiced agar until the mold has grown abundantly on the agar without spice. When the filaments reach the sides of the watch-glass they grow upward and over the edge of the watch-glass and on the spiced agar. In the following table such a growth of the mycelium is indicated by the letter *m*. It may be observed that such mycelial growth is frequently given for *Rhizopus*, only once for *Alternaria*, and not at all for *Aspergillus* and *Penicillium*. This is not to be interpreted as an equal sensitiveness of the mycelium and spores of *Alternaria*, *Aspergillus*, and *Penicillium*. It is explained by the fact that in *Rhizopus* the mycelium produces a more vertical growth and thus is much above the surface. These filaments readily grow over the sides of the watch-glass embedded in the agar. In *Alternaria*, *Aspergillus*, and *Penicillium* the growth is more horizontal and close to the substratum. The same growth of the mycelium of *Alternaria*, *Penicillium*, and *Aspergillus* from non-spiced to spiced agar has been frequently observed in such plates as were described in my former paper[1] where the non-spiced and spiced agar is in contact.

It will be observed from Table I that cloves A and B are much more effective in inhibiting growth than C, D, and E. The species of *Rhizopus* which I have used appears to be more sensitive to cloves than any

[1] Published by permission of Director of the Wisconsin Agricultural Experiment Station.

[2] Bachmann, "The Inhibiting Action of Certain Spices on the Growth of Microörganisms," This Journal, 8 (1916), 619.

[3] *Loc. cit.*

[1] *Loc. cit.*

TABLE I—EFFECT OF DIFFERENT BRANDS OF CLOVES ON MOLD GROWTH

MOLD		Dilution of spice	Brand A	Brand B	Brand C	Brand D	Brand E
Rhizopus nigricans	1	25	0	0	0	*m*	*m*
		50	0	0	*m*	+	+
		100	0	0	*m*	+	+
		200	*m*	*m*	+	+	+
		400	..	+	+	+	+
Alternaria tenuis	1	25	0	0	0	0	*m*
		50	0	0	0	+	+
		100	0	0	+	+	+
		200	+	+	+	+	+
		300	+	+	+	+	+
Penicillium glaucum	1	25	0	0	0	0	+
		50	0	0	+	+	+
		100	0	+	+	+	+
		200	+	+	+	+	+
		400	+	+	+	+	+
Aspergillus niger	1	25	0	0	+	+	+
		50	0	0	+	+	+
		100	0	+	+	+	+
		200	+	+	+	+	+
		400	+	+	+	+	+

of the other organisms and the *Alternaria* is more sensitive than the species of *Penicillium* and *Aspergillus*. This is in agreement with my earlier studies in which I found that *Rhizopus* and *Alternaria* were more sensitive to eugenol than *Penicillium* and *Aspergillus*.

Brands A and B inhibit growth in the *Rhizopus* in dilutions up to 1:300 or greater in Petri dish cultures. With Brand B a dilution of 1:300 greatly retards growth but after a mycelium is produced it grows fairly well. When grown in test-tubes a dilution of 1:400 is probably near its maximum tolerance for this brand of cloves. With this dilution I failed to get growth several times but at another time succeeded. With Brands D and E the organism always grows well in a dilution of 1:50 in Petri dish cultures.

In Table II are given the results of inoculating wort agar containing cloves in dilutions from 1 : 25 to 1 : 400 with yeast. There is very little variation in the sensitiveness to cloves in the different strains of yeast which I have used. Brand A is again the most effective in inhibiting growth and Brand E least effective.

TABLE II—EFFECT OF DIFFERENT BRANDS OF CLOVES ON YEAST GROWTH

YEAST		Dilution of spice	Brand A	Brand B	Brand C	Brand E
Yeast Foam—culture from	1	25	0	0	0	0
		50	0	0	+	+
		100	0	0	+	+
		200	0	+	+	+
		400	+	+	+	+
Fleischmann's compressed—culture from	1	25	0	0	0	0
		50	0	0	0	+
		100	0	0	+	+
		200	0	+	+	+
		400	0	+	+	+
Saccharomyces cerevisiae	1 :	25	0	0	0	0
		50	0	0	0	—
		100	0	0	0	+
		200	0	+	+	+
		400	0	+	+	+
Saccharomyces ellipsoideus	1	25	0	0	0	0
		50	0	0	0	+
		100	0	0	+	+
		200	0	+	+	+
		400	0	+	+	+
Saccharomyces anomalus	1	25	0	0	0	0
		50	0	0	0	+
		100	0	0	0	+
		200	0	+	+	+
		400	0	+	+	+

In Table III are given the results of inoculating beef broth agar containing cloves in dilutions from 1 : 50 to 1 : 400 with four species of bacteria. The brands of spice vary in their preservative value in the same way as they were found to vary when molds and yeasts were used. Brand A has the greatest preservative value, next Brands B and C, and Brand E least of all.

As with molds, there is likewise considerable variation in sensitiveness among bacteria to any one brand of spice. In my former studies I found *B. subtilis* to be very sensitive to cloves. This fact has been frequently observed in the present work. *B. prodigiosus*, on the other hand, has considerable resistance to cloves.

TABLE III—EFFECT OF DIFFERENT BRANDS OF CLOVES ON BACTERIAL GROWTH

ORGANISM		Dilution of spice	Brand A	Brand B	Brand C	Brand E
B. subtilis	1	50	0	0	0	0
		100	0	0	0	—
		200	0	0	—	—
		300	0	—	—	—
		400	—	—	—	—
B. coli	1	50	0	0	0	0
		100	0	0	0	+
		200	0		—	+
		300	0		+	+
		400	—	—	+	+
B. prodigiosus	1	50	0	0	0	+
		100	0	0	+	+
		200	0	—	+	+
		300	+	—	+	+
		400	+	—	+	+
Sarcina lutea	1	50	0	0	0	+
		100	0	0	0	+
		200	0	0	+	+
		300	0	—	—	+
		400	+	+	+	+

A similar study has been made with a few brands of cinnamon and of allspice. In Tables IV and V are given the results of this study.

TABLE IV—EFFECT OF DIFFERENT BRANDS OF CINNAMON ON THE GROWTH OF MOLDS AND BACTERIA

ORGANISM		Dilution of spice	Brand A	Brand B	Brand C
Alternaria tenuis	1	25	0	0	0
		50	0	0	0
		100	0	0	0
Penicillium glaucum	1	25	0	0	0
		50	0	0	0
		100	0	0	0
Rhizopus nigricans	1	25	0	—	—
		50	—	—	—
		100	—	—	+
Aspergillus niger	1	25	0	0	0
		50	0	0	0
		100	0	+	+
B. subtilis	1	25	0	0	..
		50	0	0	..
		100	0	+	..
B. coli	1	25	0	+	..
		50	+	+	..
		100	+	+	..
B. prodigiosus	1	25	0	+	..
		50	+	+	..
		100	+	+	..
Sarcina lutea	1	25	0	0	..
		50	0	+	..
		100	+	+	..

It may be seen from Tables IV and V that growth of the above species of molds, bacteria and yeasts has varied little on media containing different brands of allspice and cinnamon. Although the brands of allspice and cinnamon which I have used are thus more nearly equal in preservative value than the different brands of cloves, yet it is quite evident that Brand A of both cinnamon and allspice has considerably more preservative value than Brand B or Brand C.

It is desirable that the test organism used in determining the comparative antiseptic values of different brands of spice be fairly sensitive to the spice so that high dilutions of a strong spice could be used. Here again, as in my former studies, I have found that *Rhizopus nigricans* is very sensitive to cinnamon. *Aspergillus niger* is somewhat more sensitive to this spice than the *Rhizopus* and shows nicely the difference in the preservative value of the different brands that I have used. *Rhizopus* grows so readily

TABLE V—EFFECT OF DIFFERENT BRANDS OF ALLSPICE ON THE GROWTH OF MOLDS AND YEASTS

ORGANISM	Dilution of spice	Brand A	Brand B	Brand C
Alternaria tenuis(?)	1 : 25	0	0	..
	50	0	0	..
	100	0	+	..
Penicillium glaucum	1 : 25	0	0	0
	50	0	0	+
	100	+	+	+
Rhizopus nigricans	1 : 25	0	0	0
	50	0	0	+
	100	0	+	+
Aspergillus niger	1 : 25	0	0	+
	50	0	+	+
	100	+	+	+
Yeast Foam—culture from	1 : 25	0	0	..
	50	0	+	..
	100	+	+	..
Fleischmann's compressed—culture from	1 : 25	0	0	..
	50	0	+	..
	100	+	+	..
Saccharomyces cerevisiae	1 : 25	0	0	..
	50	0	+	..
	100	+	+	..
Saccharomyces ellipsoideus	1 : 25	0	0	..
	50	0	+	..
	100	+	+	..
Saccharomyces anomalus	1 : 25	0	0	..
	50	0	+	..
	100	+	+	..

on media containing cinnamon that it shows no difference at all between Brands B and C in the dilutions used. *Penicillium*, on the other hand, is very sensitive and in dilutions up to 1 : 100 showed no difference in the brands used for the results tabulated above. It may be that some species of *Aspergillus* would, by its growth on media containing cinnamon, show the comparative preservative value of many brands. It is highly probable that other organisms may be found which will serve the purpose even better than these which I have used.

Some observations have been made on the variation in sensitiveness of two other strains of *Rhizopus*. For the results given in this paper I have used a culture of *Rhizopus nigricans* which I have designated No. 4 in my cultures. It produces a very vigorous growth on culture media and grows much more readily on media containing some kinds of spice than a plus strain of *Rhizopus nigricans*. With a dilution of 1 : 7500 of cinnamic aldehyde, I found when I used *Rhizopus nigricans* No. 4 that there was scarcely any retardation of growth. With a minus strain of *Rhizopus nigricans* growth was somewhat delayed, but later quite vigorous, while with the plus strain there was no evidence of germination of the spores even after incubating the culture for a week. Using a 1 : 600 dilution of three brands of cloves, I found the plus strain of *Rhizopus nigricans* somewhat less sensitive to this spice than the minus strain.

It is again evident from the data recorded above that there is considerable difference in sensitiveness of any one organism to the different spices and also that no one spice has an equally inhibiting effect on the growth of different organisms. This makes it difficult to determine the minimum amount of spice necessary to preserve any food product. It is necessary that further data on the effect of spices on other organisms be obtained. That, of the different spices, cinnamon is the most generally effective as a preservative, as I stated earlier,[1] does not seem to have been proved. Results of further study with different brands of spice indicate that cloves may be just as effective as cinnamon. The best grades of these spices certainly exert a very considerable preservative effect, and although the amount used in flavoring a food product may not be sufficient to preserve it from spoilage, yet it may be a large factor in its preservation.

[1] *Loc. cit.*

CONCLUSIONS

Molds, yeasts and bacteria show a marked variation in sensitiveness to different brands of spices. The amount of growth of such organisms in a given time on media containing spice may be used as a means of determining the relative preservative values of the different brands of the spice.

SUMMARY

Microörganisms have been used to determine the preservative value of different brands of spices. Spices of molds, yeasts and bacteria were grown on nutrient agar containing varying amounts of spice. Tabulated results of such a study using five brands of cloves, three of cinnamon, and three of allspice are given. The results show that there is considerable variation in the preservative value of the brands used and that the growth of microörganisms on a spiced medium may be used as a criterion of the preservative value of the brand of the spice.

BACTERIOLOGICAL LABORATORY
AGRICULTURAL COLLEGE
MADISON, WISCONSIN

DISINFECTION WITH FORMALDEHYDE
A SUBSTITUTE FOR THE PERMANGANATE-FORMALIN METHOD

By C. G. STORM

Received December 7, 1917

The method proposed by H. D. Evans and J. P. Russell in 1904[1] for the rapid liberation of formaldehyde gas from its water solution, the "formalin" of commerce, in a condition suitable for practical disinfection, has been found by numerous investigators to be superior to most of the other known methods of formaldehyde disinfection, as regards simplicity, rapidity, cost and efficiency. This method consists in pouring the formalin quickly upon crystals of potassium permanganate contained in any suitable metallic vessel (for example, a water bucket), the oxidation of a part of the formaldehyde furnishing sufficient heat to cause rapid evaporation of the remainder of the formaldehyde together with the water.

The permanganate method has found very general application and is widely used in this country in practical disinfection work. Its use has, however, received a serious set-back by reason of the present scarcity of potassium permanganate and the resulting excessive cost of this chemical. Prior to the war in Europe, potassium permanganate was obtainable in this country at prices ranging usually from 9 to 10 cents per lb. It is now obtainable only at many

[1] H. D. Evans and J. P. Russell, "Formaldehyde Disinfection," *13th Ann Rept.*, State Board of Health of Maine, and *J. Am. Chem. Soc.*, **27** (1905), 714. See also Daniel Base, "Formaldehyde Disinfection," *J. Am. Chem. Soc.*, **28** (1906), 964–96.

times its former price, having held at approximately $4.00 to $4.25 per lb. for the past six months.

This fact has impressed the writer with the desirability of publishing a note regarding an analogous method for generating formaldehyde, devised by him in October, 1911, which it is believed has never been proposed for practical use, which preliminary tests indicate to be safer, as rapid, and almost as simple of operation, and which will be much less expensive, owing to the relatively low price of the material used.

The new method depends upon the action between the water solution of formaldehyde and a soluble chlorate, and is apparently analogous to the permanganate method, in that the oxidation of a part of the formaldehyde furnishes a sudden evolution of heat which serves to vaporize the remainder of the formaldehyde. It was suggested to the writer in the course of analysis of a potassium chlorate explosive. On adding formalin to the water solution of the explosive and heating the mixture, a violent evolution of gas resulted, increasing in intensity even after the tube containing the mixture was removed from the flame of the burner. The gas evolved was largely formaldehyde, apparently liberated from its solution by the heat generated in the oxidation of a part of the formaldehyde by the chlorate.

An examination of the solution remaining after the reaction had subsided, showed the presence of large amounts of chloride which had resulted from reduction of the chlorate. Repeated trials showed that the violent evolution of gas resulted only from concentrated solutions, but that the reduction of the chlorate to chloride, with a corresponding oxidation of formaldehyde, took place even in the case of very dilute solutions of chlorate. It has been demonstrated that under proper conditions this reaction is quantitative, and the results of the study of this quantitative method for determining chlorates will shortly be published.

The object of this paper is merely to call attention to what it is hoped will be a satisfactory substitute for the permanganate method of disinfection, and to offer an opportunity for a more complete study of the method, the writer's investigation having necessarily been quite incomplete because of lack of time and facilities for conducting work of this nature.

Potassium permanganate reacts immediately on coming in contact with formalin at ordinary temperatures, and if the permanganate is finely powdered instead of crystalline, the reaction may be violently explosive in character.[1] If formalin is poured on crystals of sodium or potassium chlorate, no action results until the mixture is warmed by application of external heat to about 65° C. This may be considered as a disadvantage, but as a matter of fact the reaction may be started with very little difficulty. The chlorate and formalin are placed together in a suitable metal container, such as a water bucket, of sufficient size to prevent the reaction mixture from foaming over, and the bucket, properly weighted so it will not float, placed in a large shallow pan (an ordinary dish pan will answer the purpose) containing water heated to about the boiling point.

The mixture becomes heated to the reaction temperature in a few minutes, when bubbles of gas begin to be evolved, this evolution increasing rapidly until it is so violent that the mixture may foam over the top of the bucket. The action is completed in 2 or 3 min., and with the proper proportion of chlorate and formalin the residue remaining in the bucket is practically dry and consists chiefly of chloride together with some unreduced chlorate.

Sodium chlorate seems to give just as satisfactory results as potassium chlorate, and has the distinct advantage of costing less than one-half as much as the latter. Potassium chlorate is now quoted at 50 to 55 cents per lb., while sodium chlorate is listed at 24 to 25 cents.

Several investigators have attempted to determine what proportion of formaldehyde used in the permanganate process is liberated as gas and what proportion is oxidized by the reaction. Frankforter and West[1] obtained an evolution of 62 per cent to 75 per cent of the formaldehyde from formalin by this process in a long series of experiments under laboratory conditions, using glass apparatus and absorbing the evolved gas in water, the strength of the resulting solution being determined. D. Base,[2] in experiments with the process on a practical scale, used a specially prepared room of 2,000 cu. ft. capacity, determining the amount of formaldehyde gas in the room by drawing 5 to 10 liter samples through standard KCN solution, adding excess of standard $AgNO_3$ solution and titrating the excess of the latter with sulfocyanate. Base found that not over 40 per cent of the total amount of formaldehyde used as formalin was evolved in the state of gas in the room.

It has been suggested that the reaction between formaldehyde and potassium permanganate is probably as follows:

$$4KMnO_4 + 3HCHO + H_2O = 4Mn(OH)_2 + 2K_2CO_3 + CO_2$$

It is, however, likely that other reactions proceed at the same time, in which part of the formaldehyde is oxidized to formic acid. Assuming this reaction, however, it is calculated that with the proportions recommended by Evans and Russell (100 cc. of 40 per cent formalin to 37.5 g. $KMnO_4$) 5.34 g. of formaldehyde, or about 13.35 per cent of the formalin, would be oxidized by the $KMnO_4$. With the proportions recommended by Base (100 cc. of formalin to 50 g. $KMnO_4$) 7.12 g. HCHO or 17.8 per cent of the formalin would be destroyed. These figures are considerably lower than those found in the investigations mentioned above. In any event it is apparent that in the permanganate process a considerable part of the formaldehyde used as formalin is destroyed by oxidation, the reaction supplying the heat which causes the rapid volatilization of the remainder.

It may be assumed that the behavior of the chlorate with the formalin is entirely analogous to that of the

[1] G. B. Frankforter and R. M. West, *J. Am. Chem. Soc.*, **28** (1906), 1234.

[1] *J. Am. Chem. Soc.*, **28** (1906), 1234.

[2] *Ibid.*, **28** (1906), 964.

permanganate, and that the reaction occurs according to the equation

$$2KClO_3 + 3HCHO = 2KCl + 3H_2O + 3CO_2.$$

Experiments have shown that the proportion of 25 g. of chlorate to 100 cc. of formalin is approximately the one giving best results, that is, with these proportions there is practically no liquid left in the residue after the reaction subsides, the formaldehyde being either driven off as gas or oxidized and the water evaporated at the same time.

A simple calculation shows that, according to the above reaction, 25 g. $KClO_3$ will theoretically oxidize 9.18 g. HCHO or nearly 23 per cent of the formaldehyde in the 100 cc. of formalin, leaving the remaining 77 per cent to be volatilized. It is probable, however, that other reactions occur, such as

$$KClO_3 + 3HCHO = KCl + 3HCOOH.$$

In fact, appreciable amounts of formic acid, as well as CO_2, are evolved by the reaction of formalin with either permanganate or chlorate.

In an attempt to determine in a simple manner the best proportions of formalin and chlorate, a series of roughly quantitative experiments were made, using varying proportions of the two materials. A weighed amount of powdered $KClO_3$ was treated in a beaker with a weighed amount of the 40 per cent formalin and the beaker immersed in hot water in order to start the reaction. The residue left in the beaker after the reaction had ceased was dissolved in water and titrated with standard solution of silver nitrate to determine the amount of chloride present. From the amount of KCl found, the weight of formalin representing the formaldehyde destroyed in the reduction of $KClO_3$ to KCl was then calculated from the reaction

$$2KClO_3 + 3HCHO = 2KCl + 3CO_2 + 3H_2O.$$

The results of these tests are shown in the following table. It is to be noted that if the reaction

$$KClO_3 + 3HCHO = KCl + 3HCOOH$$

is assumed, the calculated amounts of formaldehyde consumed will be just twice those given in the table.

TESTS OF RESIDUE REMAINING AFTER REACTION BETWEEN FORMALIN AND POTASSIUM CHLORATE

Test No.	$KClO_3$ Used Grams	Formalin Used Grams	Calc. $KClO_3$ Reduced Grams	HCHO oxidized (equiv. to KCl found) Grams	Formalin (40%) equiv. to HCHO oxidized Grams
1	7	12	3.917	1.439	3.59
2	6	12	3.817	1.402	3.50
3	6	12	3.620	1.329	3.33
4	5	12	3.750	1.375	3.44
5	4	12	3.726	1.369	3.42
6	3	12	2.990	1.098	2.75
7	2	12	2.010	0.738	1.85

In Tests 5 and 6 a very small amount of liquid remained in the residue after the reaction; in Test 7 an appreciable amount of liquid remained and a determination of formaldehyde showed 1.104 g. HCHO, equal to 2.76 g. of 40 per cent formalin. In Tests 1 to 5, inclusive, where the weight of $KClO_3$ was at least one-third of the weight of the formalin, the amount of HCHO oxidized was fairly constant, the KCl found indicating that only part of the $KClO_3$ had been reduced. In Tests 6 and 7 the excess of formalin was such that practically complete reduction of the chlorate was effected and the amount of formalin oxidized much less.

A number of qualitative tests were made using formalin and sodium chlorate in proportions varying from 6 : 1 to 2 : 1, the maximum temperatures reached during the reaction being noted. With the ratios 2 : 1, 2.5 : 1, and 3 : 1, this temperature was 108–109° C., while with lower proportions of chlorate (4 : 1 and 6 : 1) the temperature was slightly less, 104° to 105° C. In each case the reaction started at 60–65° C., was violent at about 75° C., and lasted only about 30 seconds, the maximum temperature being indicated near the end of the reaction.

The writer hopes that comparisons of the actual disinfecting efficiencies of the permanganate and chlorate methods will be made by those who may be interested in the practical side of the question and that the chlorate method may be found to be of some use.

ORDNANCE DEPARTMENT, U. S. R.
WASHINGTON, D. C.

EFFECT OF FERTILIZERS ON HYDROGEN-ION CONCENTRATION IN SOILS[1]

By F. W. MORSE

Received September 29, 1917

Most of the fertilizer plots at the Massachusetts Agricultural Experiment Station have been continuously treated for more than 25 years, and there are marked differences in their crop-producing powers, which in some instances appear to be due to chemical or physical changes in the soil and not to a deficit of the usual constituents of a fertilizer.

Among methods of investigating these soils, the measurement of the hydrogen-ion concentration in water extracts of the soils has given some interesting results.

The method of procedure has been as follows: 25 grams of air-dry soil were weighed into an Erlenmeyer flask of 300 cc. capacity, and 250 cc. distilled water were added. The flask was repeatedly shaken during a period of an hour, and then the mixture was filtered through a dry paper filter. The first portions of the filtrate were usually cloudy and were returned to the soil flask. When the paper became well coated with soil, the filtrate would, as a rule, be clear, with the exception of some limed samples which would persistently retain a slight turbidity from clay. The soil and water were in contact for about 3 hours before filtration was completed.

The colorimetric method was used for determining the hydrogen-ion concentration. The range for the soils was found to be covered by the indicators methyl red, paranitro phenol and rosolic acid. The standard salt mixtures used were Walpole's[2] acetic-acid-sodium-acetate mixture, Sörensen's[3] mono- and dibasic phosphates, and Clark and Lubs'[4] mixture of monopotassium phosphate and sodium hydroxide. The last named covers practically the same range as Sörensen's and is much more convenient to prepare.

[1] Presented before the Fertilizer Division, at the 55th Meeting of the American Chemical Society, Boston, September 10 to 13, 1917.

[2] *Biochem. J.*, **1914**; *J. Chem. Soc.*, **1914**.

[3] *Ergebnisse Physiol.*, **1912**.

[4] *J. Biol. Chem.*, **28** (1916), 504.

Ten cubic centimeters of the soil solution were compared with an equal volume of the standard mixture appropriate for the concentration of hydrogen ions in the former. Small porcelain dishes served the purpose for comparisons in nearly all cases, but tubes were used when necessary to check doubtful results.

The different fertilizers that had been used on the plots under investigation were acid phosphate, nitrate of soda, muriate of potash, sulfate of potash, double sulfates of potash and magnesia, sulfate of ammonia, land plaster and agricultural lime.

The range of H ion concentrations was between $P_H = 4.5$ and $P_H = 7.0$.

Neutral salts of strong base and strong acids, sodium nitrate, potassium chloride, potassium sulfate, calcium sulfate, produced little, if any, effect on the soil reaction, in comparison with unfertilized soil. The acid phosphate, a strong base with a moderately weak acid, behaved like the neutral salts just mentioned. Sulfate of ammonia behaved like a weakly ionized acid and carbonate of lime like a weakly ionized base, and the extremes of the range were always due to these two compounds.

When agricultural lime was used in conjunction with the other chemicals, it was noted that plots dressed with nitrate of soda or calcium sulfate retained the neutralizing effect of the carbonate of lime longer than the plots receiving potash salts, probably through a protective effect on the solution of the lime as bicarbonate. I have not yet demonstrated that point, however.

The effect of an application of 2,000 lbs. of hydrated lime per acre is perceptible on the crop and on the soil reaction for several years, but ultimately disappears, probably due to both leaching and transformation, but apparently due more to the former.

The comparative results obtained during this season's investigation of our plots are as follows:

	North	South		Field A
Acid phosphate	P_H 5.2	P_H 6.15	Nitrate of soda	P_H 6.0
Nitrate of soda	5.22	6.5	Sulfate of ammonia	4.9
Muriate of potash	5.25	6.15		
Calcium sulfate	5.0	6.65	No nitrogen	5.4
Calcium carbonate	6.4	7.4		
Unfertilized	5.25	5.96	Lime	6.0

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION
AMHERST, MASSACHUSETTS

THE SEEDS OF THE ECHINOCYSTIS OREGANA

By Miro Reason Daughters

Received October 26, 1917

This investigation was made to determine the possible industrial value of the seeds of the plant called *Echinocystis oregana*, but more commonly known as the Old Man-in-the-Ground or Wild Cucumber. It is a perennial plant, a remarkable feature of which is its gigantic root which penetrates to a depth of 1 to 2 meters and may weigh 50 or more kilograms. Heaney,[1] Manns[2] and Young examined the root of the *Megarrhiza californica*, a plant belonging to the same order as the *Echinocystis*, and reported on its pharmaceutical value. Heaney found a bitter glucoside, which he called megarrhizin. The root of the *Echinocystis* is decidedly bitter and is therefore unfit for food. The Indians are said to use it as a drastic purge in dropsy.

The fruit, which is borne on slender herbaceous stems varying in length from 3 to 9 meters, is egg-shaped. It varies from 25 to 50 mm. in the short diameter and is covered with soft green spines, a fact which explains the origin of the name "echinos" or hedgehog. It becomes lighter in color as the seeds reach maturity, and breaks open at times at the free end, leaving the seeds more or less exposed. Each fruit contains from one to several seeds, which are orbicular in shape, averaging 19 mm. in breadth and half as thick as broad. Fourteen to fifteen hundred of the seeds make a kilogram. The thin outer shell of the seed is readily broken and hence it is easily ground in a food chopper.

The *Echinocystis* is distributed along the Pacific slope from British Columbia to California, growing and thriving along railroad tracks, fence rows, in fields, along wooded ravines, and in the foothills. It is drouth-resistant, maturing its seeds under unfavorable conditions. So far as known no attempt has been made to grow this plant in quantity. Bearing in mind the character of the root it is readily seen why most farmers consider it a pest.

Seeds collected for three successive years had the following percentage composition:[1]

TABLE I

Sample No.	I	II	III
Date of Collection	1915	1916	1917
Ether Extract (Fat)	30.10	34.92	35.45
Protein (N × 6.25)	23.71	20.64	21.54
Starch	9.21	12.05	10.31
Crude Fiber	22.07	21.55	20.01
Moisture	4.04	3.90	4.54
Ash	2.89	2.64	2.60

Samples of oil were prepared by extraction with petroleum ether, boiling point 44 to 65° C., and by expression in the cold from the whole seed previously ground in a food chopper. The expressed oil was thoroughly agitated with fuller's earth from which it was separated by means of a centrifugal machine. The constants of the oils thus obtained were:

TABLE II

	Extracted Oil	Expressed Oil
Color	Golden yellow	Olive-green
Specific Gravity (at 25° C.)	0.9267	0.9166
Refractive Index at 25° C.	1.4700	1.4701
Solidifying Temperature	+5 to +8	+5 to +8
Iodine Number	116.8	117.0
Saponification Number	193.4	189.1

Judged by these results, the oil from the seeds of the *Echinocystis* belongs to the cottonseed oil group. The oil tastes like olive oil. Both the extracted and expressed oils become turbid when cooled to a temperature of 5° C. [illegible] of the former has the consistency of vaseline, whereas the latter is more solid.

Nearly 40 per cent of the oil content was expressed with the apparatus employed for this purpose. The pressure applied was approximately 83 kg. per square centimeter or nearly 1200 lbs. to the square inch. Freshly ground seeds gave an oil of olive-green color, which faded in a few days to bright straw to a golden

[1] All analyses were made in August, 1917.

[1] *Am. J. Pharm.* **48** (1876), 151.
[2] *Ibid.*, **53** (1881), 384.
[3] *Ibid.*, **56** (1883), 195.

yellow. Seeds which were ground for two weeks before pressing gave an oil of greenish red color in reflected light and dark olive-green in transmitted light.

When subjected to hydrogenation at 220 to 240° C., with powdered nickel—prepared from nickel oxide just previous to its addition to the expressed oil—there was produced a bland yellowish white fat with a melting point of 29 to 36° C., a solidifying temperature of 25° C., and an iodine number of 76.6.

Feeding experiments with mice attested the non-poisonous character of both the original oil and the hydrogenated fat.

Department of Chemistry
Oregon State Agricultural College
Corvallis

VARIATION IN THE ETHER EXTRACT OF SILAGE[1]

By L. D. Haigh

Received May 26, 1917

Having occasion to repeat the analysis of some samples of silage 10 months after the first analysis was made, considerable variation in the samples was noted. The ether extract in particular showed great variation, much less being found in the old than in the fresh silage. Table I shows the comparative results of the analyses of silage when new and also 10 months later. The results show that some factors entered into the determination when the silage was fresh which did not appear in the silage 10 months later.

Inasmuch as the sample must be dried before the ether extraction the effect of vacuum and oven drying on the percentages of moisture obtained was first studied. The results are shown in Table IIA. The effect of vacuum and oven drying on the results for ether extract are shown in Table IIB.

Table II—Results on Air-Dry Basis by Different Methods of Drying

A Percentage of Moisture

Drying Method Used	Silage	1	2	3	4
Vacuum		6.02	6.51	5.67	6.09
Vacuum + Oven (15 min.)		6.30	6.90	6.18	6.64
Oven 100 to 105° C.		8.73	9.31	8.71	9.13

B Percentages of Ether Extract

Drying Method Used	Silage	1	2	3	4
Vacuum, before and after Extraction		2.55	2.99	2.71	2.75
Vacuum + Oven, before and after Extrac.		2.01	2.11	1.90	2.12
Vacuum before, vacuum + oven after Extraction		2.87	3.27	2.94	3.06

It was thought that the acidity of silage might have some part in the variation of the results for moisture and ether extract. The acidity of silage is due principally to the presence of acetic acid, and lactic acid. The former is volatile in a vacuum, the latter is not. Table III illustrates the determination of the acidity of silage based on this fact.

Table III—Acidity of Air-Dry Silage

Silage No.	Total Acidity As Lactic Acid Original Air-Dry Silage	Total Acidity As Lactic Acid After Drying in Vacuo	Acidity Volatile in Vacuo Figured as Lactic	Acidity Volatile in Vacuo Figured as Acetic	Total Acidity Recalculated as Acetic and Lactic Acids
1	4.43	4.13	0.30	0.20	4.33
2	4.78	4.40	0.38	0.26	4.66
3	4.66	4.25	0.41	0.27	4.52
4	3.93	3.56	0.37	0.25	3.81

Comparison was made of the acidity of the samples before and after the determination of moisture and before and after the determination of the ether extract, in order to study the effect of the acidity upon these two determinations. The results are shown in Tables IV and V. The last column in Table V shows that water will wash from silage not only the acid but also other substances soluble in ether.

No attempt is made in this report to explain the causes for the above variation. Further studies are being made with a view of ascertaining what these causes are. We only wish to indicate at this time that variations do occur in value for ether extract depending upon changes in the sample itself on standing and upon the drying operations employed.

It is evident that the analyses should be made as soon as possible after the feed is used and that a uniform method of drying be employed, if these variations are to be avoided.

Table I—Analysis of Air Dry Silage—New and 10 Months Later

Silage No.	Date Analyzed	A—Results in Percentages on Air-Dry Basis: Moisture	Ether Extract	Crude Fiber	Ash	Nitrogen	Protein N×6.25	Nitrogen-Free Extract	B—Results in Percentages on Dry Basis: Ether Extract	Crude Fiber	Ash	Nitrogen	Protein N × 6.25	Nitrogen-Free Extract
1	3/16	5.54	3.61	21.07	5.20	1.32	8.25	56.33	3.82	22.31	5.51	1.40	8.73	59.63
	2/17	6.02	2.55	19.43	5.25	1.12	7.00	59.75	2.71	20.68	5.59	1.19	7.45	63.58
2	3/16	5.52	3.76	19.40	4.87	1.12	7.00	59.45	3.98	20.53	5.15	1.19	7.45	62.92
	2/17	6.51	2.99	17.74	4.88	1.08	6.75	61.13	3.20	18.98	5.22	1.16	7.22	65.39
3	4/16	7.85	4.81	20.05	5.72	1.24	7.75	53.82	5.22	21.76	6.21	1.35	8.41	58.40
	2/17	5.67	2.71	19.53	5.74	1.20	7.50	58.85	2.87	20.70	6.09	1.27	7.95	62.39
4	5/16	7.28	5.10	22.68	6.42	1.27	7.94	50.58	5.50	24.46	6.92	1.37	8.56	54.56
	2/17	6.09	2.75	21.67	6.53	1.25	7.81	55.15	2.93	23.07	6.95	1.33	8.32	58.73

Table IV—Effect of Acidity of Air-Dry Silage upon Moisture Determination

Silage No.	Acidity of Silage Original Air-Dry Acetic & Lactic	Acidity of Silage After Drying at 100° Lactic	Acidity Volatilized Acetic and Lactic	% Loss on Drying at 100° Moisture and Some Acidity	% Mixture After Deducting Volatilized Acidity	% Mixture By Vacuo Corrected
1	4.33	1.80	2.53	8.78	6.25	5.82
		1.89	2.44	8.68	6.24	
2	4.66	1.89	2.77	9.39	6.62	6.25
		1.97	2.69	9.24	6.55	
3	4.52	1.88	2.64	8.68	6.04	5.40
		1.75	2.77	8.75	5.98	
4	3.81	1.61	2.20	9.11	6.91	5.84
		1.56	2.25	9.15	6.90	

Table V—Effect of Acidity of Air-Dry Silage upon the Determination of Ether Extract

Silage No.	Acidity as Lactic Acid Of Air-Dry Silage after Drying in Vacuo	Of Residue after Extraction with Ether	Extracted by Ether	Total Ether-Soluble Material Found	Ether Extract Less Ether-Soluble Acidity	Ether Extract After Washing with Water
1	4.13	3.47	0.66	2.53	1.87	1.76
		3.45	0.68	2.56	1.88	
2	4.40	3.69	0.71	2.90	2.19	1.82
		3.63	0.77	3.08	2.31	
3	4.25	3.62	0.63	2.88	2.25	1.50
		3.62	0.63	2.55	1.92	
4	3.56	3.04	0.52	2.70	2.18	1.30
		3.06	0.50	2.80	2.30	

[1] Presented at the 54th Meeting of the American Chemical Society, Kansas City, April 10 to 14, 1917.

Agricultural Experiment Station
Columbia, Missouri

LABORATORY AND PLANT

SOME METHODS OF ANALYSIS FOR NEBRASKA POTASH SALTS AND BRINES

By A. H. McDowell

Received October 29, 1917

The so-called Nebraska potash salts consist of alkali carbonates, sulfates, and chlorides in varying proportions, with a small amount of SiO_2 (usually less than 0.3 per cent), a small amount of organic matter, and moisture from 0 per cent up.

These salts are produced by evaporating to dryness the brines (salines) obtained from wells driven into the beds of certain alkaline lakes in the Sand Hills section of western Nebraska. They are largely used in the manufacture of fertilizers and are of value on account of the potash occurring in them, the price per unit K_2O (per cent per ton of 2000 lbs.) being the basis on which they are sold.

The determinations most frequently called for are K_2O and moisture at 120° C. and the potash content of the commercial product is rarely less than 20 per cent or more than 30 per cent. Complete analyses are not needed in connection with sales, but furnish useful information for investigations and development work.

The analysis of brines is essential principally in connection with prospecting for new sources of supply. In this connection it is of interest to note that the composition of mineral solids is not necessarily constant in different parts of the same lake, or in fact at different depths in the same well, and that the percentage of solids may vary widely in samples from wells driven in different parts of the same lake. The usual analysis includes specific gravity, mineral solids, and the content of the solids in K_2O, Cl, and alkalinity as Na_2CO_3. In general, the alkalinity will be found between 45 per cent and 80 per cent and in most cases a relatively high alkalinity is accompanied by relatively low K_2O and *vice versa*.

The details of the following methods of analysis have been developed during several months' experience with these materials. The platinum chloride method for K_2O is given preference because it is simple, accurate, and official with the A. O. A. C., and because of the ease with which both platinum and 80 per cent alcohol may be recovered.

METHODS FOR COMPLETE ANALYSIS OF SALTS

MOISTURE—A 10 g. sample (30 mesh) is dried at 120° C. to constant weight. Two hours are usually sufficient. Weigh to the nearest milligram.

K_2O (MODIFICATION OF THE OFFICIAL LINDO-GLADDING METHOD)—A 5 g. sample (30 mesh) is dissolved in 500 cc. of water and 20 cc. (0.20 g.) are taken for a determination. The portion for analysis is measured into a porcelain or platinum dish and 2 cc. of 1/1 sulfuric acid are added carefully to avoid spattering.

Evaporate the water on the steam bath and continue the evaporation over the flame very cautiously to drive off H_2SO_4, finally heating every part of the dish to redness to destroy all organic matter and decompose bisulfates.

Cool the dish and add a drop or so of concentrated HCl and about 10 cc. of water from a wash bottle, washing down the sides of the dish. Warm to complete solution of salts and filter through a small paper (to remove SiO_2) into another dish. Wash the paper thoroughly with hot water.

Add 2 cc. 10 per cent platinum solution for material carrying up to 20 per cent K_2O, or 3 cc. for material carrying up to 50 per cent. Evaporate on the steam bath to a pasty mass (that will solidify on cooling).

Wash the precipitate six times with 80 per cent alcohol, using 4 or 5 cc. each time and pouring the washings through a tared Gooch crucible. During each washing rub the precipitate hard with a policeman to break up lumps. This also aids in separating the sodium sulfate which is easily distinguished from the yellow crystals of K_2PtCl_6. Wash the Gooch crucible twice with alcohol.

Continue washing the precipitate exactly as above (six times by decantation and twice in the Gooch) but using 20 per cent NH_4Cl solution saturated with K_2PtCl_6 to remove impurities not soluble in alcohol.

Pipettes are used for measuring the wash solutions, insuring uniformity of procedure and doing away with the ammonium chloride wash bottle, which is generally messy.

Finally bring the precipitate on the Gooch crucible with alcohol and wash free from NH_4Cl. Taste the bottom of the Gooch. A sour taste indicates insufficient washing.

Dry at 110° C. one-half hour and cool in a desiccator one-half hour. Calculate $K_2PtCl_6 \times 0.1938 = K_2O$.

Keep alcohol washings separate so that platinum and alcohol may be recovered.

Cl—Use 100 cc. of the above solution. Acidify with HNO_3; render slightly alkaline with $NaHCO_3$; add a few drops of saturated potassium chromate solution and titrate with $N/10$ $AgNO_3$ solution.

CO_2 (ALKALINITY)—Titrate 40 cc. of the above solution with $N/5$ H_2SO_4, methyl orange indicator. Make deduction for soluble silica determined later.

SO_3—Determine as $BaSO_4$ in 100 cc. of the above solution.

LOSS ON IGNITION—Heat a 1 g. sample of salts in a tared platinum dish to quiet fusion and weigh after cooling in a desiccator. The weighing must be done quickly as the fused salts absorb moisture very rapidly from the air.

INSOLUBLE MATTER—Treat a 1 g. sample of salts with hot water and filter. Ignite the paper and weigh.

Na_2O AND SiO_2—Evaporate the filtered solution with an excess of H_2SO_4. Ignite and weigh the mixed sulfates and SiO_2, using a tared platinum dish. After weighing take up with hot water and filter to remove SiO_2. Deduct SiO_2 and calculated K_2SO_4 from the weight found for mixed sulfates and calculate the remaining Na_2SO_4 to Na_2O.

METHOD FOR THE ANALYSIS OF BRINES

SPECIFIC GRAVITY—Determine with the Westphal balance. Temperature correction is 40° F. = 0.010 sp. gr. The specific gravity at 60° F. is an approximate indication of the per cent solids. Thus 1.100 sp. gr. indicates about 10 per cent mineral solids.

SOLIDS—Use a pipette to measure into a tared platinum dish an amount of brine containing about 1 g. of solids. Evaporate to dryness and fuse. Cool and weigh rapidly to the nearest milligram.

Cl, ALKALINITY AND K_2O IN SOLIDS—Using the same pipette as in the determination of solids, measure out the same amount of brine for the determination of Cl. A similar sample is taken for alkalinity, and a third similar sample is made up to 100 cc. and 20 cc. taken for the determination of K_2O. The methods given on the preceding page under "Analysis of Salts" are used.

From the weight of solids found the size of sample taken for the other determinations and the percentages found can be calculated.

RECOVERY OF ALCOHOL AND PLATINUM

ALCOHOL—Most of the platinum in the alcohol washings will be found precipitated as $(NH_4)_2PtCl_6$ by the NH_4Cl in the final washings. The alcohol is decanted through paper to separate it from this precipitate. The filtered alcohol is then distilled on the steam bath. The residue not distilled over is treated as below for Pt recovery and any platinum precipitated in the distillation flask is dissolved in aqua regia and reprecipitated with the other platinum solutions for recovery.

PLATINUM—The contents of the Gooch crucibles containing K_2PtCl_6 are washed into a beaker and treated with hot distilled water slightly acidified with HCl. This will dissolve the K_2PtCl_6, leaving the asbestos, which may be used again. This solution is filtered (through the filter previously used for the alcohol washings) into the alcohol suction flask containing the bulk of the $(NH_4)_2PtCl_6$. Washing the asbestos is continued until all Pt salts are in solution. This solution is then transferred to a wide-mouth bottle, where the Pt is precipitated with aluminum. A piece of aluminum rod 3/8 inch diameter and about 3/4 inch long is convenient for this purpose. Precipitation is not complete until the solution is clear and colorless. It may be necessary to add more acid to complete the precipitation within a reasonable time.

The solution above the precipitated platinum is decanted and filtered through paper with or without suction. The remaining precipitated platinum is washed into a beaker, where it is heated with fairly strong HCl until effervescence entirely ceases. This is to remove any adhering Al or other metallic impurities. Stirring at this point will aid flocculation and make filtering easier. The Pt is then washed onto the filter previously used and washed with hot water until free from acid. It is then dried, ignited to destroy the paper, and weighed. It is then dissolved in aqua regia and evaporated to small volume several times to remove Cl and HNO_3. This solution is filtered through a tared Gooch crucible and the weight of insoluble matter is deducted from the amount weighed as Pt. The weight of insoluble matter is usually a few centigrams and probably consists of unburned carbon from the filter paper.

The platinum solution for use in analysis is of such strength that 10 cc. contain 1 g. of platinum.

THE HORD ALKALI PRODUCTS COMPANY
LAKESIDE, NEBRASKA

SUGGESTIONS ON SOME COMMON PRECIPITATIONS

By GEORGE H. BROTHER

Received October 20, 1917

A number of my friends engaged in analytical work have spoken to me about filtration difficulties they have encountered in some of the most common determinations. According to their statements, they are unable to get filters which will "hold" unless they resort to the very retentive, but comparatively slow papers. After considerable investigation of the subject, I have come to the conclusion that their blame is largely misplaced. The fault, in the great majority of cases, lies not so much in the paper used as in the method of precipitation. For this reason I am giving a few "tricks of the trade" which, I am sure, will be helpful to any analyst not already acquainted with them, if used in standard methods given in any reputable reference, such as Treadwell-Hall.

BARIUM SULFATE

The sulfate solution should be about 200 cc. in volume and weakly acid with hydrochloric acid (1 cc. 1.2 sp. gr. to a neutral solution). It should be heated to a temperature just below boiling,[1] and about half of the solution of barium chloride necessary for excess added drop by drop, stirring well meanwhile, and allowed to digest for about 5 minutes. The remainder of the precipitant is then added (not necessarily so slowly, though the solution should be stirred during the addition) and it is allowed to digest 10 or 15 minutes longer. It is then ready for filtration.

A precipitate formed in this way will be found quite crystalline and will be readily retained by a paper of moderately close texture. I have quite satisfactorily used Whatman 40, C. S. & S. 589 "White Ribbon," and Munktell's 0 instead of the slower Whatman 42, C. S. & S. 589 "Blue Ribbon," or Munktell's 00. In this way time may be saved in the filtration as well as in the much shorter period of digestion.

[1] "Just below boiling" gives all the advantages of precipitation and digestion in hot solution and eliminates the risk of superheating and loss through frothing or bumping.

CALCIUM OXALATE

Heat the solution of the calcium salt to just below boiling. Add excess ammonium oxalate solution, then just enough hydrochloric acid (sp. gr. 1.2) to dissolve the precipitate. Add ammonium hydroxide solution drop by drop until distinctly ammoniacal, then run in a good excess. Digest at a temperature just below boiling for about half an hour. Filter while hot and wash precipitate with hot water.

The important point in this determination is the acid oxalate solution from which calcium oxalate is precipitated by the addition of ammonia. The formation of calcium hydroxide is in this way prevented and a crystalline precipitate of the oxalate insured. The method works out the same if the original calcium solution is made acid, the ammonium oxalate (or oxalic acid) added, then the ammonium hydroxide solution, as above. The objection to this procedure is, of course, the absence of an indicator to prevent the addition of an unnecessary excess of acid. For volumetric lime determinations, where an ashless paper is an unnecessary extravagance, Whatman 3 and 30 or Munktell 100 will be found quite satisfactory if the precipitation is done by this method.

AMMONIUM PHOSPHOMOLYBDATE

The principal difficulty with this precipitation is the adherence of many analysts to the old rule, *viz.*, heat the phosphate solution to about 70° C., precipitate and digest at no higher temperature. If this procedure is followed, digestion for several days is necessary to secure a filterable precipitate, and even then success is uncertain. I have found the method of Woy with modifications, as given in Treadwell-Hall's "Quantitative Analysis," (1915), p. 437, to be very satisfactory. The essential point of this method is precipitation and digestion at a temperature just below boiling. The phosphate solution should be made distinctly alkaline with ammonium hydroxide, then nitric acid added to slight excess. This is a convenient way to insure the presence of ammonium nitrate in the solution and prevents the addition of too great an excess of nitric acid. It should be heated to boiling, then, while stirring, add the ammonium molybdate solution drop by drop from a pipette. Digest on a hot plate at a temperature just below boiling until the supernatant liquid is clear and colorless (usually about 15 minutes). Decant, wash and filter as usual. Occasionally when the precipitant is added, no precipitate immediately forms, but instead the solution becomes colored yellow. Digestion, as described above, will bring about complete precipitation and conversion of the yellow solution to colorless, but in such cases more than 15 minutes' digestion is usually required. The precipitate thrown down in this way is coarse enough to be retained by quite open textured papers, such as Whatman 1 and 31, C. S. & S. 595, or Munktell's OB.

MAGNESIUM AMMONIUM PHOSPHATE

Here, again, I think the difficulty lies in the use of old methods, which called for the addition of magnesia mixture to an *ammoniacal* solution of the phosphate *in the cold*. The method of B. Schmitz, as outlined in Treadwell-Hall (*Loc. cit.*), p. 434, gives much more satisfactory results. The phosphate solution is treated with excess magnesia mixture solution, hydrochloric acid added just to dissolve the precipitate and it is heated to boiling. Ammonium hydroxide solution is added slowly until a crystalline precipitate forms. If the precipitate is not crystalline, it should be redissolved by the addition of hydrochloric acid and reprecipitated with ammonia. When a distinctly crystalline precipitate has formed, the solution is made ammoniacal, it is removed from the hot plate and allowed to cool. When cold, add a volume of ammonia (sp. gr. 0.9) equivalent to about one-fifth the volume of the solution, and at the end of about 10 minutes it is ready to filter.

The reverse of these determinations, *i. e.*, the determination of magnesium by precipitating with a soluble phosphate, are carried out analogously. A number of chemists in brass work are having trouble with filtering tin dioxide. I have undertaken to investigate this determination, and hope to have some results on it before long.

OTTAWA, CANADA

A NEW PORTABLE HYDROGEN SULFIDE GENERATOR

By W. Fairlie Munn

Received November 5, 1917

Because of the objections to hydrogen sulfide generators in general, namely, the renewal of the acid, the leaking of gas following the completion of the precipitation after the supply is not further desired, and bulkiness, the following apparatus is recommended.

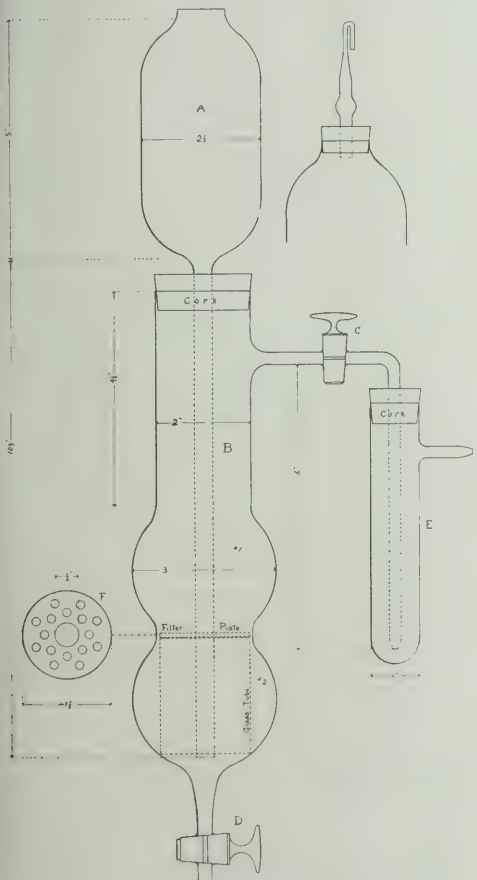
The generator is quite light, practically in one piece, self-adjusting, made in a size adapted to most analytical work, and is supported by a condenser clamp to an iron support, thus enabling the chemist to carry it easily to all corners of the laboratory. Although designed for the preparation of H_2S, it may be used for preparing CO_2, H, or any of the other gases.

The fairly heavy glass tube *B*, which is the main part of the apparatus, has a stopcock, *C*, fused to it near the upper extremity. Two bulbs are blown on the lower half of the tube and below these bulbs a stopcock, *D*, with a fairly wide bore, is fused. A lead plate, with holes as shown in the drawing, is supported between the bulbs by means of a piece of tubing having about the same diameter as the plate and cut to a length such as is required to bring the plate support to a point between said bulbs. This glass support rests on the lower part of bulb 2. Both the plate and support should be of such diameter as to just allow them to easily clear the walls of tube *B*.

The tube *A* of the apparatus and at least the capacity as given, acts as the reservoir for the acid. This consists of a $2^1/_2$ to 3 in. diameter tube, 5 to 6 in. long, with a $^3/_8$ in. diameter tube $10^1/_2$ in. long sealed to its lower extremity. This tube passes through a rubber stopper placed near its upper end, while the lower part passes through the filter plate and nearly to the

bottom of bulb 2. The stopcock *C*, which has already been mentioned, has its tube bent as shown in the figure and supports a 1 in. diameter fairly heavy-walled test-tube, which in turn has a side tube fused to it near its upper end. This test-tube contains a small quantity of water and acts as a purifying chamber for the gas evolved. No support for this tube is required.

To fill the generator, the glass tube for supporting the lead plate is first carefully placed in position. The lead plate is then cautiously slid in. The tube sealed



HYDROGEN SULFIDE GENERATOR

to the lower extremity of *A*, after putting the cork in position, is lowered into the bulb *B*, until the end has just passed through the center of the lead plate. (The center hole in this plate must be of a size which will allow the free passage of this tube.) The apparatus is then inclined and small lumps of iron sulfide cautiously rolled into tube *B*, until bulb 1 is filled. The tubes are then placed in a vertical position and tube *A* lowered until the lower extremity of the glass tube reaches the bottom of bulb 2. When the tube has reached this point the rubber stopper should be at the correct point for securely fastening in the neck of *B*. The apparatus is now fastened to a condenser clamp, at a point just above bulb 1, of tube *B*. Stopcocks *C* and *D* should be closed, and then dilute H_2SO_4 (1 : 8) poured into the top of *A*, until about full. The cock *C* is now opened until the acid has filled half of bulb 2. The cock *C* is then again closed and enough acid added to *A* to again fill it. The comparative volumes of tubes *A* and *B* should always be kept in mind because if *A* is made smaller than herein given, or bulbs 2 and 1 made larger, *A* will not be large enough to hold sufficient acid to supply bulbs 2 and 1, and still have space enough for the returning acid when the supply of gas is stopped. It is therefore advisable to make tube *A* about 6 in. in length to keep on the safe side.

By opening the cock *D*, the lower portion of acid, which has been in contact with the iron sulfide and which finally becomes inactive, may be removed without disturbing the apparatus or causing the escape of gas. This arrangement allows one to use all of the acid added to the generator and permits complete renewal of acid in a very short time. The removal of spent acid through cock *D* also washes out the black sediment which is always left after the decomposition of the sulfide.

The firm of Eimer and Amend have made up one of these generators for exhibition purposes.

RESEARCH DEPARTMENT
LEDERLE LABORATORIES
NEW YORK CITY

AN AUTOMATIC HYDROGEN SULFIDE STOPCOCK

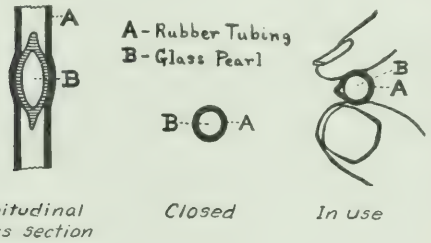
By CARL H. CLASSEN

Received November 15, 1917

In students' laboratories there has long been a need for a simple, efficient, and fool-proof hydrogen sulfide stopcock. Metal stopcocks, in general, are obviously impossible. Hard rubber or glass stopcocks are very useful so long as they do not stick or break, but in themselves they do not furnish any safeguard against being left open, or any easy control of the flow of gas. Rubber tubing with pinchcocks is also useful, but the prolonged squeeze of the pinchcocks rapidly weakens the rubber. Although screw pinchcocks give an excellent control of the flow of the gas, they, too, do not furnish any safeguard against being left open; also, the rubber is likely to be excessively squeezed, and even cut through with the consequent danger of hidden leaks. Except for the injurious squeeze and the loose adjustment, the ordinary pinchcock comes the nearest to the ideal stopcock. A satisfactory solution is particularly desirable where stopcocks are to be used in connection with numerous branch pipes from hydrogen sulfide mains.

Probably the nearest approach to a satisfactory solution is the device which is being used this year

at the Rice Institute, Houston, Texas. To each small branch pipe of the hydrogen sulfide main, thin-walled, gum-rubber tubing one foot long and of convenient diameter is attached. Near the branch pipe, and inside the rubber tubing, is a glass "pearl" made from glass tubing of a diameter slightly larger than that of the rubber tubing—the rubber should not be stretched too much. The device is merely another application of a similar device that is used with ordinary Mohr burettes.



The advantages of the device are obvious: the student must "be on his job;" open stopcocks are impossible; the flow of gas can be regulated with certainty and extreme ease; the device is not easily put out of order; it is easily and quickly replaced; there is no prolonged, excessive squeeze; the pearl may be moved to a new position when necessary; the cost is ridiculously low; the gas is not wasted.

The device has been in use only one month and, consequently, it is too early to say that it is an entire success where the durability of the parts is concerned. Where its use by the student is concerned, there can be no question of its entire success; its simplicity, and the ease and neatness of its manipulation make a "hit" with the student. Undoubtedly improvements in design and material are possible.

Rice Institute
Department of Chemistry
Houston, Texas

A SIMPLE AND EFFICIENT FILTERING TUBE[1]

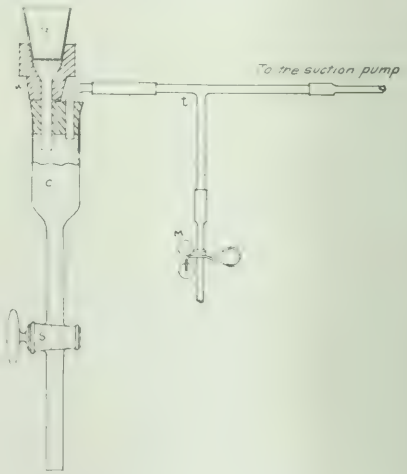
By William M. Thornton, Jr.

Received October 8, 1917

The apparatus here depicted was designed particularly for handling those precipitates whose solubilities are sufficient to necessitate great economy with the liquid used for transferring and washing. Although it resembles somewhat the filtering devices of Zöpfchen[2] and of Bailey,[3] it is not, however, identical with either. Moreover, the appliance can easily be put together from materials to be found in any well-equipped laboratory.

A straight glass tube, having a stopcock at its middle point, is sealed to a carbon filter tube. The latter is fitted with a two-hole rubber stopper. The stem of a Walter crucible holder passes through one hole of the stopper while the other contains a right-angled exit tube. The rubber hose leading to the suction pump is intercepted by an ordinary T-tube, the free end of which is joined to a short piece of rubber tubing. A Mohr clamp is kept in readiness. The whole is held in position by a stand with two clamps appropriately placed—one to grasp the main tube and the other to support the T-tube.

The manipulation is quite obvious. Having prepared the asbestos felt in the regular way, the perforated crucible *G* is set in the collar *W*. After the suction has once been adjusted, it need not be interrupted throughout the entire filtration. When the cock *S* and the clamp *M* are closed, the carbon tube *C* serves the purpose of a small filter flask. When the clamp *M* is opened and pushed upward past the shoulder on to the tube *t*, atmospheric pressure is restored within the apparatus (or nearly so); and then, on opening the cock *S*, portions of the clear filtrate can be delivered into the original beaker. The cocks



are then closed, and, after the usual application of the "policeman," the liquid is again poured over into the perforated crucible *G*. These operations can, of course, be repeated as often as may be desired.

With the aid of the above-described outfit, the author succeeded in transferring and washing a certain precipitate (the washing being accomplished by four small portions of iced water successively applied) so that the sum total of the filtrate and washings did not exceed 27 cc. Furthermore, the apparatus is so convenient that filtrations can be very quickly performed with its help—thus reducing to small dimensions the losses incurred in handling those precipitates which suffer an increase in solubility on rise of temperature.

Johns Hopkins Chemical Laboratory
Baltimore, Maryland

[1] Published by permission of the Chemical Director, E. I. du Pont de Nemours & Company.

[2] *Chem.-Ztg.*, **25** (1901), 1008.

[3] *J. Am. Chem. Soc.*, **31** (1909), 1144.

ADDRESSES

THE AUTOMATIC CONTROL AND MEASUREMENT OF HIGH TEMPERATURES[1]

By Richard P. Brown

Probably no employee causes the average works manager so many sleepless nights as does the furnace man, on whose shoulders rests the responsibility for the accurate heat treatment of the steel and the uniformity of the product. This is not only true of a steel plant, but is also equally true in the chemical industry, where the temperature of numerous processes must be accurately controlled; in the glass industry, where the melting of the glass and its annealing must be carried on within very narrow limits of temperature; in the brick industry, where the kiln firing is of the utmost importance, and I might continue the list throughout the whole industrial field.

The old furnace man, through years of practice, will endeavor to gauge the temperature of the furnace with his eye. Providing he has not been up all the previous night and his eye is clear, he will probably judge the temperature fairly accurately. If he is of a reasonably kind disposition, he may permit the manager to install pyrometers to guide him in controlling the temperature, and he may even in time use the pyrometers and rely on them.

But we can pardon the works manager or director for asking, "Suppose John dies, gets sick or quits his job, how am I to handle the output of these furnaces?" He would like to have an understudy for the old furnace man, but the latter does not like the idea. So he wonders why someone does not develop a device to automatically control the temperature of the furnaces, so that he can cease worrying about them.

This is one reason why a great amount of study has been given, not only to perfection of pyrometers, but also to the automatic control of temperature. It has, however, been only recently that real results have been accomplished in automatic temperature control.

First of all, it was necessary to perfect the temperature-measuring instrument in order that it could be relied upon to uniformly indicate the actual furnace temperature. It was then necessary to apply to the pyrometers attachments to throw the switches on the electric furnaces, or to open or close the valves on gas or oil furnaces.

My experience in the United States has shown that, for industrial service, an instrument actuated by the expansion of nitrogen gas is the most satisfactory for temperature measurements up to 800° F. or 425° C. The gas-expansion instrument consists of a bulb of copper which is inserted in the heat, and this bulb is connected by capillary tubing to an indicating or recording gauge containing a helical expansive spring.

The expansion of the gas in the bulb exerts a pressure in the capillary tubing which is conveyed to the spring in the instrument, and the pointer, attached directly to this spring, moves across the scale or chart.

It is essential in this instrument that the capacity of the bulb be some 50 times as great as the capacity of the capillary tubing and spring. This is essential to reduce to a minimum errors due to changes in atmospheric temperature along the capillary tubing or at the instrument. In consequence this instrument is not desirable for use where the gauge must be placed more then 100 feet from the bulb.

For use at moderate temperatures, where the measuring instrument must be placed at a considerable distance and for temperatures above the range of the gas-expansion instrument, the thermo-electric pyrometer has been almost universally adopted in the United States. A thermocouple of base metals, usually formed of one wire of nickel 90 per cent and chromium 10 per cent, and the other wire 98 per cent nickel and 2 per cent aluminum, is preferred for temperatures to 1800° F. or 1000° C. For temperatures above this, and as high as 2800° F. or 1500° C., thermo-electric pyrometers using a platinum-rhodium thermocouple are the most satisfactory. For still higher temperatures, a radiation type of pyrometer is available, consisting of a thermocouple in the focus of a reflector at the rear end of the tube, which is pointed at the door or opening of the furnace.

For measuring the voltage produced by a thermocouple, whether of base metal, platinum-rhodium, or the radiation type, high resistance millivoltmeters are available. We are producing in the United States such millivoltmeters of some 1000 ohms or more. This remarkably high resistance is naturally desirable to practically eliminate the errors due to changes in the resistance of the line or wiring connecting the thermocouples and the instrument, and also to nullify the effects of any changes in the resistance of the thermocouples due to heating.

Changes in resistance may be due to actual changes in length or changes in atmospheric temperature, which in turn affects the resistance of the line or wiring. We have been able to secure this exceedingly high resistance by reducing the weight of the moving element to a minimum, and I have a sample of this moving element for exhibition.

The total weight of the moving element in our high-resistance pyrometer, including pointer and springs, is 526 mg. This extreme lightness is secured by the use of an aluminum alloy wire, which we have succeeded in enameling. The enamel coating is much thinner than the silk insulation formerly used and more turns can be secured on a coil of a given width. Likewise, by the use of the aluminum wire, the weight has been reduced 66⅔ per cent as compared with copper wire which was formerly used for these moving elements. The aluminum wire is 0.003 inch in diameter and drawing this wire has been quite a mechanical problem.

The pointer tubing in this moving element is of aluminum with an inside diameter of 0.008 inch, an outside diameter of 0.012 inch, or a total thickness for the wall of the tubing of 0.002 inch. Even this weight for the pointer tubing could probably be reduced by the use of magnesium instead of aluminum, but to date we have been unable to satisfactorily draw magnesium.

I only cite these points regarding the construction of our present-day high-resistance pyrometer millivoltmeter to show what development work can produce. Instruments of this type made by Siemens and Halske, of Germany, were never developed to this extent, at least, prior to the outbreak of the war, and their moving element was several times as heavy as the sample I have here, and in consequence the resistance of their pivoted meter was several times less. Incidentally, I think we have about reached the limit of development along this particular line.

It will be understood that the same electrical system, such as I have described, can be used either to indicate the temperature, or, combined with the proper apparatus, to record the temperature constantly on a recording sheet. There are both portable and wall-type indicating pyrometers, and recording pyrometers are produced to make a record on a circular chart 8 inches in diameter, or to make a continuous record of the temperature on a roll of paper lasting two months or more. By the introduction of suitable switching mechanism a record of the temperature of quite a number of thermocouples can

[1] Read before the Faraday Society, London, by the Secretary of the Society, November 7, 1917.

be made on the same record sheet. These temperature records are distinguished by using different colors for each record line, by using numbers corresponding to each thermocouple, or changing the form of line produced on the chart for identification.

For even greater precision in temperature measurements than is secured with the high-resistance millivoltmeter, we have developed a new instrument, which we call the Brown Precision Heat Meter. This instrument is suitable for either temperature measurement or automatic control of temperature, and brief description of this new instrument might be of interest.

My idea in the heat meter has been to eliminate all the bad features or drawbacks met with in using a millivoltmeter for temperature measurement.

Possible sources of error in the use of a millivoltmeter in temperature measurements, even one of high resistance, consist in changes in resistance of the circuit comprising the thermocouple and the leads or wiring, due to changes in length or changes in atmospheric temperature; also errors can occur due to temperature coefficient of the meter, that is, errors caused by changes in atmospheric temperature in the meter itself. Another source of error is a change in the actual indication of the instrument, due to spring fatigue, abuse or sticking, and to overcome these possible sources of error we have developed this rather interesting instrument.

Briefly, its operation is as follows:

With our standard millivoltmeter of high resistance, we supply an ordinary dry cell about 1^1_2 inches in diameter by 2^1_2 inches long, and furnish suitable rheostats to reduce the voltage of the dry cell from approximately $1^1/_2$ volts to a range from 0 to 60 millivolts, the maximum voltage produced by the thermocouples.

In our first operation, we oppose the voltage developed by the thermocouple to the reduced voltage of the dry cell, and when the pointer stands on zero, it indicates that the voltage from each source is the same. We now in operation No. 2 cut out with a switch the voltage of the thermocouple and read the voltage of the dry cell circuit by direct deflection. This eliminates the line resistance entirely as in a potentiometer.

We now have a deflection indicating the actual temperature developed by the thermocouple at the moment of reading the instrument, but fluctuations in temperature of the thermocouple will not be indicated, as we are reading the voltage from the dry cell. We have, however, incorporated other operations in this meter.

In operation No. 3 we connect the thermocouple with the meter instead of the dry cell circuit and we note whether the indications are the same. By switching back and forth quickly, the voltage from the thermocouple circuit or from the dry cell circuit can be noted. If excessive line resistance has caused the indications of the millivoltmeter to be lowered as compared with the dry cell circuit, a rheostat is operated to bring up the indications of the thermocouple circuit to that shown when we are reading the voltage of the dry cell circuit.

We now leave the instrument indicating on the thermocouple circuit and the errors, if any, which might be due to line resistance or changes in temperature of the line, have been eliminated, and we have a direct reading millivoltmeter, indicating the correct temperatures.

A rheostat of 15 ohms is supplied in the meter which permits of adjusting the indications for a total change of line resistance equivalent to 15 ohms, or a circuit of two copper wires almost a mile long.

We have eliminated the temperature coefficient of the meter by furnishing a copper resistor in the meter equivalent to the copper or aluminum of the coil, hence, in balancing the voltage from the dry cell against that of the thermocouple we also automatically eliminate errors due to the temperature coefficient of the meter itself.

There is now left only one possible source of error, the change in the actual indications of the meter due to sticking of the pointer, abuse of the instrument, spring fatigue, etc. To obviate this source of error we can supply with the instrument a standard cell with suitable resistors, and by the potentiometer method used in testing the meter we can check this meter. We supply three resistors, for example, where a meter is calibrated for 60 millivolts (we furnish resistors equivalent to a deflection of 20, 40 or 60 millivolts on the scale), and after balancing the standard cell against a part of the voltage of the dry cell, through these suitable resistors we can note whether the pointer swings to 20, 40 and 60 millivolts, respectively, on the scale. If it does not, the error can be noted and the actual error in calibration is detected.

Where the instrument is supplied with standard cell the temperature of the instrument should always be between 5° C. and 40° C., or 40° F. and 105° F.; in fact, standard cells of cadmium sulfate or zinc sulfate will be injured if the temperature rises or falls beyond these limits. This is true of any standard cell employed in instruments

In this instrument we have all the good features of the potentiometer method of measuring temperature with the advantage that we have a direct reading instrument which can be adjusted once every day or oftener if desired, for the actual line resistance with which it is used and the surrounding atmospheric conditions. The meter will then indicate correctly throughout the whole scale range, and the furnace man has the instrument to guide him without hand manipulation, and an inspector can daily check the calibration of the instrument.

Naturally, this instrument is equally as suitable for automatic temperature control as the instruments previously described, when properly designed for this service.

AUTOMATIC TEMPERATURE CONTROL

Attempts have been made in the past to electrically operate switches and valves by permitting the pointer of the pyrometer to come in contact with adjustable contact arms on each side of the pointer. Unfortunately, the millivoltmeter, used with the thermoelectric pyrometer, has an exceedingly weak control for the pointer. One is easily able to blow the pointer across the scale with the breath

In consequence, simply permitting the pointer of such a pyrometer to move into contact, is not sufficiently positive to be satisfactory for automatic control work.

The automatic control pyrometer exhibited here operates in the following manner. A thermocouple formed of a nickel-chromium alloy is installed in the electric furnace, the temperature of which is being controlled. The thermocouple actuates a high resistance millivoltmeter. Below the pointer and adjustable throughout the whole scale range, is a table carrying two contact pieces, separated by a thin piece of insulating material $^1_2$ inch thick. The depressor arm driven by a small electric motor, or by a clock if preferred, depresses the pointer at regular intervals, usually every ten seconds, and in doing so the pointer forces together the two contact pieces below.

Let us assume the pyrometer controller is required to control the furnace at a temperature of exactly 1400° F. The knob on the left of the instrument is turned until the index in front of the scale stands at 1400° F. This index corresponds to the position of the thin insulating material which separates the high and low contact

The switch connecting the furnace in the line is closed and the pointer slowly rises across the scale as the temperature of the furnace rises. As the switch is already closed, when the pointer is depressed on the low contact, the switch continues to remain closed, and no change occurs until the pointer passes

over the neutral insulating piece and is depressed on the high contact. The switch indirectly operated by a solenoid and relay is now instantly actuated and the circuit opened. The temperature of the furnace begins to slowly fall, and when the pointer is again depressed on the low contact, the circuit is again closed. This operation continues as long as the furnace is to be operated.

When the switch opens and closes the main circuit, the current is either full on or off, and the fluctuations are continuous within narrow limits of some 10° to 20° F. These continuous risings and fallings of temperature can be largely reduced and closer control can be procured by the use of two rheostats in the furnace line. The solenoid-operated automatic switch is then used to simply cut in and out of circuit the second rheostat.

Assuming it is desirable to continually maintain 1400° F. in the electric furnace, irrespective of fluctuations of voltage, the two rheostats are set so that with only one rheostat in the circuit the temperature will rise to approximately 1500° F. With the second rheostat in the circuit the temperature drops to 1300° F.

When we now use the solenoid-operated switch to cut in and out the second rheostat, we naturally control the temperature only between 1500° and 1300° F., and we do not have the rapid surges or ups and downs in temperature, and thus maximum control is secured.

It is realized that the same form of switch can be used to operate a valve to control a gas or oil furnace. We have found it desirable to use an automatic valve in a by-pass so as to control simply a portion of the gas or oil supply, and in the same manner as in the electric furnace control, eliminate the maximum fluctuations caused by the complete opening and closing of the switch or valve.

Assuming that we have a 2-inch supply pipe for the gas to the furnace, it is customary for us to by-pass this and use a $^1/_2$-inch automatic valve, which gives us approximately 25 per cent control. This is sufficient to control the usual fluctuations in gas supply and secure very satisfactory control. This method also eliminates the difficulty which would occur where the gas is completely shut off and then turned on in full, as would occur without the by-pass control.

TEMPERATURE SIGNALING PYROMETER

In addition to an instrument to automatically control furnace temperatures, there has been a demand for an instrument to automatically signal by lights whether the temperature is too high, correct, or too low in any particular furnace.

It has been common practice in plants in the United States, where there are a number of heat treating furnaces, to maintain an operator at a central pyrometer and by colored electric lights at the furnace to signal whether the temperatures are right or not. It is common practice to locate three lights above each furnace—red, white and green; the red light burns when the temperature is too low, the white light when the temperature is within certain limits, for example, within 20° F. of the correct temperature, and the green light burns when the temperature is too high. The fireman who operates the furnace is guided entirely by the lights and a central pyrometer is used to control the temperatures.

We have been able to develop an instrument to automatically signal by lights whether the temperature is correct or not, and in this way the services of the operator at the instrument are eliminated. The same form of instrument is used for this purpose as we use to automatically control the furnace temperatures, and the pointer is depressed at intervals of every ten seconds onto contacts corresponding to the red, white and green lights.

No special battery or other source of current than an ordinary service line, is required to operate these lights. The supply may be 110 or 220 volts, either a. c. or d. c. The current which lights the lamps does not follow through the instrument, but is made and broken by an auxiliary device containing the necessary mechanism. A high resistor is in series with the circuit connected with the pyrometer, which reduces the current flowing through the contractors within the instrument, to less than 0.07 amp. This prevents sparking at the contractors and errors due to the heating effect of a current of higher amperage. The lamps may be any reasonable distance from the pyrometer, in fact, they are operative at a mile or more if desired.

The various thermocouples in each furnace are connected successively to the instrument through switching mechanism, and at the same time a switching mechanism connects the various sets of lights at each furnace. We have constructed an instrument of this character to automatically take care of signal lights at 12 furnaces.

This form of equipment gives the fireman or operator of the furnace an indication by lights which he can easily understand, and he adjusts the valves or fires the furnaces accordingly. It is simple to instruct a man to keep the white lights burning and to explain what the red and green lights mean, and it requires a less experienced workman to control the furnaces in this manner than to read temperatures on a pyrometer scale. This newly developed instrument also eliminates the man required to read the temperatures at a central pyrometer.

The extensive use of pyrometers to measure or record high temperatures will serve to

(1) Eliminate guess work as to the temperature.

(2) Reduce fuel consumption through the maintenance of the correct temperature and not excessively high temperatures.

(3) Reduce time for heating of the product due to the maintenance of the correct temperature.

(4) Increase efficiency in operating a plant through the savings outlined above.

Instruments to automatically control the temperature, when properly constructed and applied, will eliminate entirely the personal element. The maintenance of the correct temperature in the furnace is automatic, and this is a step forward and an improvement over temperature control through pyrometers.

I do not doubt but that the next few years will see further improvements in pyrometers and temperature control. There will always be room for improvement, and the coöperation of the industrial works and the pyrometer manufacturers will largely hasten the development of practical instruments for the measurement and control of high temperatures.

THE BROWN INSTRUMENT COMPANY
PHILADELPHIA, PENNSYLVANIA

AIRPLANE DOPES[1]

By Gustaves J. Esselen, Jr.

"Dope" is the term applied to the varnishes used on the wings of airplanes to render the fabric taut and waterproof. An airplane wing is made by covering a frame work of the proper size and shape with a linen or cotton fabric. There are then applied to the fabric several coats of a suitable varnish, of which the base is either cellulose acetate or cellulose nitrate. The term "dope" seems to have arisen in the slang of the factory workman, but is now firmly fixed and is used to distinguish the cellulose acetate or nitrate "dopes" from the spar varnishes made up of gums and oils, which are sometimes used as a finishing coat. The chief function of the dope is to tighten up the fabric and give a smooth, taut, waterproof surface, resistant to the weather,

[1] Address presented before the Northeastern Section of the American Chemical Society, October 19, 1917.

and preferably also to oil and gasoline. It also adds to the tensile strength, the percentage increase depending somewhat upon the strength and character of the fabric, and upon how much the fabric was stretched before doping. The tentative specification of the Bureau of Standards requires an increase of at least 25 per cent in the tensile strength of linen fabrics, and of 15 per cent with cotton fabrics. In practice considerably greater increases are often obtained.

The fabric most in demand for airplane wings is linen, because of its strength and toughness and the difficulty with which it tears. Owing, however, to the present scarcity of linen, specially woven cotton fabrics are being developed. While some of the latest of these have a tensile strength as great as that of the best linen, they still seem to tear more readily. The average weight of an acceptable fabric is about $3^1/_2$ to 4 ozs. per sq. yd., and the tensile strength is in the neighborhood of 90 to 100 lbs., per inch width. In general, the dope, when dry, adds about 2 to $2^1/_2$ ozs. per sq. yd., but in certain types of war machines it is considered necessary not to let the combined weight of fabric and dope exceed 6 ozs. per sq. yd.

The dopes which are at present in use may be divided into two classes: first, those consisting essentially of a solution of cellulose nitrate or pyroxylin; and second, those made by dissolving cellulose acetate. The usual concentration is about 8 ozs. per gal. Among the more common solvents for the acetate are acetone and combinations consisting largely of tetrachlorethane and alcohol. The acetone may be either pure or some of the commercial grades containing methyl acetate and methyl alcohol. To dissolve the nitrate, the usual solvents such as amyl acetate and acetone are used, and the solution diluted to the proper strength with suitable non-solvent liquids. In addition, some substances are usually added to preserve the flexibility of the coating, or modify the shrinkage power, as, for example, castor oil, which is often present in nitrate dopes. It is possible in this way to get all gradations of shrinking power from almost none to an amount sufficient to twist the frames out of shape.

The great outstanding difference between the coatings given by cellulose acetate and cellulose nitrate dopes is the inflammability of the latter, a difference which will probably be emphasized more and more as the use of airplanes for peaceful purposes increases. Cellulose acetate dopes leave a non-inflammable finish. The relative behavior of the coatings left by the two types of dope is well illustrated by the fact that some gasoline can be poured on a piece of fabric coated with a good cellulose acetate dope and allowed to burn, and the fabric does not ignite. The same test applied to a pyroxylin-coated cloth results in the immediate ignition of the coating, and in a very short space of time there is nothing left of the fabric or coating but a puff of smoke.

The initial cost of pyroxylin dopes is somewhat less than that of cellulose acetate dopes, and on this account some manufacturers have tried to effect a compromise between expense and inflammability by applying three coats of pyroxylin first, and finishing with two or three coats of acetate. This gives a fire-resisting surface, even though the coating is not non-inflammable all the way through. In Europe only acetate dopes are used, and it seems to me only a matter of time when the users of airplanes in this country will demand that every possible factor of safety be taken advantage of, which will mean the use of a non-inflammable dope.

You perhaps remember that in one of the editorials of the September number of THIS JOURNAL, Mr. Leon Cammen, Vice-President of the *American Aeronautical Society*, is quoted as saying that the ideal dope "should make the fabric waterproof, air-proof, fire-proof, or at least slow-burning, should give low visibility, prevent deterioration, and be non-poisonous."[1]

[1] THIS JOURNAL, 9 (1917), 826.

In these specifications, one or two essential points have been omitted, probably because they were taken for granted. One of these is smoothness and another adhesion. Smoothness is a quality which in this case can readily be measured by the wind resistance, and much attention has been and is now being given to such measurements.[1,2] An interesting calculation has been made by Gibbons[3] showing that in a moderately large machine the difference in wind resistance between a doped and an undoped fabric would correspond to a difference in lifting power of from 150 to 180 lbs., in other words, the weight of one man. As regards adhesion, a good dope should adhere well to the fabric, so that in case of an accident causing a break in the cloth, the coating will not be started and peel off. The dopes at present on the market vary considerably in this respect, but it sometimes happens that dopes are blamed when the real fault lies in the sizing of the cloth. One of the factors which seems to affect adhesion is the penetration. As a general thing, dopes do not penetrate well on sized fabrics. These are exceptions to this rule, and the explanation may be that in those cases where dopes do penetrate well on sized fabrics, the particular sizing involved is soluble in the solvent used, and blends with the dope. Another factor which probably enters in, is the character of the solution which constitutes the dope. While it has not been definitely established, the indications are that the more nearly the dope approaches being a true solution, the greater the penetration; whereas the more colloidal it is, the less it will penetrate. For any given dope, it has been demonstrated that it will penetrate better, adhere better, resist atmospheric conditions better, and wear better in every way when applied to an unsized fabric than it will on the same fabric sized. A reasonable way of accounting for this would be to assume that where there is no sizing the dope has a greater tendency to penetrate the fibers of the fabric, rather than merely between the fibers, and thus when dry becomes more nearly a part of the fabric. Since most sizing can readily be removed by boiling, either in soapy water or a weakly alkaline solution, it is a simple matter to insure good adhesion.

It may be interesting to know how near to the ideal the present-day dopes come. As to being waterproof and air-proof, all dopes which are used at all fulfill these requirements, because those are the first properties to be tested, but the extent to which they resist continued exposure to atmospheric conditions varies with the dope. The usual method of testing dopes is to try them out on linen stretched on frames about 12 to 15 in. square, and expose them on some convenient roof. This is much more severe treatment than airplanes ordinarily receive. The first desirable property to disappear is usually the flexibility, and the length of time before this happens can ordinarily be taken as a measure of the relative value of different dopes. The great difficulty with this test is that it varies so according to the season of the year, owing to the wide variation in atmospheric conditions. Another objection to the test is that it is not strictly parallel to service conditions, in that a wing in actual service is subjected to a very severe vibration to which the test panel is not. On the other hand, if a dope remains flexible the vibration alone should not cause it to crack. The Bureau of Standards at present requires a dope to retain its flexibility at least 60 days when constantly exposed to the weather. There is a certain weakening of the fabric on exposure, and tests[3] have shown that this is much less with acetate than with nitrate dopes. Especially is this true of cotton and in a less marked degree of linen. This is what might be expected when one recalls that cellulose acetate is a much more stable compound than cellulose nitrate. In addition, any free nitric acid formed

[1] Zahm, *Phil. Mag.*, **8** (1904), 58.

[2] Report of National Advisory Committee for Aeronautics for 1916, pp. 176ff.

[3] Gibbons and Smith, *Ibid.*, p. 168.

by the decomposition of the pyroxylin would have a much greater weakening effect on the fabric than would a similar amount of acetic acid, even if the rate of decomposition of the two cellulose esters were the same. In one instance the tensile strength of cotton fabric doped with a nitrate dope after 3 weeks' exposure was reduced to 48.5 per cent of the original, while linen coated with the same dope was reduced to 68 per cent. With an acetate dope under similar conditions, the tensile strength of the cotton was reduced to only 87.2 per cent and the linen to 84.8 per cent. All of these were taken in the direction of the warp.

In order to give a more waterproof surface, it is the general practice with some companies to apply one or two coats of spar varnish over the usual dope. The use of spar varnish has one disadvantage, however, and that is in the matter of patching. As a rule, a hole in a wing can be patched with a piece of fabric by using dope as a glue. On spar varnish, however, most dopes do not stick, so that in order to make a repair, the varnish first has to be removed.

There is one bane of the dope room which might be mentioned here, and that is the formation of white spots during the drying of the dope. They are due to moisture condensation during the drying and show up as a rule only on humid or rainy days. They can be removed by going over them with a little solvent, or better by applying a cellulose acetate dope designed for the purpose. Of course, the white spots can be prevented, even on damp days, by regulating the amount of moisture in the air of the dope room, but this, as a rule, requires a rather elaborate ventilating system.

Of Mr. Cammen's ideal properties, we have now considered all but the last two, *viz.*, that of being non-poisonous and that of low visibility. The biggest bone of contention as regards poisoning has been tetrachlorethane. Tetrachlorethane is one of the best solvents for cellulose acetate. Unfortunately, however, its vapors when inhaled affect the liver, and before its poisonous character was recognized, a few deaths had resulted abroad. These were the result of inadequate ventilation. As soon as suitable ventilation was provided, the trouble almost entirely ceased. Some argue for the total exclusion of tetrachlorethane as a solvent in cellulose acetate airplane dopes, but it gives the finished wing a certain resilience which nothing else does. Some of the British experts are very strong in their assertions that it is indispensable as a constituent of dopes for scout machines. However, the report is that for some months the use of tetrachlorethane has been forbidden in England. The policy for this country has not as yet been absolutely established, but should it prove desirable to use tetrachlorethane, it would seem possible to do this, if ample ventilation of the proper type were provided.

As regards low visibility, the dopes, being transparent and almost colorless, do not make the fabric appreciably more visible than if it were not doped, except possibly when the sun might be temporarily reflected from a glossy wing. The use of a dull surface would obviously remedy this. Should it be found that some color other than that of natural linen would blend better with the color of the sky background, either the dope or the fabric could be dyed. The goal of low visibility, however, is a transparent wing. Doubtless many of you saw a newspaper account a little over a year ago of a foreign airplane that did not have transparent wings. That no further reports of such machines have appeared would seem to indicate that as yet, at least, they are not very common. The wings of the machine in question were made of transparent cellulose acetate sheets, and it was claimed that at a height of a few thousand feet, the machine was almost invisible. It had the further advantage that the field of vision of the operator was much increased. Cellulose acetate sheets in a thickness of $^{10}/_{1000}$ of an inch, which thickness has the necessary strength, weigh about nine ounces per sq. yd., which is a little heavier than most doped fabric. The chief difficulty in using them is the fact that a tear once started spreads very rapidly. A patent has been taken out for remedying this difficulty by reinforcing the transparent sheet by means of a fabric such as silk woven rather loosely. As is readily seen, a wing of this sort would be waterproof, air-proof and non-inflammable, would have low visibility, would not affect the workmen applying it, and would give no trouble from stripping or peeling. In other words, there seems no doubt that if it can be obtained of the proper weight and strength, it will prove to be the ideal wing covering.

CHEMICAL PRODUCTS COMPANY
BOSTON, MASS.

THE COLLABORATION OF SCIENCE AND INDUSTRY[1]

By V. GRIGNARD

I am much honored that you have asked me to speak before you, but I must apologize for my ignorance of the English language which prevents my speaking at length without abusing your courteous attention.

I appreciate deeply the great honor done me in making me honorary member of the Mellon Institute and I wish to express my deep gratitude to the corps of professors and especially to the Director, Mr. R. Bacon.

My collaborator, Monsieur Engel, who speaks English fluently, will tell you better than I of the excellent impressions we have received in the course of our visit in your beautiful country; but I wish to emphasize myself all the gratitude which I feel toward your great industrial establishments and scientific institutions for the uniform kindness which we have received from them, for the courtesy with which they have facilitated our visits and have furnished us with literature.

I wish to express to you also all the admiration which I feel for the remarkable scope of your industry. You have made magnificent use of your immense natural resources, thanks to your will, your initiative, your faith in the future. These valuable traits the American race owes to the very conditions under which it has evolved: the first colonists, a small group of enterprising men constituting an élite because of their aptitude and their scientific knowledge which two centuries ago (and even less) was the lot only of the privileged few, found themselves struggling in a nearly virgin land with the many difficulties which social life has imposed upon humanity. They acquitted themselves with honor and if they did not always find the most scientific solutions, those which they did bring forward were marked for their daring and practical character.

And it happened sometimes that some of these solutions, obtained uniquely in the experimental way, proved superior to those of the European engineers; this was the case, for example, with the turbine.

But life becomes more and more difficult even for the most prosperous nations such as yours and the problem becomes singularly complicated when it is no longer simply a question of supplying a national market, largely open, but of entering into commercial competition, from within and from without, with new industries strongly organized. It becomes necessary then to reduce the net cost to the minimum, searching out the most rapid and most economical processes, allowing no loss of anything which represents any value.

Furthermore, the terrible war which has been imposed upon us and in which we are fighting side by side for the triumph of justice and of liberty, this terrible war has demonstrated that there exists for each large nation a certain number of vital industries which it cannot neglect without exposing itself to the danger of some day being at the mercy of its enemies. The nature of the problem changes. Scientific and technical in-

[1] Translation of address delivered in French at Mellon Institute on December 8, 1917.

struction become necessary and in this your universities succeed wonderfully.

But this again does not suffice; it is necessary that the manufacturer should not allow himself to be elated by his earlier success and should understand the necessity of commencing, or rather, of continuing the contest, without waiting for this prosperity to be menaced by better-informed competitors. And that still is not all; when the manufacturer has comprehended his real concern it is not always possible for him to erect suitable laboratories, to endow them with the necessary equipment, and above all, with a specially trained personnel.

It is then that institutions like the Mellon Institute come into play, a production of genius which has solved in a manner truly American a problem already old but without satisfactory solution in Europe—that of direct collaboration between science and industry. In visiting it the day before yesterday I took account of its strong organization and of the incalculable service which it can render.

Between the too naïve disinterestedness of the majority of the French investigators and the German form, fruitful without doubt, but too materialistic, which has made of too many German scientific schools veritable industrial laboratories, for the glory and above all the profit of their directors, there was room for a solution considering the rights of the manufacturer but also considering the dignity of the university. This solution you have found and the success of Mellon Institute since its foundation proves that the way in which you have been doing it is the proper one.

Without doubt it will be necessary to struggle for a long time yet against acquired habits, as we say, against the routine, but further it will be necessary that the manufacturer have well impressed on his mind this truth: in the period of beginning the improvements to be realized are numerous, researches give results rapidly, but little by little the framework contracts, investigations require more and more specialized work, more time, and more money. And it will not be necessary that the manufacturer's interest should clash with that of research, the more difficult it becomes the more raison d'être will it have in the midst of the great economic struggle which, after the war, will array, on a new account, one part of the world against the other.

France, who has never considered herself behind in the march of progress, cannot fail to organize all her forces for this collaboration, too much neglected by her, of science and industry. She cannot be inspired by a better model than the Mellon Institute. Again, it will be necessary that our manufacturers accept the necessary sacrifices for the foundation of laboratories and of scholarships for research. But we can, I trust, have all confidence; the war has opened our eyes and demonstrated once again the truth of the proverb, "He who does not advance, falls behind."

I, therefore, salute with all my heart your magnificent Institute which I consider a wonderful instrument of scientific and industrial progress.

PERKIN MEDAL AWARD

The Perkin Medal for 1918 was conferred on Auguste J. Rossi, in recognition of his distinguished contributions to the metallurgy of titanium, at the meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club, January 18, 1918. Introductory remarks by Mr. Jerome Alexander, Chairman of the Section, were followed by an address on "A. J. Rossi and His Work," by F. A. J. FitzGerald, Past President American Electrochemical Society. The presentation of the medal by Dr. William H. Nichols, Past President of the Society of Chemical Industry, was followed by an address of acknowledgment by Mr. Rossi. The addresses are printed in full herewith.

The usual informal dinner was held before the meeting in the dining hall of the Chemists' Club, giving the members the opportunity of meeting the recipient of the medal.—EDITOR.

INTRODUCTORY ADDRESS

By JEROME ALEXANDER

Nothing could be more illustrative of the cordial solidarity that unites us to our Allies, England and France, than this evening's meeting; for here before the New York Section of a British Society we are about to award the Perkin Medal to Auguste J. Rossi, a native of France.

France! How the heart of every true American, yes, of every true democrat throughout the world, leaps at the mention of that name! Fair are her fields and beautiful her cities, but France is much greater than all these—her artistic, literary, scientific and spiritual gifts to humanity and civilization have made us her debtors for all time, and to-day the civilized world is fighting under her slogan of "Liberty, equality, fraternity."

As a consequence of this dreadful war, and under the lash of its stern necessities, we have fortunately been brought in closer relationship with our French fellow chemists. For some months past we have been planning the formation of a New York Section of the French *Société de Chimie Industrielle*, the sister society of the British *Society of Chemical Industry*, and to-night, immediately following our meeting, it will be formally organized

We will, therefore, proceed with our program, and hear an account of Mr. Rossi's life and work from a gentleman well known to you all, Mr. Francis A. J. FitzGerald, Past President of the American Electrochemical Society.

NATIONAL GUM AND MICA COMPANY
NEW YORK CITY

MR. A. J. ROSSI AND HIS WORK

By F. A. J. FITZGERALD

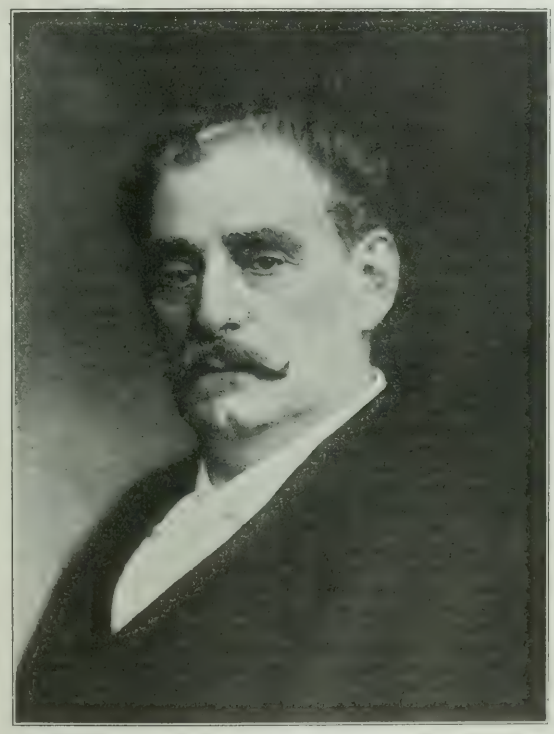
It was, I think, in the year 1899 that I first made Mr. Rossi's acquaintance. There was much speculation in Niagara Falls at that time as to what he was doing. In those days there was always much gossip whenever some new work was started at Niagara Falls for it was still in the early period of power development before the MacFarlands and politicians got busy and we were all watching eagerly the rapid electrochemical developments,—aluminum, carborundum, caustic soda and chlorine, calcium carbide, etc. Wonderful stories would float about as to what newcomers were doing. When the Oldbury Chemical Company started, the most astonishing stories were afloat, caused I think largely by the high brick wall which surrounded the factory. It was told with bated breath that this works was engaged in the manufacture of cordite by a new and secret process and that you could not get inside the brick wall except over the body of an armed guard.

I cannot recall now what various stories were told about some remarkable work in the Porter house and the old stone barn which stood where the Acheson Graphite Company's plant now is, but these were sufficiently startling, and all agreed that it was a French chemist named Rossi who was working on some new invention.

I soon made Rossi's acquaintance, for in the electrochemical work of those days there was a fine spirit of cooperation, which indeed has become to a great extent permanently characteristic of Niagara Falls, and before long I got to know him very well. During visits to him I learned a great deal about his researches on the smelting of titaniferous ores, about the experiments he was then making on the manufacture and use of ferrotitanium and

about many other chemical and engineering works with which he had been associated in his varied professional career. Although I may repeat some things which Mr. Rossi speaks of himself, I believe you will be interested in a brief history of his work.

In the year 1855 at the early age of 16 Rossi graduated from the University of France with the degree of Bachelier des Sciences et Lettres and four years later, after he had also graduated from the École Central of Arts and Manufactures, where the studies covered mechanical, civil and metallurgical engineering work, he came to New York. Here he soon obtained a position as assistant engineer with the Morris and Essex R. R., holding this until 1864 when the railway was taken over by the D. L. and W. After this he got a job which kept him busy for a year making the survey of a property in Boonton, N. J., which was to be converted into a park under the direction of Mr. Calvert Vaux, the architect of Central Park, New York. Next we find him engaged in building a railway to the Boonton Iron Works; but when Fuller, Lord Company of that concern found out that Rossi had studied chemistry and metallurgy at the École Central they put him in charge of a laboratory at the Iron Works.



AUGUSTE J. ROSSI, PERKIN MEDALIST, 1918

It was here that Rossi's attention was first called to titanium, for the ores used in the blast furnaces at the Iron Works were magnetites from Morris County, N. J., containing in the best samples about one per cent titanic oxide and in others 2.5 per cent or more. Beyond noting the existence of titanium in the ores Rossi was not particularly interested in it until he met the work of Professor Cook, the State Geologist of New Jersey. This work called attention to the existence of titanium in nearly all the New Jersey ores, from fractions of one per cent to as high as 15 per cent titanic oxide. Professor Cook also established a relation between phosphorus and titanium in the ores, low phosphorus apparently going with high titanic oxide content. This set Rossi to work hunting up all the scanty, and incidentally very contradictory, literature he could find on the subject of titanium. None of this work was of any practical importance so far as the running of the Boonton Works was concerned, but several years after he had left his metallurgical work to devote his attention to tests on the pumping engines at Fall River, to calculations of the stability of the Beaver Bridge Dam, to work on refrigeration and the manufacture of ice-making machinery, his researches on titanium became of value because of a law suit in relation to his old firm of the Boonton Iron Works.

This law suit was of great importance so far as Rossi's future work was concerned as it no doubt established his reputation as an expert in the smelting of titaniferous iron ores. Thus, after Rossi had established an office in New York as a consulting engineer and when in 1890 Mr. James MacNaughton was interested in the development of the immense titaniferous ore deposits of the Adirondacks, it was to Rossi that he went for advice. Since that date Rossi has devoted most of his time to titanium.

The problem presented in this case was a study of the feasibility of smelting the titaniferous ores of the Adirondacks. Rossi, as a result of his researches years before, was well acquainted with what had been done in Europe in this field and of special interest were the records he had of some blast furnaces near Stockton-on-Tyne, England, where ores running as high as 35 per cent titanic oxide had been smelted successfully by forming a slag that consisted of a silico-titanate of lime. This, of course, involved adding considerable quantities of lime and silica to the charge. Here lay the great objection to the Stockton-on-Tyne practice, for on account of the low iron content of the ore it was necessary to make about 4 tons of slag for 1 ton of iron.

Rossi told his client that success with the Adirondack ores could be obtained provided that the titanic oxide could be slagged off without using an enormous excess of fluxes and that so far as the pig iron produced was concerned, it would probably be of a very superior quality.

The upshot of the consultation was that Rossi went to examine the ore deposits and two small blast furnaces which had been run there by Mr. MacNaughton's grandfather from 1840 to 1858. In a curious old iron chest Rossi found the blast furnace records. Studying these and knowing the composition of the ore, the fluxes added and the amounts of these going into the charges of the old blast furnaces, Rossi found that the practice of the Stockton-on-Tyne furnaces had been anticipated. He also found that the iron produced was of such superior quality that a Gold Medal had been awarded to it in the great London Exhibition of 1851. Moreover, certain steel made from this iron won high commendation from the Navy Yards of Springfield and Washington, the report stating that it compared favorably with the best Swedish steel.

Rossi then began a series of experiments on slags with the object of replacing silica with titanic oxide in the normal blast furnace slag and, following his success in this direction, built what might be described as a laboratory blast furnace in which several hundred pounds of excellent pig iron were made from the titaniferous iron ores. Next followed a small blast furnace built at the New York Car Wheel Works in Buffalo, where the Mill

Pond ore running 16 to 17 per cent iron was successfully smelted.

In this way Rossi did the pioneer work in demonstrating the value of the great ore deposits of the Adirondacks in 1894. Twenty years later we find this work confirmed by Mr. Frank E. Bachman, General Manager of the MacIntyre Iron Company, Port Henry, N. Y., in an interesting paper, "The Use of Titaniferous Ore in the Blast Furnace," presented to the American Iron and Steel Institute in October, 1914.

Turning now to ferrotitanium—Rossi was convinced from what he had observed in the work on smelting titaniferous ores that titanium had a beneficial effect in the manufacture of iron. A natural deduction from this was that an alloy of iron and titanium would be of value for the treatment of iron and steel in the process of manufacture.

This led to a series of experiments in small electric furnaces and finally to the construction of larger furnaces in Niagara Falls in 1899 where considerable quantities of ferrotitanium were manufactured, thus permitting of a great number of tests being made on a large scale in steel works and foundries.

This may be considered as closing the experimental period in the development of the manufacture and use of ferrotitanium. Rossi had now convinced himself of its value and the next problem was the education of others in its use.

I shall not go into the consideration of the commercial development of titanium, but merely discuss the principal causes of the great difficulty Rossi experienced in convincing the technical world of the value of his invention.

Perhaps this may be most vividly shown by means of an analogy presented by the practice of medicine. There are a number of drugs of known value, some of them absolute specifics, in the treatment of human ills, but every year we have added to our drug list a number of new medicines. Some of these are at once recognized as of real value by a few, but it often happens that their general recognition is delayed by the exaggerated enthusiasm with which they are greeted at their first appearance; moreover, it frequently happens that the injudicious use of the new drug gives it a bad name. Now, there cannot be any doubt that the very same causes which often delay true appreciation of a new medicine existed in the case of ferrotitanium. Among some there was an unwarranted enthusiasm as to the field of its usefulness and there were plenty of examples of complete failure in its application due simply to ignorance of the proper methods of using it. While, therefore, the value of ferrotitanium has always been recognized by some, there existed for a long time a prejudice against it in the minds of many and in some quarters this exists even to-day. Thus, in spite of all Rossi showed as regards the possibilities of titanium seventeen years ago, skepticism was for long very general and is not yet completely eliminated. I hope, therefore, that you will pardon me if I call attention to a brief note I made some three years ago on certain statistics in regard to the use of titanium in rail steel, which I think very clearly disposes of the assertion frequently made at that time, that titanium has no effect on steel.

In this note are given the statistics of 155 heats representing the production of 9000 tons of rail steel, in some of which titanium was used while in others it was not. Where no titanium was used only 36 per cent of the steel came within the particular specification limit. Where 0.053 per cent of titanium was used 43 per cent passed, with 0.077 per cent titanium 84 per cent, and with 0.10 per cent titanium 100 per cent passed.

In the earlier days of the exploitation of titanium the chief drive was made on its use in rail steel and the data I have given show something of what can be done in that way. But of recent years much greater efforts have been expended in applying titanium to miscellaneous steels. Thus in the last ten years the ratio between titanium going into other kinds than rail steel has enormously increased, for while a decade ago the miscellaneous applications were only 12 per cent of the total, they are now 96 per cent and have increased in volume about 150 times.

Thus Mr. Rossi, after more than a quarter of a century of work followed with the greatest perseverence and undaunted by difficulties of all sorts, has not only shown what can be done with the titaniferous iron ores formerly regarded with distrust by the iron smelter, but has demonstrated that the very element supposed to make these valueless can actually be used for improving the manufacture of the metal they yield.

THE FITZGERALD LABORATORIES, INC
NIAGARA FALLS, N. Y.

PRESENTATION ADDRESS

By WILLIAM H. NICHOLS

The world is beginning to get a gleam of what it owes to the chemist, and the chemist himself is beginning to be better understood. As a rule he works so much in the quiet of his laboratory and without the aid of that publicity which is such a prominent part of our life to-day, that many of his most important discoveries are made known only to his fellow chemists, who in turn incorporate them in their own fund of knowledge and thus make use of them. Once in a while, however, something very striking comes out of a laboratory and attracts attention by its novelty, or by its usefulness, or both. Under this category comes the wonderful discovery of young Perkin which has given to the world, through those who have succeeded him, the great synthetic dye industry, the long list of synthetic remedies, and the various contributions to the "gentle art of war," which have followed Perkin's original work. What wonder, therefore, that when fifty years had elapsed, the chemists of the world should fittingly celebrate the work of the young Englishman, and what wonder that the occasion should be seized upon for the founding of a medal to be given to those who, following Perkin, should give to the world something of themselves which should forever be of great value to all mankind. Thus the Perkin Medal was founded, and thus it has annually been bestowed upon some great man who has made the world a better place to live in because he has lived in it himself.

Since the founding of the Medal, we have been exceedingly fortunate in having it presented annually by our own Professor Chandler, who was the first American selected to fill the great office of president of the Society of Chemical Industry. We have been in the habit of looking forward to these annual occasions and the part which Professor Chandler would take in them, and I am sure we all greatly regret that he has not found it practicable to be with us to-night to assume this duty which we are so in the habit of associating with him. Unfortunately, his health does not permit it, but let us hope that next year, and for many more to follow, he will stand in this place and perform this act in his usual graceful manner. It, therefore, falls to my lot as the next succeeding American president to present the Medal, and this task I undertake with great diffidence, feeling, as I do the disappointment which you all sustain in not hearing from the grand old man himself. It is not, however, the first time in which I have undertaken this work, as I had the honor of presenting the first Perkin Medal to Perkin himself during the jubilee celebration in New York.

It is particularly appropriate that this Medal should be presented at one of the stated meetings of the New York Section of that great English Society of Chemical Industry which counted among its presidents so many great Englishmen, including Sir William himself. During the recent terrible years, the members of this Society have almost remade Great Britain from a chemical standpoint. Similar work of the highest grade has been accomplished by our French brethren. American chemists have taken great interest in the British society, and they are now to have an opportunity of doing similar work for the Société de Chimie Industrielle, the New York Section of which is to

be formed to-night. We have always had a warm place in our hearts for our French friends and I am glad that we are going to have an opportunity of again proving this, if any proof be necessary.

You have heard from Mr. FitzGerald a statement of some of the work which Mr. Rossi has done and it is not my intention to add to that list a single statement. If Mr. FitzGerald has omitted anything, Mr. Rossi himself will please supply as much of the deficiency as his modesty will permit.

CONFERRING THE MEDAL

Mr. Rossi, there have been several candidates for the honor which is to be conferred upon you to-night. The claims of each have been carefully weighed by a committee, whose only desire has been to select the candidate best qualified to receive the Medal this year, when everything has been considered. You have been their choice, and are, after a long life full of hard work and the usual disappointments that come to every successful man, to receive the greatest reward which your fellow chemists can bestow upon you You are joining a body of very brilliant men. You may well feel gratified that those who know best consider you worthy of the honor of that company, and in token of that selection I beg to express to you, what I am sure is the thought of every man in this room and of every other who knows of your work, our hearty congratulations on a life well spent, and our cordial "bon voyage" as you turn your face to the setting sun. Coupled with this is the hope that you have before you yet many days of usefulness, and that you will be able to return our confidence with something accomplished of even greater value than what has gone before. With the heartfelt respect of the entire chemical fraternity, and a hand-clasp as its token, it is my privilege to present to you the Perkin Medal of 1918.

NEW YORK CITY

ADDRESS OF ACCEPTANCE

By AUGUSTE J. ROSSI

I am not much used to making public speeches. True, once upon a time, I was asked by the president of the Polytechnic Department of the American Institute to deliver a lecture on "Ice and Refrigeration" at Cooper Institute. It seemed to be appreciated, at least so the president told me, but it was very long ago, so long that I am afraid I have forgotten about it. It was on a subject with which I was familiar, but to-night I have not only to speak on a definite subject of applied science, but to express my feelings for the distinction you have conferred on me and of which I appreciate all the honor. I have had occasion to notice that sometimes brilliancy of diction covers a multitude of sins, but to such brilliancy I cannot lay claim. However, there is another aspect to the question to-night—one which tells—it is the part which comes from the heart, the part which makes one say what he feels, not the way in which he expresses it, and that is precisely my case to-night, so I will let my feelings speak, not my oratory.

By your conferring on me this honor, I see an appreciation, a recognition of a continuous and continued work in lines which had not been much investigated before, so far, of course, I mean, as their industrial possibilities. I thank you heartily for this honor, personally, but also because it will prove an incentive for me and for others to devote to any researches they may pursue, this truthfulness, this interest that any professional chemist or technical investigator worthy of the name must give to his work. This I have tried to do and I see to-night with all my heartfelt thanks and appreciation that it is to this devotion to science, to this perseverance in working out a comparatively new problem, to the sincerity of the work done as much as to its value, that you have conferred this honorable reward to stand as a beacon to guide others, entering young in the career, to be as thorough, as devoted to an idea, as conscientious in recording results, as they can be. It is in part, I am sure, to this perseverance in trying to overcome such difficulties as have arisen, such criticisms and doubts as have been expressed that you have given your appreciative recognition by this honorable distinction you have conferred on me, and which can only encourage me, even at this stage of my life, to persevere to the end and develop certain possibilities of titanium compounds for other than metallurgical purposes, in other branches of industrial chemistry; and now that I have let my feelings speak and express how proud I am of the appreciation of my peers, I may be allowed, as an interesting history of the case, to explain to you, as briefly as possible, what little encouragement I could find in what had been written on the subject in a literature curiously contradictory and so many times misleading.

My special attention was called to the subject of the possibilities of titaniferous iron ores in 1890 by Mr. James MacNaughton, a graduate of Yale, interested in these immense Adirondack deposits, as an inheritance from his grandfather, Mr. MacIntyre—deposits of such a magnitude that Mr. Berkenbine, then president of the American Institute of Mining Engineers, at the Montreal meeting of the Institute in 1893, said of them, "these marvelous deposits seem to have been placed by Providence where most inviting, as they can be made available to tide water." I had been directed to Mr. J. MacNaughton by Professors Chandler and Rickett, as one who could give information on this subject as I had had occasion before to write a paper entitled "Titanium in Blast Furnace" for the *Journal of the American Chemical Society*.

Having been for some eleven years (1864–1876) technical director of the Boonton blast furnaces (Boonton Iron Works, Fuller, Lord Co., proprietors), I *knew* from actual practice that the presence of titanic dioxide (TiO_2), averaging 1.50 per cent in Morris County, New Jersey, ores which we were smelting and 2 to 2.50 per cent in our slags, had had absolutely no effect on the working of our furnaces, or the behavior of our slags as to fluidity and fusibility, so much so that I even ignored its presence, considering it as so much additional silica in the ores.

And still when the question of smelting these ores, alone or in mixture, arises, one can read in the proceedings of a well-known scientific technical society (A. I. M. E.) "that 1 per cent of TiO_2 in a slag was enough to make it pasty to impossibility of tapping." The advanced copy of the paper (in my hands) says, "the slags had to be pulled out with tongs." How can young men, new in the profession, be blamed for being skeptical about the smelting of this class of ores after such statements as I have quoted verbatim?

In 1876 the death of the two owners of the Boonton Iron Works and the legal complications it involved between the estates forced the closing of the works, involving rolling mills, plate mills, puddling and re-heating furnace, nails machines, etc. The furnaces were blown off, but not dismantled. Workmen and all had to leave and the small town was deserted for several years.

Later on in the 80's, Mr. Eckert of Reading, Pa., who was making there what is called stove iron, having decided to use our puddled cinders of which we had the accumulation of years, with some of our ores containing 2 per cent TiO_2, leased the two blast furnaces which were still standing with all the blowing apparatus and appurtenances. They made a failure of this run for technical reasons foreign to my subject and which could easily have been foreseen by one familiar with blast furnace work. Having stopped the furnaces after a very few months' run, they tried to get out of their contract binding them to use a stipulated number of tons of puddled cinders and ores by claiming that the presence of TiO_2 in our cinders and ores had been the cause of their non-success. I was retained as an ex-

pert by the estate and had no difficulty in proving by my books of analyses and statements of founder and keeper and others that the presence of TiO_2 to the extent their own analyses had shown in the materials of the charges was in no way greater than the amounts that I had found during an eleven years' practice to have had absolutely no effect on the working of the same furnaces, so they had to compromise and pay a heavy forfeit. I had to enter into these details to render intelligible what follows.

The suit came before the chancellor of New Jersey and I have on hand the brief submitted by the plaintiff, containing all the sworn testimonies of their experts.

No. 1—One of the experts, Mr. X, manager of one of the Durham furnaces (Cooper, Hewitt and Co.), testified, under oath, that 0.75 per cent of TiO_2 in an iron ore rendered it unfit for blast furnace purposes as it would be only a matter of a short time before the furnace would be "clogged up" if the use of the ore were not stopped.

No. 2—Also a manager of another Durham furnace, Mr. Y, testified, under oath, that not 0.75 per cent but 0.25 per cent of TiO_2 in an iron ore excluded its use in a blast furnace, it being merely the matter of a little longer time before the furnace should be clogged up.

No. 3—Mr. Eckert, of Reading, Pa., under oath, testified that from his 20 years' practice in iron making in blast furnace, not 0.25 per cent, but *traces* of TiO_2 were sufficient to produce the same result as above mentioned, ores containing *traces* of of TiO_2 being unfit for blast furnace uses.

This is only one of the many examples, if really a striking one, of the criticisms, prejudices and objections I met with in my fight for these much-abused ores. Such was the encouragement I found in the profession. When in 1894, at the New York Car Wheel Works, Buffalo, N. Y., in a small furnace of a capacity of three to four tons a day, which I planned and erected, at Buffalo, I melted, without mixture, titaniferous iron ores from the Adirondacks, containing 15 to 18 per cent TiO_2 and 55 to 56 per cent metallic iron, the slags as run from the furnace analyzed 25 to 30 per cent TiO_2, with some 15 to 18 per cent silica with lime, alumina, and magnesia as bases, magnesia having been recognized by me as an essential constituent of the slags to insure the best running. These ores, being inaccessible to a railroad, had to be transported on corduroy roads at that time to North Creek where they could be loaded on cars. It brought their cost to $15 per ton delivered at Buffalo. This excluded the idea of making a test on a larger scale, unless we could find a furnace small enough, one of some ten tons' capacity, which it proved impossible for us to do. Within the last two years, Mr. Bachman has smelted similar titaniferous iron ores in one of the large blast furnaces of Weatherbee-Sherman & Co., at Port Henry, making with these ores some 15,000 tons of a pig iron which he found in the tests for tensile or transverse strength of superior quality. In a very elaborate, comprehensive, scientific and technical report, Mr. Bachman has given the fusibility and fluidity of the titaniferous slags run in the furnace, analyses of all materials and results of tests for strength as compared with those of the average pig irons run without titaniferous iron ores in the charges. His conclusion as a whole is a confirmation of my own as drawn from this run in Buffalo in 1894-95 in my small furnace. One of them particularly is worth mentioning, as I had come to the same conclusion in Buffalo. He says, "This run with titaniferous ores was made with an economy of fuel per ton of pig metal smelted," and one can read in technical publications in 1894 that the smelting of titaniferous ores even if admissible meant such an excessive consumption of fuel per ton of iron, that on this score alone they are unsuitable, leaving aside titanium deposits in the furnace and pasty slags," an obvious contradiction. If the furnace is to be "clogged up," as claimed, by titanium deposits which remain in the furnace, they do not go into the slag and the latter need not be pasty on this score, or, if it goes into the slags making them pasty, it does not remain in the furnace as titanium deposit. These titaniferous ores of the Adirondacks are magnetic, associated with ilmenite ($FeTiO_3$), an iron titanate, just as iron silicate is found ($FeSiO_3$) in certain ores (ferruginous periodotite). They are like almost all titaniferous ores, low in phosphorus and sulfur, some as low in phosphorus as 0.017 per cent and sulfur 0.02 per cent, with 55 to 56 per cent metallic iron and little silica, 1.50 to 2 per cent. The iron smelted from them is an ideal open hearth steel and to-day open hearth steel has superseded Bessemer steel.

Tests made by me and in many foundries of such pig metal added to ordinary pig iron in certain proportions have shown an increase of strength over cast iron not treated, of 29.5 per cent in tests made and reported by Wm. Cramp and Co. and an increase of 4 per cent over cast iron treated with nickel.

These titaniferous iron ores, at least those found in the Adirondacks, are of plutonic origin. Professor Kemp told me they are not stratified or in veins but the metallic mass seems to have been pushed through the rock formation in fusion. He showed me photomicrographs in which you could see the rock, perfectly distinct and clear from ore, with big black patches of titaniferous ores free from rock. A corroboration of this fact is found by soundings made at the foot of a solid wall of ore, some 400 ft. wide and some 50 ft. high. The soundings at the foot of this ore wall went down 450 ft. of ore with only 10 per cent of rock, so the word inexhaustible seems not to be exaggerated as applied to these deposits as, on that property, the same kind of ore has been prospected on some 9000 acres. I have always claimed that these ores and similar ores would prove the resources of the future. Abundant, rich in iron, 50 per cent or more metallic iron without concentration, free from phosphorus and sulfur to such an extent as they are found to be, they are what were called Bessemer ores par excellence; and ores of this kind non-titaniferous, low in phosphorus, have been taxed to the utmost, so much so that what was called the Bessemer limit in phosphorus for steel making, had to be raised from a few hundredths of 1 per cent (0.08 or less) to 0.10 per cent.

If such work as I have done, confirmed by the very recent blast furnace runs on a large scale made by Mr. Bachman, has had and will have the result of calling the attention of the metallurgists to these much-abused ores, I will not have worked in vain.

But however much value these ores may have, alone or in mixture with other ores as blast furnace stock, their use for making alloys of iron or copper with titanium for the treatment of cast iron, steel, copper or copper alloys has opened a new and more important field of applications in metallurgy.

Checked by the difficulties I met in securing such large quantities of ore as are required for blast furnaces of the size and capacity of our present furnaces, as explained above, I proposed to Mr. MacNaughton in 1900 to make, so to speak, a concentrate of titanium which, added to ordinary cast iron or steel, would be likely to secure for the metal baths thus treated the same beneficial influence which tests had shown to be secured in pig metal smelted from these ores TiO_2 not being reduced to any great extent by carbon at the temperatures prevailing in the blast furnace, I had to have recourse to electricity. And I may say here that Mr. MacNaughton was the one who supported me in these times of trial by his implicit confidence in me and in the possibilities of my work. He died in 1905.

About 1900 I started making ferrotitanium at Niagara Falls at the old Porter house by the electric current, the furnace itself, made of a masonry of graphitic materials, forming the cathode, and a carbon electrode, movable vertically in the cavity of the furnace by means of proper mechanical device or auto-

matically by the current itself, forming the anode. It was an arc furnace. A mixture of the titaniferous material and of the carbon required for the reduction of both the TiO_2 and the oxide of iron, properly comminuted, was then charged gradually into the furnace as the current was turned on. Whenever the relative proportion of the TiO_2 and the oxide of iron of the titaniferous material were such as to produce an alloy higher in titanium than desired some scrap iron was charged with the mixture to dilute the alloy, so to speak. I made in this manner alloys containing from 10 to 25 per cent or more, but practice in steel and other works has shown that an alloy containing some 15 per cent of titanium, or thereabout, was best suited for most purposes.

Whenever the presence of carbon in the ferrocarbontitanium was considered objectionable for special applications, I reduced the titaniferous materials by my aluminum bath process. Instead of using a mixture of finely powdered aluminum and titaniferous materials as per Dr. Goldschmidt's Thermit process, the aluminum I used for the reduction of the oxides was melted in the electric furnace and the titaniferous materials (omitting the carbon) charged directly into the bath of aluminum. In such cases I used preferably TiO_2 as rutile, in order to avoid using the aluminum which would have been required for the reduction of the oxide of iron of the ore, charging scrap iron with the rutile to dilute the alloy to the content of titanium desired. In this manner I made ferrotitanium practically free from carbon, containing only from 0.18 to 0.50 per cent carbon more or less, and by reducing the amount of scrap iron added, I was able to make ferrotitanium containing as high as 80 to 85 per cent titanium. Titanium as a metal is as white and as shining as silver but very hard and brittle, so that, as such, it has no particular use. The high alloys of titanium, such as 75 to 85 per cent of titanium and even those with less titanium, are also white like silver and scratch glass and even quartz deeply

This aluminum bath process is of a more general application. If into the aluminum bath a tungstic ore containing oxide of iron is charged, a ferrotungsten is obtained free from carbon. I have made thus 85 per cent tungsten alloy.

By using manganiferous ores I was able to make in the electric furnace 85 to 88 per cent ferromanganese free from carbon; by using chromic iron, a ferrochrome at about 80 per cent chrome, free from carbon.

The advantages of the electric furnace and of the use of baths of aluminum lie in the fact that if the reduction can be secured in a blast furnace as for ferromanganese, for ferrochrome, ferrotungsten, and other ferroes when high in the constituent metal, the ferroes obtained would be melted with difficulty, if at all, in the blast furnace in certain cases.

By adding to a bath of steel, for instance, or to cast iron a ferrocarbontitanium containing some 15 per cent of titanium, the bath of metal was cleansed of dissolved or occluded gases such as oxygen and nitrogen and also of such oxides of iron generally present in steel, especially in Bessemer steel made by the pneumatic process. When air is blown through the molten pig iron, the titanium of the alloy combines with the oxygen to form TiO_2, with the nitrogen to form titanium nitride, and the oxide of iron is reduced to iron by the titanium and the carbon of the alloy, the titanium combining with its oxygen to form TiO_2, and the slag, carrying with it the titanic dioxide and the titanium nitride, rises to the top of the ingot or ladle, the TiO_2 rendering the slag more fluid and fusible as experiments I have carried on for Dr. P. H. Dudley, the expert of the N. Y. C. R. R., have proved. A slag collected by him at the top of an ingot and containing 6.5 per cent of TiO_2 had a melting point of 1290° C., lower than or about the same as that of ordinary blast furnace slag. By adding enough TiO_2 to such a slag as to have in the slag some 13 per cent TiO_2, its melting point was lowered to 1190° C., as determined by Mr. FitzGerald. This infusibility of titanic slag was another objection I met to the use of these ores; it can be read in the Geological Survey of New Jersey in an article on the refractory properties of fireclay that 3.50 per cent of TiO_2, frequently met with in these clays, lowers their melting point two or three cones of Ziegler. "So," it is added in this report, "TiO_2 must be considered in these clays as a flux." As traces, or only a few hundredths of 1 per cent at most, of titanium are found in the steel treated, the titanium seems to act as a scavenger, as it has been called sometimes.

The presence of titanium in steel to the extent of 1 per cent or more imparts to the steel certain very special properties to which, later on, I may have occasion to call attention more particularly. The head of a crucible steel ingot treated with titanium, cast in 1900 at Atha & Illingworth's, East Newark, was drilled with five holes to obtain specimens for analysis. These holes are as bright now as they were when first drilled, though exposed to the air in my office. It contains 1 to 1.10 per cent titanium and the sheet was so hard that it was drilled with difficulty.

Copper, as is well known, absorbs, when melted and exposed to air, a large amount of gas and the bath contains oxide of copper. For the treatment of copper and its alloys such as bronzes, brass manganese or aluminum bronzes I have made a coppertitanium containing any amount of titanium, though 10 to 15 per cent appears best adapted. The titanium of such an alloy acts, as in steel, as a scavenger of the copper bath. I have also made aluminumtitanium containing 45 per cent titanium for seasoning aluminum bronzes. They are made in the same manner as ferrocarbontitanium or ferrotitanium in the electric furnace. For coppertitanium, TiO_2 and aluminum are charged in the furnace in a bath of copper. For aluminumtitanium, the TiO_2 is charged directly in the bath of aluminum. The reaction of aluminum on oxides being *exothermic*, much less current is required for the reduction proper.

As is well known the affinity of titanium for O and N is such that the metal burns at 800° C. or thereabout in an atmosphere of these gases (Wöhler and St. Claire Deville). It is such that when large cakes of alloy free from carbon, such as we make, are cast in the casting trough from the furnace at a dazzling white heat and broken while hot, the section exposed to the air colors itself with fine irisations presenting all the colors of the rainbow; blue (probably TiO), gold (probably nitride), copper color (probably cyanonitride formed by the small amount of carbon still present in the alloy) and combinations of these colors. I have been able to reproduce these irisations artificially on small pieces of alloy. These pieces look like gems, scratch glass deeply and even cut it. I had occasion to show samples of these at a meeting of this Society last year. All the details of these operations have been fully described in the patents which I have secured for our company, as also in many articles which I have written on this subject in technical publications here and abroad. In short, this modest beginning at the Porter house has developed into the manufacture of these alloys for iron and copper on a scale which requires the labor of several hundred men.

Some of my work has been in an entirely different line. I have used for purposes of artificial production of cold instead of liquefied gases such as sulfur dioxide, carbon dioxide, or ammonia, a binary liquid composed of one moderately volatile liquid holding in solution the vapors of a much more volatile liquid. In ice-making and refrigeration the volatile liquids are charged in a special vessel, the refrigerator being immersed in a bath of uncongealable liquid so called, such as a strong solution of sodium or magnesium chloride, or glycerine; or indirectly, by causing this liquid to circulate in a tank in which cans, containing the water to be frozen, are immersed, or circulated through pipes in the cellars of the brewery or storeroom. By relieving the pressure of the volatile liquid on itself, at ordinary temperature, by means of a double-acting pump run by any power (steam engine or other), the liquid boils and by its latent heat of evaporation

cools the refrigerator contents. The vapors entering the pump are compressed in a condenser cooled by circulating water, are liquefied again under this pressure and cooling, and combined again, re-forming the original volatile liquid, which is returned by proper devices to the refrigerator, rendering the operation continuous.

One of the binary liquids I proposed and used for machines erected in breweries and cold storage plants was ordinary ether holding in solution sulfurous dioxide. Ether will absorb its own weight of SO_2, showing but a very few pounds of pressure (5 to 6 lbs.) per sq. in. at 90° F. By using such binary liquid instead of SO_2, for instance, when the mixed vapors enter the compressor to be compressed and discharged into the condenser, ether liquefies *first* being cooled by the circulation of water around the condenser, absorbing anew the SO_2 and causing the pressure in the compressor and condenser to reach the figures it would have reached had SO_2 alone been used, thus saving on the mechanical power required. I have a patent in collaboration with Mr Tessié Du Motay for this system of refrigeration.

The other liquid I used was sulfurous dioxide which can absorb carbonic acid gas to the extent of some 5 to 10 per cent of its weight. In this case, the same advantages as with the ether binary are secured, but to a much greater extent. CO_2 gas boils at about 100° F., and the pressures required to liquefy its vapors are considerable. On this subject of artificial refrigeration and the thermodynamic questions it involves, I have contributed several articles to the technical paper *Ice and Refrigeration*, published in Chicago, and to other technical publications here and abroad.

In the domains of metallurgy I have written a paper which I read at the meeting of the Electrochemical Society at Lynn and Cambridge, Mass., on the utilization of the blast furnace waste gases for generating power in gas engines for electrical purposes or other. In districts in which pig iron is manufactured on a large scale, as in the Pittsburgh district for example, and even in others, the amount of these waste gases is far above what is necessary to heat the blast and I proposed to use this surplus in gas engines to generate power which could be utilized for the blast engine, leaving a large surplus for generating electricity for illumination, making alloys of metal, or any other purpose. In the paper I have written on this subject, assuming the most conservative figures for the volume of such waste gases and their calorific potentialities, it could be shown that after having utilized for the furnace itself a part of it, a surplus of some 1,000,000 H. P. could be obtained in the Pittsburgh district and some have placed this figure at nearly 2,000,000 H. P. But assuming even a possibility of only 500,000 H. P., what a waste of power easily saved with gas engines, at a time when waste counts for so much! Even in districts much less favored than the Pittsburgh and more or less isolated, the same possibility would exist for local purposes, and were electricity to be generated it could be transported and utilized through a very extensive radius. At the Falls we send electric power to Buffalo, some 23 miles distant, and even to Syracuse, over 200 miles away. A careful scientific study of this question appears to us to justify a more complete investigation.

Before dismissing this subject of titaniferous iron ore, I will say a few words on the results I have obtained in experiments made in smelting titaniferous ores in mixture with phosphoric ores even to the extent of obtaining a pig iron high in phosphorus. I used phosphoric ores containing as much as 1.50 to 2 per cent of phosphorus pentoxide (P_2O_5), even adding apatite (lime phosphate) to the mixture so as to obtain a pig iron as high in phosphorus as I could. Contrary to what might have been expected, the pig metal containing 0.40 per cent titanium and from 2.50 to 3.50 per cent phosphorus had the strength and the rating of fair No. 1 or No. 2 pig iron. This suggested treating phosphoric pig metal, generally weak and close grained, with ferrotitanium so as to incorporate a divided amount of titanium in it. The results were very encouraging and were published by me in a paper read before the A. I. M. E. at the Pittsburgh meeting in 1896. They were commented on in the *Engineering and Mining Journal*.

I have proposed using copper titanium to treat the copper which is used with gold and silver for coin or jewelry. The use of the alloy making the copper denser and harder, the gold and silver alloyed with such copper could be expected to be hardened, which for coins would prove quite a saving in circulation or in transit. The Philadelphia Mint considered this scheme very favorably and asked us to make such alloys for them to try. Obviously if there is anything in the scheme, such tests to have any value should be made officially by the Government, and I did not give any more special attention to it.

But if titanium alloyed with other metals has found important and increasing applications in metallurgy, if its ores have been shown to supply a valuable stock for blast furnace smelting, other of its compounds possess such special properties as to justify industrial application in other lines.

If a ferrotitanium, practically free from carbon, made by my aluminum bath method, preferably as high in titanium and low in iron as possible, is dissolved in hydrochloric acid, in which it readily dissolves at a gentle heat, a fine violet solution is obtained, a ferrous titanium chloride, and with such violet solution I have been able to bleach cotton, silk and wool. As is well known, silk and wool cannot be bleached in agents capable of generating free chlorine which injures and attacks these fabrics. Still I was able to bleach completely some 2000 yards of such fabrics by digesting them in this diluted violet solution at boiling temperature, for a shorter or longer time according to the intensity of the dye to be bleached or the yellowish tint of the white fabrics. Silk and wool, *colored* or yellowish, were thus bleached without injury to the fabrics. Such double chloride contained about 40 to 50 per cent titanous chloride, $TiCl_3$, the balance being ferrous chloride. During the operation, especially as the temperature approached the boiling point, TiO_2 precipitated, thus showing clearly that the chlorine must have been set free, and, as I explained it or tried to, must have combined with the ferrous chloride to form ferric chloride, the chlorine generated acting in the nascent state without even appearing as free chlorine in the solution. The experiment repeated several times with the same success was conclusive and suggests the possibilities of a very important application.

The fact that the TiO_2 was precipitated from one of its compounds by these organic matters suggested to me the possibilities of precipitating TiO_2 from other of its compounds by vegetable or animal organic matters and the results were very remarkable. If to a solution of titanic sulfate, $Ti(SO_4)_2$, is added a water extract of vegetable or animal substances and the liquid gently digested to boiling and boiled for a short time, TiO_2 is precipitated, and when calcined is obtained as a soft, smooth, flour-like, pure white powder requiring no mechanical pulverization. This is so characteristic of the action of these organic substances that a number of them, such as water extracts obtained from dry leaves, green leaves, sawdust, tannin, wood pulp, wood-pulp liquor, horsechestnuts, beans, docks, cranberries, radishes, etc., and urea itself, have given the same result, a TiO_2, smooth, soft, pure white. One of the interesting features of this process of obtaining TiO_2 as a pure white, smooth, and impalpable powder is that if this same titanic sulfate solution be precipitated by NH_3 or Na_2O and boiled, and the TiO_2 calcined, the product is granular and buff-colored. Even if this solution is freed by proper treatment of such metallic oxides as are found in the ores and remain in the solution during the process of extraction of the melt, the TiO_2 precipitated by alkalies is white but granular, requiring mechanical pulverization for special uses. As by

addition of these organic extracts to the solution of crude titanic sulfate, the TiO_2 precipitates white and smooth by boiling, it must be that these metallic oxides are likely to form with these organic matters, compounds which are retained in the solution while the TiO_2 precipitates. This seems to be confirmed by experiments I have made, adding to the crude solution iron oxide, copper oxide, manganese oxide, dissolved in sulfuric acid. By boiling such solution with the same organic compounds as I had used with the crude titanic sulfate solution without these additions of metallic oxides, the TiO_2 precipitates as a white, smooth, impalpable powder. The patent for this method of obtaining TiO_2 *white* and *smooth* by means of organic substances has just been granted within the last two or three weeks.

This method finds a direct application in the production of a white titanic pigment, a product which our company, working under several other patented methods, is to manufacture on a large industrial scale in a special department of our works. TiO_2, calcined, possesses the remarkable property of covering when used as paint material alone or in mixture with such other pigments as are used in the trade for paints. Its superiority on this score when prepared with proper oils over white lead or zinc white is remarkable, and in addition, TiO_2 pigment is not attacked by sulfurous gases and is stable under climatic and atmospheric influences.

I have found that TiO_2, obtained as a gelatinous titanic acid, $TiO_2.2H_2O$, and dried at 212° F., has the property of fixing coloring matters like that of alumina. It can be prepared by known methods, but the one I have studied is much more economical, as I can obtain it from a waste product of some of our manufacture.

In that state it dissolves readily in oxalic acid yielding a titanium oxalate which can be used in the same manner and for the same purposes as potassium titanium oxalate which is much more difficult and costly to make.

Thanking you once more for the honor conferred on me, I will show you some photographs of historic interest in the case.

1—A photograph of the small furnace which I planned and erected at Buffalo in 1894–95 to smelt titaniferous ores without mixture.

2—The old Porter house where ferrotitanium was made on an industrial scale for the first time as early as 1900.

3—The transformer room.

4—My primitive laboratory.

5—The furnace room.

6—The furnace in operation.

7—Titanium jewels and other specimens.

And for the convenience of those who might be interested and cannot see them to-night I will leave them at the Chemists' Club temporarily.

NIAGARA FALLS, N. Y.

BRITISH PROGRESS IN DYESTUFF MANUFACTURE

BRITISH DYES LIMITED[1]

By JAMES FALCONER, M. P.

Gentlemen, I rise to move the adoption of the report which has been circulated to the shareholders, and before doing so I would like to state that Sir Gilbert Claughton, one of the members of our Board, is unavoidably prevented from being present by public business of an urgent nature, which makes it impossible for him to leave London to-day; and Dr. Forster, another member of our Board, is at present in America conducting some investigations. The circumstances under which this report has been issued have been explained. The fact that we have not been able to submit a balance sheet is due to its having been found impossible, for an indefinite time, to arrange the allowances and other amounts which have to be adjusted with the Ministry of Munitions and the Inland Revenue Department, with regard to the munitions levy and excess profits tax. You can understand it is as much a disappointment to us as it is to you that we have not been able to submit these figures to you in the ordinary course, but it seemed to us to be better to have our meeting, as many other companies have, and do our business, rather than wait indefinitely before meeting one another to discuss the work of the year.

Our subscribed share and loan capital, as on April 30, 1917, amounted to £2,084,138, as compared with £1,851,914 at the commencement of the year, being an increase of £232,224. The number of our shareholders is now 1,445.

As regards the financial results of the year, it is not possible to make any satisfactory estimate, and I shall, therefore, refrain from submitting any particulars, except to say that I am sure when we are in a position to submit them they will be generally regarded as satisfactory. Our policy has been to charge prices for our products which would enable us to build up a fund sufficient to meet the great extra cost of constructing our works during the period of the war, and with that fund to write off our plant so as to reduce it to a reasonably low figure. We are satisfied that the results of the year will enable us to go a long way in this direction, to the extent of a good many hundreds of thousands of pounds, but I do not want you to get any exaggerated estimate of the profit we have made. Apart from the amount which is necessary to enable us to meet the depreciation to which I have referred and to pay the interest and the limited dividend, it will be no object of this Company to make large profits, because, being a controlled establishment, we should simply hand them over to the Exchequer. We are assured and have the authority of the Auditors for being satisfied that we may safely pay the shareholders 6 per cent. The amount of the interest on the Government Loan has been paid, *viz.*, £40,615. The dividend at 6 per cent on the ordinary shares will amount to £30,945, making together £71,560. Whatever we may make, 6 per cent, of course, is the maximum we are allowed to distribute.

Now, in dealing with the work which we have carried out during the year, I would like the shareholders to realize that we have three departments of work, each of them of great importance. The first is for carrying out certain work of national importance for the Government; the second is for the supplying of dyes for the immediate needs of our shareholders; and the third is for the building up of a national industry for the permanent supply of dyes for this country.

First, as regards the Government work to which I have referred; the situation did not permit me to refer to this question in the previous year for reasons that no doubt will be obvious. The position is that when we acquired the business of Read Holliday & Sons, Ltd., there were certain arrangements in force with regard to the work and certain negotiations were taking place. A few months after we took over the business the arrangements were all settled and new contracts were entered into for different products, all of them of real importance. I am glad to be able to say that we have punctually fulfilled all our obligations and at present our deliveries are all months ahead of our contract dates. At that time our deliveries were of vital national consequence and when you cast your thoughts back to the winter of 1915–16 and realize the extent to which the fate of our armies and our country was dependent on such supplies, I am sure you will agree with me that it is a matter of great satisfaction that we were able to do the part we undertook to do. I have heard, from time to time, the criticism that other companies were confining themselves to manufacture of dyes and

[1] Chairman's Address delivered at the Second Ordinary General Meeting of the Shareholders of British Dyes Ltd., Huddersfield, October 31, 1917.

we ought to have done the same. That has not been our view either of our duty or of the true interests of the Company

With regard to the immediate supply, by which I mean the supply of the needs of our shareholders during the period of the war, our output during the year has been substantially increased. Now the output of colors is more than three times the amount of the pre-war output, and when you consider that we have, in addition, made most of our intermediate products and many of our raw materials to enable us to increase our output, I think you will agree that this is a very substantial effort to have accomplished. Not only is there the question of volume, but, as you gentlemen know, there has been an increase in the variety of dyes which we have supplied. In addition to our own production we have continued, as far as the means of transport would allow, the supply of materials and intermediates to Swiss manufacturers to enable them to produce dyes and to send them back to this country, either through us or directly. The result has been that by our efforts and the efforts of other dye manufacturers, the users of dyes in this country have been kept supplied, not with all they would like to have or would require in ordinary times, but sufficient to keep their works running, and I believe there has been no unemployment in any trade through want of a supply of dyes. When you recall the situation at the time when the Company was originally formed and consider the apprehension which existed that workpeople would be unable to find employment through the complete failure of the supply of dyes, I think you will agree that the fact that we have so far succeeded is a matter on which we may congratulate ourselves.

I come now to the third branch of our effort, the laying of the foundation of a permanent supply of dyes for the country. I have said we have produced already a considerable number of colors which we were not able to produce before. We are producing a series of colors which, although far from what ultimately has to be done, is nevertheless a substantial list. We have during the year increased the plants for intermediates, some of them are in operation, others are being pressed forward, and we must always keep in view, in estimating the amount of work involved in the manufacture of these intermediates, that they require for their operation general services on a very large scale, steam, power gas, electricity, water, compressed air and also supplies of acids and other raw materials. To provide these services requires plant on a scale which can only be properly realized by inspection, and I am to express the hope, on behalf of the Board, that as many shareholders as possible will take advantage of the invitation to see the works. Every building that we have is already allocated to plant, a good deal of which has been erected or is in course of erection. To some extent the allocation is in respect of plant for which arrangements for erection are being carried through. I have heard the criticism that we have built too much. As a matter of fact, it is quite the reverse. We made it our policy to press on the building as fast as we could, knowing that difficulties of labor were going to increase, but we find that we have not enough in the way of buildings, and in order to accommodate the plant for necessary intermediate products we must erect further buildings. When you look at the number of buildings we have put up, then I think you will appreciate the effort which must be made in order to fill these buildings with plant, and to supply them with all the services necessary to enable them to be successfully operated.

Our procedure with regard to the erection of plant is as follows: We must first get the process worked out in the laboratory—I am dealing now with some processes that we have not hitherto worked. Then we have an experimental laboratory containing plant on a small scale, but with everything working according to the ordinary commercial conditions, and the process is put through that experimental laboratory. Difficulties are thus discovered and remedied and then the plant is erected on a commercial scale. All this takes time, because these processes involve great care and considerable delicacy in their operation and a very small error will upset a chemical process. When you find, therefore, that a plant has been put up you will know that a great deal of study and experiment has been devoted to the task, from first to last, until the plant is completely erected and working successfully. In addition to these works to which I have referred, we have purchased a site suitable for the erection of dwelling houses, because we see that a real problem is coming in regard to the supply of dwelling houses for our workpeople. There is a greater scarcity of dwelling houses in Huddersfield than probably in any other part of the country, and dwelling houses are very scarce everywhere. We are also providing canteens in our old works and in our new works for the convenience of our workpeople, and we have established a club for our chemists.

Now that is a very sketchy outline of the work that we have done, but I think I have said sufficient to justify me in asking the shareholders to acknowledge the efforts which have been made by Mr. Turner, by the chemists, by the engineers, by our workpeople and by all our staff, in doing this work during the course of the year with which we are dealing. All of them are overworked, all of them are full of zeal and, so far as the Board are concerned, they have all our most sincere gratitude for their loyal efforts on behalf of this Company during a time of so much difficulty. And I think the country also owes to them an acknowledgment of the very special work they have been doing, and doing with such complete success, so far as the national requirements are concerned.

Now at the same time, while I am bound to recognize the work which has been done, I am bound also to say, in perfect frankness, that it is only the beginning of the work that has to be done before you can have a really adequate supply of dyes manufactured in this country. In the report there is mentioned the magnitude of the German concerns with a capital of £35,000,000; and I dare say you all must know something of the dimensions of the German works. While of course their output has been far in excess of what was required for Germany alone, still one can form some opinion of what will be required here in the way of chemists, in the way of scientific work, in the way of staff, if we are going to reach our goal. I am not in the least disposed to take a despondent view but, on the other hand, I am not at all disposed to underestimate the task we must perform, and I think it is well that the shareholders should realize its magnitude. The Germans have been working on this problem for over 30 years, with thousands of chemists and with almost tens of thousands of experienced workmen; and we cannot hope in a year or two to come up alongside of them. It will require earnest work for many a long day before this country reaches the position to which it ought to attain in providing a supply of dyes sufficient for the needs of this country

I should like to refer to the necessity of research. There are two ways in which research can be carried out. There are the scientists who study the properties of substances or groups of substances, seeking to learn the laws which govern their action without any immediate practical purpose before them. They go out merely seeking for truth In this field Britain has always been supreme. If you think of the great discoveries made in science you will almost invariably find they are the work of great British scientists. The discovery of the principle of synthetic aniline dyes is an illustration of it. That was not discovered by a man who was looking for a method of making a mauve dye by a synthetic process He was looking for something else altogether, carrying out, no doubt, his research in the most scientific and careful manner possible. Many other discoveries of the first magnitude have been made by British scientists. My belief is, and my confidence in the industrial future of this country is largely based on this, that the people of this country have a genius for original discovery and invention

which is not surpassed by any other nation, and indeed, so far as the history of the past shows, no other nation has attained to our position in the field of original research.

But there is another branch of research, and that is the study of the application of scientific principles to particular problems and to improvements in methods of operation. Take a great example, the following out with extraordinary zeal and at great expense of experiments with a view to discovering how to manufacture synthetic indigo commercially. In this and many other instances where the original principles have been discovered in this country by British scientists, the application of them to industry had been left to other people. Others have reaped where our scientific men had sown. Here, we must admit, in the past, has been our failing. I am not going to discuss the vexed question as to who is to blame most. You must have an enlightened far-seeing spirit of commercial enterprise, with a body of scientific men sufficient to do all the scientific work necessary to carry forward discoveries to practical operation and to overcome all difficulties that arise in practical operations. My belief is that the reason for which the aniline industry left this country was that, at that time, there was not available a sufficient number of chemists qualified to carry through the operations and to overcome the difficulties. There was much enterprise among the commercial people and if there had been a body of chemists, trained and qualified to carry out chemical processes, then, I think the aniline color industry would probably have been developed in this country as it has been in Germany. I do not enter upon the dispute as to whether it was the commercial men who were to blame for not encouraging the chemists, or whether the blame attached to the chemists in that they did not adapt themselves to the requirements of the commercial men. The really important point is that they must combine. I have dwelt upon this question because I want to say, and to say it with all the power of which I am capable, that it is essential to the success of an enterprise such as ours that a sufficient body of qualified chemists be provided for the carrying out of the work of the future.

We have established in different universities, colonies of research students who are in our employment, and who are acting under the guidance of Professor W. H. Perkin at Oxford; Professor A. G. Perkin at Leeds; Professor R. Robinson at Liverpool, and we are greatly indebted to these gentlemen for placing themselves at our disposal for supervising the work of these research laboratories. We have research work constantly going on in our new works laboratories and elsewhere among the chemists employed in our works since, when a man is carrying on practical work, you cannot prevent him, when he has got brains, from considering what better method could be devised for carrying out his operations. In order to encourage the supply of chemists, we have made an offer to the universities that, if they will send us a qualified chemist, we will find him a post at a satisfactory salary with an engagement for three years. It seems to me this is the best inducement we can offer to any young man thinking of working at chemistry. We are offering special facilities to the members of our staff of chemists to pursue their studies either in Huddersfield or in Leeds. In that way we are trying to make the most of all the material that exists. But there is a further difficulty, *viz.*, that of men, and we have made up our minds that we will take special steps to encourage promising young men to devote themselves to chemistry and to send them to technical schools and universities, and to do whatever is best for them. That, of course, will take time and cost money, but no figure that anyone can think of would be too much to pay for securing a really efficient staff of chemists for our work in the future, and we rely upon the support of the shareholders for any expenditure we may have to make in order to carry out that scheme. We have a long way to go. We welcome the help of all the experts that we can get. I do not say that we are anywhere near our goal, but we are earnestly and diligently pressing forward.

There are two questions to which I should like to refer. The first is that of the manufacture of indigo. You will remember last year I stated the steps which we had taken to place ourselves in a position to manufacture indigo and to tender to the Government for the purchase of Ellesmere Port Works, and that we were refused permission to tender. I said we had made every effort to ascertain the reason for which we were not allowed to tender, but had been unable to do so. In one quarter or another attempts were made to cast some doubt upon the statement I then made, and as the question is a matter of great consequence for the user of dyes I will tell the shareholders exactly how it stands. When we were asked to submit evidence of our ability to manufacture indigo by the process at Ellesmere Port, we appointed a committee consisting of Dr. Forster, chairman of our Technical Committee, Mr. Turner, Mr. Dean, chief chemist at the Turnbridge Works, and Mr. Robinson, an engineer of great experience and ability, one of the first mechanical engineers in the country, who was good enough to place himself at our disposal practically as soon as the Company was formed, and who has knowledge of our plant and premises. They went to Ellesmere Port and saw the plant there. They then went to France, to Creil, and saw a plant similar in every respect, in practically every respect—there were, I believe, some little details of no consequence—similar to that at Ellesmere Port. They made a report which was submitted on behalf of the Board to the Board of Trade. Here is a passage from their report which deals with our ability to manufacture: "The indigo plant at Creil is an exact duplicate of the Ellesmere Port plant. The plant was working on the occasion of our visit and we carefully investigated its operation at all the important stages. We also obtained from the chemist information with regard to the quantities, proportions, temperatures, times, etc., required in the operation. We entertain no doubt as to our ability to manufacture indigo with the plant at Ellesmere Port. Further, we have provisionally arranged with the Ministry of Commerce that if the Company should acquire the plant at Ellesmere Port, the services of the chemist, who is a French subject, and a mobilized soldier, should be made available to assist the Company in overcoming any difficulty which might present itself."

We sent that to the Board of Trade with the intimation that if there were any doubts we would be glad to supply further particulars upon any point. The answer we got was that, after considering the reports of the two independent referees, to whom the reports from Messrs. Levenstein and ourselves had been referred by the Board of Trade, they had decided that Messrs. Levenstein, and Messrs. Levenstein alone, should be allowed to tender. We asked them again and again to state the reason for which we were not allowed to tender. We failed to get an answer. We asked for an interview with the President of the Board of Trade and the whole of our Board of Directors attended. We repeated the question, but still without obtaining an answer.

There are two things for which we have pressed. We have asked whether the referees recommended that we should not be allowed to tender. We have got no answer to that, except that the decision of the Board of Trade was given after considering the report of the referees, and on further pressure we were told that it was not a matter which was referable. But I have got no answer to the question: "Did they or did they not in fact recommend that we should not be allowed to tender?" It would have been easy to answer.

I asked a further question. "In what respect did the referees consider that we were not able to manufacture by the Ellesmere Port process?" but I have got no answer to that. Now I have had a good deal to do with references of one kind and another. We were asked to submit our statement and Messrs. Levenstein

were asked to submit theirs We were asked to pay half the fee and I think we should have been entitled to know what was the award and why it has been kept back. My reason for pressing this is that neither of the referees was a practical man. They were both eminent scientific men—teachers of chemistry—but, so far as I am aware, neither of them had anything to do with the operation of any chemical process in connection with dye-making. The process so far as the scientific theory is concerned was well known and the only question was how to operate a particular plant, and in the face of a signed declaration and the statement of responsible practical men that they were perfectly satisfied they could manufacture indigo by that process—in the face of that particular declaration it was not for two professors to say offhand that these men could not do so. That does not seem to be the way in which business of the greatest importance to the textile industries and to the country should be dealt with. Until I am shown their report and told in what respect we are unable to manufacture indigo by the process, I decline to accept the view either of the Board of Trade or of the distinguished referees whom they appointed. I always make this reservation, I gravely doubt whether these referees made any recommendation which would justify the refusal to allow us to tender.

Now there is another feature in connection with this matter to which I think it right to refer. At the meeting of Messrs. Levenstein, Ltd., shortly after I made the statement, Sir John Lonsdale, who is the Chairman of Messrs. Levenstein, Ltd., referred to my statement and said he did not think we had anything to complain of. The reasons he gave were: that they had long and intricate negotiations with the Board of Trade on the subject of the Ellesmere Port Works so far back as February, 1916; that they were the first firm in the country to approach the Board of Trade intimating their desire to purchase; and that as soon as the Receiver or Controller told them the minimum price to be accepted they made an offer to purchase at that price. Now, in the first place, Sir John is misinformed in thinking that he made the first approach on the question of Ellesmere Port, because long before February, 1916, I had made enquiry with regard to it, and I was told that the Government proposed to continue working under a Controller. At the end of January I heard, incidentally, from the President of the Board of Trade, that the Committee which was dealing with the shutting down of German concerns in this country was going to consider the question of closing down the Ellesmere Port Works and of selling them. I then intimated that we should desire to purchase and I was told that the purchase was going to be by tender, and that the terms and conditions would be arranged by the Judge to whom application would have to be made. And I was under the impression that the sale was to be by tender, right down to July, when we got intimation that we were not to be allowed to tender. It, therefore, comes to me as a surprise that during that period there should have been long and intricate negotiations with one party, while the other was being held at arms length. As a matter of fact it was with the utmost difficulty that we could get the time extended to enable our deputation who had visited France to come back. A sale by tender conveys to my mind that everyone is to be treated in the same way and to have the same opportunity. And if there were negotiations with one party and if a price had been arranged I think it was unfair that we should not have been informed. In fact there should have been no such negotiations if there was to be a sale by tender. Everyone should have had a fair chance, and I suspect that these long and intricate negotiations which took place had practically settled the question before the referees were appointed, and before our memorandum went in. I raise this question now, not for the purpose of swelling upon any grievance, because everybody—every business man, at any rate—knows that the least valuable possession any man can have is a grievance. The best thing to do is to write it off and to go on with one's work. But I raise it for two reasons. I want to explain what has taken place in justice to our staff, and to the men who signed the memorandum. I do not think we could justly allow it to go out that we are not able to manufacture indigo by this process. In the second place, I want the shareholders to know the serious position in which users of indigo are placed. This Company was formed, and the capital was subscribed, on the invitation of the Government on the footing that users of dyes would have an undertaking which would control the supply of dyes as regards price and other terms, and that everyone would be treated alike. Now we find that this most important plant is given to a firm subject to no control as regards supply or price or conditions, such as making purchase of other dyes a condition of giving a supply of indigo. It would take a great deal to justify the action of the Government in this respect. It is said that this process, along with other processes, has been sold by Messrs. Levenstein, Ltd., to a large American firm who had hitherto nothing to do with dyes, and unless the conditions of sale submitted to us have been modified there is nothing in them to prevent it. No doubt there could be established in America, in that way, a very large undertaking for the manufacture of indigo. They would have power to supply all the markets of the world, whereas our hands are tied. But not only are Messrs. Levenstein, Ltd., allowed to do that, but they are entitled to give to anyone else their power to manufacture by this process without any responsibility to the users of dyes in this country. I venture to repeat that the transaction is one that has given us a shock. We have a process for the manufacture of indigo, a different process, and we shall do everything in our power to be placed in a position to manufacture and to supply anyone. But the difficulties of putting up large plants at the present time are undoubtedly very great. It will require all the support of the shareholders and the support of all the large users of indigo to enable us to carry out that program, and in any event there must be delay before it could be carried out even if we commenced it to-day.

Now there is only one other matter which I want to speak about, and that is the question of coöperation which is mentioned in the report. The position is this—that in July of last year arrangements were made for a meeting between all the dye manufacturers in this country for the purpose of endeavoring to bring about some arrangement which would prevent overlapping, and which would enable them to deal in the best way with the supply of the country. But at that time the question was taken out of our hands by the Board of Trade, who set on foot certain negotiations by committees and otherwise. Our attitude is this, and has been throughout, that we are in favor of any arrangements which will enable us to work together for providing a better supply. In the words of the report: "We would welcome any tangible proposals for coöperation with other manufacturers provided that the interests of the textile and other industries dependent upon the supply of dyes are safeguarded, and that the coöperation can be carried into effect in a manner consistent with the object for which this Company was established." Various suggestions have from time to time been made, and we have maintained that attitude throughout. We have been really anxious to bring about an arrangement but so far nothing definite has been reached. The difficulties have not been in the least of our making, but nothing has been arrived at, and we are to-day practically just where we were 12 months ago. Now let me say this. We still remain of the same opinion and we shall welcome any practical tangible proposals that comply with these conditions. But I want to say quite definitely that, if you are going to have combination, it is essential in the interest of the industries of this country that there should be adequate control to protect the textile industries, and that a monopoly of dye-making in the hands of one company without

control would be a danger to which the industries of this country should not for a moment be exposed. I have had opportunities of studying the operations of some of the conventions made by the German dye-making combinations, and can assure you that there are many ways in which industries may be punished through the action of dye-making concerns which would probably never come to the surface, or would be imagined by those who have not had an opportunity of seeing the inner workings of those concerns. I therefore want shareholders to understand our view, *viz.*, that it is essential in any such combination that there should be adequate protection of the public interest and of the textile industries. We are all in favor of coöperation and combination not only at home but with the Swiss and with the French. Dr. Forster, at the present moment, is in America studying the question of how we may be able to supplement the supply of dyes to this country by coöperation with American manufacturers.

One thing I would say about this matter is, that it is no use talking of coöperation unless there is a genuine desire for people to work together, and I am bound to say that, as I study the atmosphere at the present time, I find, instead of an atmosphere which would lead towards coöperation, what seems to me to be an organized attempt to create hostility to this Company which does not promise very well for coöperation. We have taken no notice of general discussions on the merits of business men and of scientists. It is absurd to waste time on that, but there have been some definite statements made which do call for notice.

The first of them was made by Professor Pope, one of the impartial referees on the Ellesmere Port transaction, in which he says in the midst of a great deal of general discussion: "The Government organization (that is our Company) has proved to be not only a great failure, but has had the further effect of inhibiting the re-establishment of the coal-tar industry. That is to say, the organization apparently was to do everything that was necessary and consequently private effort was to a considerable extent hampered." Another professor repeats the statement. My object in referring to statements of this kind in regard to this Company is to say, in the first place, that they are not true. Further, the gentlemen who make them, so far as I am aware, have never been inside our new works and know nothing of the plant we have put down or of our program, nor of the research we have been carrying out, nor of our general policy. Why then these wild statements? As a rule you pay no attention to them, but when talking of coöperation, if you are going to coöperate, it can only be with people who are willing to work honorably and loyally with you, and not with people who write and publish statements like that in regard to you. The situation with which we are faced is far too grave, too important, for men of science or others, who may be able to give help, to indulge in recriminations or talk of this kind. And I want to make an appeal to them and to all dye manufacturers and to everybody engaged in the business each to carry on his business in healthy rivalry, and do everything he can to make it a success, but do not let us get into the old bad position of past days when it was the business of every man to try to do as much harm to his neighbor as he possibly could.

The task is one which is worthy of our best efforts. I can assure you we are only too anxious to get the coöperation and assistance of anybody and everybody able to help for the purpose of producing the dyes which it is our object to supply to the country.

LEVENSTEIN LIMITED

The following account appeared in the *Journal of Commerce and Commercial Bulletin* for Thursday, January 10, 1918:

London, Dec. 21—Instances of the progress made by the British dye industry were given yesterday by Sir John Lonsdale, presiding at the annual meeting of Levenstein's Ltd. That it is possible for Great Britain to produce all the dyestuffs it needs was one statement made by Sir John. On this point he said:

"If the Government is prepared to give the necessary financial assistance and special priority for the erection of plant, we, for our part, will guarantee to make this country independent of Germany or any other foreign source for dyestuffs. Let there be no misunderstanding on this point. In our organization the State has an asset of the greatest value, for we have the knowledge and experience to free the textile trade from German domination in dyes, and we shall undoubtedly produce the results required, given the necessary help from the State."

The original works of this company were erected by Germans solely to comply with the Patents Act of 1907; they were only designed to carry out the last stage of the manufacture of indigo, no provision being made for the manufacture of the all-important intermediate product without which it was impossible to obtain the finished dye. The war shut off the import of this intermediate material, and the present management, which purchased the German property, proceeded to erect the large plant necessary for the production of the essential intermediate.

PROGRESS OF DYE INDUSTRY

One of the many difficulties involved was the fact that the Government had already commandeered all the supplies of the raw material required. Accordingly, a new process from another raw material was developed, and with the remarkable speed extraordinary results were achieved. Ever since the outbreak of war the company has been by far the largest supplier of aniline dyestuffs to the War Office and Admiralty and to the Colonial and Allied armies, also shipping large supplies to the United States to cover the requirements of American textile manufacturers who had contracts with the Allied Governments. By March, 1915, the company had sufficient plant installed to meet the entire demands of the textile mills of the world for naval and military purposes outside the Central Empires.

"This achievement, effected without any financial assistance from the Government, entitles the chairman of the company to speak with the highest authority," says the *Financial News*. "The work done by Messrs. Levenstein at Blackley and Port Ellesmere in relieving the dye famine of the world and helping to break down the German monopoly of a key industry which had become a source of great economic power is of the highest national importance. But Sir John Lonsdale clearly demonstrates that much remains yet to be done if the British dye industry is to be placed in a position rendering it capable of resisting German competition after the war.

"Before the war the British textile industry and other dye users were dependent upon Germany for 80 per cent of the dyes employed—that is to say, British industries, representing £200,000,000 of capital, were practically at the mercy of German dye makers. Now the peace requirements of these industries are widely different from those of war time. The range of dyes manufactured in this country to-day has to be very widely extended. The manufacture of the peace requirements of the dye-using trades is limited (as far as Messrs. Levenstein, Limited, are concerned) not by their scientific knowledge, but by the extent of their plant.

AID OF GOVERNMENT SOUGHT

"The intention underlying the formation of the British Dyes Company and the investment of £2,000,000 of public money therein was excellent, says Sir John Lonsdale, but it has not solved the problem of securing adequate peace supplies of British-made dyes. Messrs. Levenstein, he declares, manufacture to-day more dyes and a wider range of dyes than all the other British makers of aniline dyes combined, but much more remains to be done. The company possesses the knowledge; what it requires is more plant, and the provision of such additional plant is governed solely by financial considerations.

"Sir John Lonsdale, on behalf of his company, therefore,

throws out this challenge—or perhaps it should be termed invitation—to the nation: 'If the Government is prepared to give the necessary financial assistance and special priority for the erection of plant, we, for our part, will guarantee to make this country independent of Germany or any other foreign source of dyestuffs.'

"This is an undertaking which cannot be ignored by the Government. In the Levenstein organization the country has an asset of the highest economic value. After the war Germany's dye industry will be one of her strongest economic weapons. Tariffs will not exclude German dyes if the necessary plant does not exist in this country to meet trade requirements. British Dyes Limited, in which the Government is interested, has not yet displayed the capacity for production of the country's requirements, and it is essential that further steps should be taken. We hope that the fullest impartial consideration will be devoted to Sir John Lonsdale's statement and that prompt action will be taken, as the question admits of no delay."

CURRENT INDUSTRIAL NEWS

PLATINUM IN SPAIN

A memoir published by the Spanish Geological Survey gives some details of the platiniferous deposits of the Serania de Ronda. The region of Southern Spain, situated between Malaga and Gibralter, is of very complex structure. It has formed in recent years the object of investigations by mining engineers commissioned by the Spanish Government. Samples were taken of river sand and the gravel from a river the bed of which is dunite, and others from rivers in which dunite was absent. In the first case, the presence of platinum was revealed, but not in the second. On washing considerable quantities of sand and gravel, small, lucent grains of platiniferous ore were discovered, the platinum content of which varied from 78 to 82 per cent of pure ore. In some zones the ore contained from 2 to 3 grams of platinum per cubic meter of substance examined, while in others the yield was as low as 0.25 to 2 grams per cubic meter. From the economical point of view, the nature of the platiniferous sand or gravel is considered excellent, as it does not contain clay. The first river to be investigated systematically between February and June, 1916, was the Rio Verde over a stretch of $3^1/_2$ kilometers. The platinum contained in this area gradually increased from 8 to 20 centigrams per cubic meter from the point at which prospecting was begun to the finishing point.—A. McMillan.

TUNGSTEN IN MALAYA

According to the *Mining Journal*, **119** (1917), 657, a rich deposit of mixed wolfram tin ore was discovered recently near the village of Changloon in Sungei Sintok. The discovery was made by Chinese who were working for tin on some small adjoining leases. The discovery caused a rush and as there were over twenty applications for the area, the Kedah Government decided to put the property up at auction. Subsequently, however, the area of 3000 orlongs was given to a local firm. The monthly output hitherto has been about 300 pikuls (1 pikul = 142.7 lbs.) but an increase to 800 pikuls is expected shortly. The rich discovery seems to be confined to this localized area and no further discoveries have been made outside. The ore occurs in quartz veins but as no regular prospecting work has been done upon it, no reliable idea can be formed as to its life.—M.

TUBULAR CYCLE COMPONENTS

A catalog issued by Messrs. Accles and Pollock of Birmingham, England, illustrates a wide range of tubular parts for the construction of cycles, motor-cycles, and aeroplanes, such as handle bars, seat pillars, seat-pillar laps, frame lugs, bridge pieces and loop struts, stays and front forks, and steering tubes. Full-size illustrations are given of 268 special sections in cold-drawn, weldless steel tubing, as well as of a number of sections from the Air Board's standard lists, and there is a description of an attachment called the "Apollo Mykarmo," which, when cramped on the thimble of standard micrometer calipers, at once converts them into a limit gauge having a tolerance of from 0.0001 in. to 0.022 in., with variations of 0.001 in.—M.

MAGNETO MACHINES FOR POCKET TORCHES

A recent issue of the *Elektrotechnische Zeitung* gives some particulars of a new type of pocket torch being developed in Germany and Austria in which the lamp is supplied with current from a small hand-driven magneto. The shortage of certain material is putting a limit to the manufacture of dry cells and small accumulators for public use and this is no doubt responsible for the tendency to utilize hand-driven sources of current for pocket lamps of various kinds. Lamps of this kind are more expensive than the ordinary kind but do not require refills or charging.

One of the types described depends on the release of energy from a series of springs put into tension by the pressure of the thumb on a lever. The whole arrangement weighs about 1 lb. and is so contained that the release of the spring supplies enough energy to keep the lamp alight for 3 min. In order to secure a light for 10 min. a heavier machine, weighing about 5 lbs. and requiring to be wound up with both hands, has been designed. In these lamps the armature is the rotating part but in another variety, due to O. Pletscher, the field revolves in ball-bearings round a T-shaped armature. This lamp is stated to weigh only about $^1/_2$ lb. The application of this principle of portable electric lamps seems quite simple and practicable.—M.

THERMIT WELDING

The British Board of Trade have now given formal sanction, says *Engineering*, to a new company with works in London and Liverpool and known as the British Barimar Thermit Welding Company to take up and exploit the Thermit-Welding process which prior to the war was exclusively in German hands. Thermit is especially applicable for tramway welding and for repair of heavy castings and machine parts. The registered offices of the new company are at 10 Poland St., London.

The Thermit Co., Ltd., of Commercial Rd., London, are not connected with this new company which has only rights to work certain of their patents. They continue their manufacture of various Thermit compounds and are at present especially engaged upon the manufacture of certain metals and alloys in connection with the war.—M.

REFRACTORY PROPERTIES OF MAGNESIA BRICKS

A contribution to the Proceedings of the Paris Academy of Sciences was recently made by MM. LeChatelier and B. Bogitch on the refractory properties of magnesia bricks, either made in the laboratory from pure magnesia or from commercial specimens. The resistance to crushing was measured at 15, 1,000, 1,300, 1,500 and 1,600° C. for two bricks and at 15, 1,500 and 1,600° C. for the remainder. All the magnesia bricks show a sudden fall of resistance to crushing at a temperature depending on the degree of purity, a fact which explains why, in practice, it has been found that magnesia bricks stand less well in furnaces than silica bricks, although their fusing points observed in the ordinary way without reference to resistance to crushing are higher than the silica bricks.—M.

PREVENTION OF SCALE IN BOILERS

The necessity of reducing to a minimum the formation of scale on the heating surface of steam boilers if efficiency is to be maintained was referred to in an article in the *Times Engineering Supplement* for September and in this connection Messrs. J. Dampney and Co., of Cardiff, Wales, draw attention to their "Apexior" compound as a remedy against both scale and the pitting of the plates. The compound consists of 98 per cent pure amorphous carbon combined with a neutral organic vehicle. It is painted over the internal surfaces of the boiler and well rubbed in, and, when dry, it presents a peculiar surface which is antagonistic to the building up of a hard scale of crystallization. Any deposit which may take place, the makers state, can generally be removed easily without the use of a chipping hammer and falls off readily over large areas by concussion. In cases where, through the use of soft water, the plates are attacked by pitting, the compound not only acts as a preventive but also arrests the progress of the pitting if it has already begun. The substance is not affected by boiling water or by steam under pressure, and, owing to its nature and the thinness of the film, the transference of the heat to the water is practically not interfered with.—M.

ELECTRIC HEAT STORAGE IN BOILERS

In a recent issue of *Engineering* an account is given of a new type of electrical generator invented by Col. Revel, an engineer in the Italian army. The essential idea in the apparatus is the direct conversion of electric energy into heat by making use of the resistance of the water to be evaporated. Alternating circuits of 200 to 3,600 volts can be applied and this apparatus is stated to be automatic and to require no regulation. Lack of feed water merely diminishes the production of steam until the supply of water is renewed. The efficiency is claimed to be 97 to 98 per cent. The Revel apparatus is constructed to work up to 14 atmospheres and can be connected up at any time to the steam pipes of an ordinary boiler. In this way, temporary use can be made of hydroelectric supplies and their utility can be judged by the fact that they were often used before the war when the price of coal in Italy did not exceed $8 per ton. An illustration is given of an installation of 8 generators taking three-phase current at 6,000 volts and each developing 900 to 1,000 kilograms of steam per hour. The production of steam varies according to the area of electrodes immersed. The sediment collecting at the base of the apparatus from water containing calcareous material can be released without interrupting the process.—M.

BRITISH BOARD OF TRADE

During the month of November the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply of the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

Artificial musk
Boot buttons (manufacturers wanted)
Camel-hair brushes
CHEMICALS:
  Calcium carbonate (precipitated)
  Green stain for eye shades
  Sulfonated castor oil (50 per cent volume)
  Strontium carbonate
  Bicarbonate of soda
  Borate of sodium
  Calcium silicide
  London purple
  Paris green
Corrugated paper
Commercial dried blood for pharmaceutical purposes
Die-casting machines
Disinfectant attachments for telephone mouthpieces
Fiber tubes, 1/4-in. diameter
Flat handles for camel-hair brushes
MACHINERY AND PLANT FOR:
  Making felt wads for use with sport rifles
  Production of clocks and parts thereof
  Making electric light carbons
Maple or hickory skewers, spoons and forks, cheap, tin and zinc
Nichrome drawn wire
Oiled cloth for electrical insulation
Pumice powder (20 to 50 tons)
Self-making stamp pads
Spectacle and eye glass frames gold-filled
Silver leaf for coating pills
Sugar-cane wax
Vegetable extract
Vegetable parchment paper
White chip oil

—M.

MINERAL PRODUCTION OF VICTORIA

The annual report for 1916 recently published gives the following yields of the various metals and minerals for the year:

Gold	276,168 oz.
Black Coal	417,183 tons
Brown Coal	2,915 tons
Antimony Ore	12,382 tons(*a*)
Tin Ore	122 tons
Manganese	85 tons
Gypsum	1,853 tons
Wolfram	314 tons
Magnesite	100 tons
Kaolin	810 tons

(*a*) Yielding 3,259 tons concentrates.

—M.

MANUFACTURE OF ELECTRODES

According to the *Ironmonger*, a company called the Norske Elektrodeverker is erecting a factory at Fredrikstad, Norway, for the manufacture of carbon and graphite electrodes. The capacity is 4,000 tons of carbon or 1,000 tons of graphite electrodes a year, and the works were expected to be in operation by the end of the year 1917. Carbon electrodes are expected to be the first article of manufacture. The machinery is almost exclusively of American make. The orders already in hand are said to ensure the profitable working of the factory for some time and it is stated that the factory is working in coöperation with the Norwegian Government. The company will use power from the great waterfall of Sarpsfall, but in anticipation of this being inadequate, it has purchased the rights to the entire power from the waterfall near Kristiansund.—M.

RECOVERY OF POTASH AND MAGNESIA FROM CANADIAN LAKE

The *Official Canada Gazette* of September 8, 1917, publishes an announcement to the effect that the Committee of the Privy Council have concurred in the recommendation of the Minister of the Interior that he be authorized to lease certain lands abutting upon Lake Muskiki in connection with the recovery and utilization of minerals from the bed and waters of the lake. These minerals, chief among which are potash and sulfate of magnesium, are intended for medicinal and other purposes and preliminary plans submitted by the company show that the proposed utilization of the waters of the lake will require the construction near the lake of a pumping plant, evaporating machinery, bottling works, etc. The name and address of the above-mentioned company may be obtained by manufacturers desirous of supplying plant, etc., on application to the Board of Trade, 73 Basinghall St., London. Reference No. 374 should be quoted.—M.

FLUXES

The fluxes commonly used in melting aluminum scrap, says the *Brass World*, are fluorspar, cryolite and salt. An excellent way of utilizing such material when a part of the scrap is small and not clean is first to melt a bath of aluminum using solid material and to allow it to reach a temperature of approximately 850° C., then to add the sweepings in such quantity that the bath will absorb them without losing its liquidity. The bath is then reheated and more scrap charged, the process of charging and reheating being alternated until the crucible is as full of metal as desired. The metal will most likely be pasty and a small piece of fused zinc chloride is added and the bath well stirred. The resulting action will free the mixed oxides and the metal will assume its natural fluidity. The crucible should be emptied immediately of aluminum before any reaction can occur between the metallic aluminum and the heated oxide on the one hand and the oxygen and nitrogen of the atmosphere on the other, as such action will consume metallic aluminum and greatly reduce the percentage recovered.—M.

WATERPROOF VARNISH FROM OIL

A French patent for the above has recently been published, in which oils vulcanized with sulfur chloride are dissolved in amyl acetate. The following method of preparation is used: One thousand parts of castor oil are mixed with 2,000 parts of amyl acetate and stirred up well with 250 parts of sulfur chloride. In a short time, the mixture sets to a fairly solid jelly and gives off large quantities of hydrochloric acid from the acetyl chloride formed. If, however, the product be left in a tightly closed vessel for several days it will be found to have become completely liquefied and dissolved. The acid is then neutralized with barium carbonate and, after the precipitate has been removed by decantation and filtering, a clear almost colorless liquid is left consisting of a perfect solution of the vulcanized oil, hitherto regarded as insoluble. This solution may be used for waterproofing fabrics, leather, paper, etc. On the other hand, if it be mixed with other solvents, *e. g.*, alcohol, benzene, acetone, acetic ether, and employed to dissolve a certain amount of nitrocellulose, there results an excellent varnish for glossy leather—the gloss resisting action of soap, friction, etc.—a leather polish, a varnish for oil cloth and when mixed with pigments, a waterproof, quick-drying paint which will stand washing and changes of temperature.—M.

SHELLAC DERIVATIVES

A paper on the "Investigation into the Inbibition Exhibited by Some Shellac Derivatives" by Messrs. A. P. Laurie and C. Ranken was read at the Royal Society, London. The paper dealt with experiments made on the substances obtained by boiling shellac with carbonate of soda or borax. The solid substances, very similar in consistency to gutta-percha, are found to expand rapidly when placed in water. The control of the expansion by the addition of soluble salts is not the same as in the case of gelatine, since, at any rate, in a large number of cases, it does not seem to depend upon the nature of the salt but simply upon the strength of the solution, and the amount of expansion increasing with the diminution of the strength of the solution. If the expansion is allowed to become complete in cold water, the mass cannot be contracted again, but if expansion takes place in a salt solution, then contraction will take place again if the mass is put into a stronger solution. Strong salt solutions are also found to precipitate the soluble portions of the shellac-borax compound.

As a result of the experiments described, the authors suggest that the facts can be best explained by supporting the shellac-borax mass to consist of a soluble organic nucleus surrounded by elastic diaphragms through which the organic nucleus cannot pass, but the salt molecules can pass, the organic nucleus being soluble in water but insoluble in strong solutions of salt.—M.

CELLULOSE TURPENTINE

During the treatment of wood for cellulose by the sulfite process there is obtained a considerable amount of a turpentine-like oil mixed with various impurities containing sulfur and having very objectionable odors. The amount of turpentine so obtained reaches as much as 22 lbs. per ton of wood treated where pines are used. The oil has recently been extensively examined, says a contemporary, the sulfur compounds being first removed by means of mercuric chloride dissolved in alcohol. The principal portion of the oil consists of alpha-pinene which is well known to be the main constituent of ordinary turpentine oil. It is, therefore, clear that this terpene is very stable or it could not stand the drastic treatment of the sulfite process When the sulfite process is used, the pine is almost completely broken down to para-cymene. Beta-pinene is also present in the oil and probably di-pentene.—M.

SUBSTITUTE FOR OIL IN PAINT

According to the *Oil and Color Trade Journal*, a mixture of 100 parts of rosin, 20 of soda crystals and 50 of water melted over a fire and mixed with 250 parts of water containing 24 parts of liquid ammonia gives a syrupy liquid which can be used as a substitute for boiled oil or turps in the manufacture of paint. Such paint dries quickly without requiring any driers and has good covering power and withstands the influence of temperature, wet and dry. The substitute is improved in appearance and gloss by the addition of a mixture of 2 parts alcohol, $3^1/_2$ parts ordinary glycerine and 1 part of wax in proportions up to 10 per cent.—M.

DYE FROM SULFITE LYES

After chemical research succeeded in the useful application of sulfite lyes for the production of alcohol and of coal dust for heating purposes, an engineer in Finland, says the *World's Paper Trade Review*, claims the economical production of valuable color stuffs from the remarkable sulfite off lye. He claims especially the new production of methyl alcohol, cymol and furfurol for the transformation into coloring material as they are gained in Germany from coal tar. The inventor has claimed patents in the Scandanavian countries, Russia and Switzerland, and a color factory is being erected at Tammerfors, the centre of the Finnish textile industry, with a capital of 200,000 marks.

The inventor, Dr. Wiljanen, delivered an interesting lecture relating to his invention at the Technical Club, Tammerfors, and exhibited about ten different colors produced from cymol and numerous others containing cymol as a substantial part. He explained that about 300,000 kg. of cymol are obtainable in Scandanavia as a by-product wherefrom yellow and red cotton and wool colors could be produced in a simple manner.

Finland's largest paper mill association has installed apparatus in its factories for separating wood spirits, cymol and furfurol and investigations are being continued at the new Tammerfors factory with a view to obtaining new raw color material from home products. Preparations are being made to start, in the near future, the manufacture of cymol colors.—M.

ELECTRIC ARC WELDING

The welded fastening, reports the *Railway Mechanical Engineer*, has always been looked upon as a stronger fastening than the riveted or bolted joint. As a general proposition the riveted or bolted joint has the tensile strength of the original piece while the welded joint is as strong as the original section. There are two kinds of electric welding, known as the carbon electric welding and the metal electrode welding. In the former, an arc is drawn between a carbon electrode, the piece to be welded and the metal to be added are fed into the arc in the form of a "melt-box." The method is not used extensively in railway work due to the fact that the welding may only be done in the horizontal plane in this manner and that the work is in general inferior to that done with the metal electrode process. The metal electrode process as the name implies—a metal electrode—the arc being drawn between the electrode and the piece being welded. The heat of the arc melts the metal of the piece and the metal of the electrode simultaneously. As the metal of the electrode melts, it is drawn across the arc and a complete and homogeneous union is formed with the molten metal of the piece. With the exception of work with certain electrodes (manganese steel and slag-covered electrodes) the electrode is always made the cathode or negative, *i. e.*, the current flows from the piece being welded to the metal electrode. The voltage required for metal electrode welding is about 20 volts and direct current is necessary.—M.

SCIENTIFIC SOCIETIES

REDUCTION OF WASTE

The importance of reducing and preventing waste has been brought to the attention of the AMERICAN CHEMICAL SOCIETY by the following communications:

December 22, 1917

TO THE CHAIRMEN AND SECRETARIES OF THE SECTIONS OF THE AMERICAN CHEMICAL SOCIETY:

The Alabama Section of the American Chemical Society early this autumn passed resolutions looking to the prevention of all wastes as far as possible and referred the question of a national movement in the American Chemical Society to the President of the Society. At a meeting of the Advisory Committee of the Society held in New York on December 8, it was decided to take up this movement as a most important one in which the National Society could be and should be active. It was decided that the emphasis should be placed not so much on a talk propaganda against wastefulness but, since the Society consists of experts in the field of recognizing and preventing waste, to ask the Sections to emphasize the need of pointing out specifically in as many instances as possible where waste occurs and how it is to be avoided. It is recognized that in many cases large problems of research would be involved in reaching recommendations as to how waste is to be avoided but chemists could be active in pointing out these problems and urging that the necessary investigations be undertaken by the concerns involved.

In accordance with this action, I would ask that you appoint a committee of your ablest men to take this matter in hand and to organize a campaign against waste in the most effective way possible. It might be desirable in given localities to appoint a very large committee to cover all the different kinds of waste or to appoint a number of committees each to take care of a definite field of effort. Such organization is left to the judgment of the local sections. In conclusion let me say that Past President Little pointed out to the Boston meeting that the saving of waste alone in this country would be sufficient to pay off the tremendous war debt which we are incurring in the space of a very few years.

In case any Local Section would like specific advice in regard to any matter connected with this movement it is urged to bring the matter up with the President of the Society.

Thanking you in advance for your coöperation in this most important movement, I am

Yours sincerely,
(Signed) J. STIEGLITZ,
President, American Chemical Society

. . . . . .

38 Albemarle Street
Rochester, N. Y.
December 21, 1917

DR. JULIUS STIEGLITZ,
University of Chicago,
Chicago, Ill.

Dear Sir:

In reading an article in the July number of the *National Geographical Magazine* on rats and mice, I was very much impressed by the enormous economic loss to this country caused by this pest. The thought struck me that it is most absurd for the American people to strain at every point to conserve and increase their food supply and yet to ignore wholly a cause of loss which is estimated to cost the country from $100,000,000 to $200,000,000 per annum.

With this thought in mind I took up the matter with the Rochester Section and obtained their approval for me to act in this matter. Enclosed are copies of the correspondence to date.

My object in writing to you is to see if your views on the subject are in accord with mine and, if so, whether it would not be possible for you to help in this matter through your office and the Local Sections.

I realize that it is impossible for any one community to make a successful fight, for in the first place the rat, being migratory, will appear again shortly after being exterminated locally. In the second place, there is such an enormous indifference to be overcome such as, "Rats never bothered me, why should I worry?" that it is almost impossible to accomplish anything unless there is governmental authority behind it. Therefore, it appealed to me that there never could be a more fitting time to start a campaign against this pest than the present when nearly everybody is willing to do their bit. Besides the loss of food enormous damage is done to property and, by no means the least, there is the constant menace to health.

I would ask that you kindly give this matter your careful attention and let me have your opinion relative to it.

I received your letter of December 17, and will carry out the instructions given therein.

Sincerely yours,
(Signed) H. LE B. GRAY,
Chairman, Rochester Section

. . . . . .

Chicago, Ill.
December 27, 1917

MR. H. LE B. GRAY,
38 Albemarle St.,
Rochester, N. Y.

Dear Mr. Gray:

I have your letter of December 21 with the interesting correspondence in regard to the economic loss due to the rats and mice in this country. A few days ago I sent out letters to all the Sections of the American Chemical Society asking them to coöperate in the elimination of waste in this country and especially to indicate in specific cases where waste occurs and how it could be avoided. This letter no doubt has crossed your present letter. I think a movement to reduce the destruction by the rats and mice would be particularly desirable at this time, as it would not only save food and other important products but also be a safeguard in regard to the health of the community. I have no doubt that we shall have the same experience as they have had in Europe, notably in Germany, France and Italy, where the food shortage has been the most severe, and shall find that the necessity of saving of food will lead to reduced resistance towards disease and the increase of disease in this country. In view of that situation it would be especially desirable to offset this decreased resistance by such a positive element toward health as the reduction in rats and mice that you propose. I would recommend, therefore, that you take up this problem with each of the Sections of the American Chemical Society as timely and important.

Yours sincerely,
(Signed) JULIUS STIEGLITZ

. . . . . .

38 Albemarle Street
Rochester, N. Y.
January 4, 1918

DR. CHAS. H. HERTY,
Chairman, New York Section,
New York City.

Dear Sir:

Pursuant to the recommendation made by Dr. Stieglitz in his letter of December 27, 1917, replying to mine of December 21, 1917 (copies of which are enclosed), I am writing you with the hope that I may interest your Section in a matter which appeals to me as vitally affecting the country, especially at the present time. Local campaigns and those without official

authority would be futile and it seemed to me that by the combined action of the Local Sections of the Society sufficient interest could be aroused to start a national campaign backed by governmental authority.

The matter has already been taken up with the U. S. Food Administration and in reply they state, "You are advised that the movement of your Society, as indicated in your letter, has our heartiest approval and support, and we trust your Society will do its utmost to aid in the elimination of these pests and the conservation of much needed food thereby"—and in a subsequent letter—"permit me to suggest that you take this matter up with Dr. Hayward, Chief of the Bureau of Insecticides and Fungicides, Department of Agriculture, who have their permanent representatives in all sections of the country and would, therefore, be in a better position to take charge of this matter, the importance of which we realize, than the food administration."

A letter together with a copy of this one will be sent by me to Dr. Hayward.

Any action which you or your Section may take to further this movement will be greatly appreciated.

Very truly yours,

(Signed) HARRY LE B. GRAY

SEVENTY-FIFTH ANNUAL MEETING AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, PITTSBURGH, PA., DECEMBER 28, 1917—JANUARY 2, 1918

The seventy-fifth annual meeting of the American Association for the Advancement of Science and the affiliated societies was held in Pittsburgh, Pa., from December 28, 1917, to January 2, 1918.

The first general session of the Association was held in the Music Hall of Carnegie Institute on Friday evening, December 28. President Charles R. Van Hise of the University of Wisconsin, retiring President of the Association, delivered an address on the subject "The Economic Effect of the World War in the United States."

A meeting of Section C, Chemistry, was held on Friday morning, December 28, presided over by the chairman, Professor Wm. A. Noyes. The feature of the evening was the informal but exceedingly enjoyable address of the retiring chairman, Professor Julius Stieglitz of the University of Chicago, upon the subject "The Electron Theory of Valence and Its Application to Problems of Inorganic and Organic Chemistry." After an extended discussion of the address, Doctor David Horn of Bryn Mawr presented a paper on "A Chemical Study of Formalin Fumigation." A paper by J. Davidson of the Bureau of Chemistry, Washington, D. C., entitled "Do Seedlings Reduce Nitrates?" was read by title.

On Friday afternoon the Section met with Section D, Engineering, and the Society for the Promotion of Engineering Education.

On December 29, a joint symposium was held with Section E, Geology and Geography.

Officers for 1918 were elected by Section C, as follows:

Vice-President and Chairman: Alexander Smith, Columbia University.

Secretary: A. H. Blanchard, Massachusetts Institute of Technology.

Member of Section Committee: Benjamin F. Lovelace, Johns Hopkins University.

AMERICAN METRIC ASSOCIATION

The second meeting of the American Metric Association was held in Pittsburgh in conjunction with the meeting of the American Association for the Advancement of Science on December 28 and 29, 1917.

The sessions on the afternoon of the 28th and the morning of the 29th were held in conjunction with the Section on Social and Economic Science of the A. A. A. S. and at these sittings papers on standardization were read by J. W. McEachren of the Crane Company, Chicago, and by F. O. Wells of the Greenfield Tap & Die Co., Greenfield, Mass. In his paper, Mr. Wells pointed out that he employed 1700 hands and that he calculated that he would save $100,000 by the introduction of the metric system. Other papers were read by W. C. Wells, of the Pan-American Union, who discussed measures of volume in metric and other measurements, and by H. T. Wade who pointed out the importance of the metric system as a means of international standardization.

The session held on the afternoon of the 29th was presided over by Dr. John H. Brashear, of Pittsburgh, and was devoted to reports from President George F. Kunz, Secretary Howard Richards, Jr., and Treasurer A. P. Williams, showing the healthy condition of the association. Fred R. Drake read the report of the executive committee and outlined the activities of the association in the way of publicity and of coöperation with other national bodies. Dr. H. D. Hubbard, of the Bureau of Standards, gave an interesting address in which he pointed out some of the fallacies of anti-metric arguments.

In the evening there was held a metric dinner with a menu based on war-time conditions, the calorie value of each viand being expressed in exact units. At the close of the meal impromptu addresses were made, followed by an election of officers resulting as follows:

President: G. F. Kunz, of New York.

Vice Presidents: William Jay Scheffelin, of New York; E. P. Albrecht, of Philadelphia; and H. V. Arny, of New York.

Secretary: Howard Richards, Jr. of New York.

Treasurer: A. P. Williams, of New York.

ANNUAL MEETING TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, NEW YORK CITY FEBRUARY 5-7, 1918

The annual meeting of the Technical Association of the Pulp and Paper Industry will take place in New York City at the same time as the annual convention of the American Paper and Pulp Association, the Waldorf-Astoria Hotel being headquarters for both associations. The program will consist of a symposium on acid sulfite manufacture and a discussion of problems relating to engine sizing.

NEW YORK SECTION OF THE SOCIETE DE CHIMIE INDUSTRIELLE

Following the presentation of the Perkin Medal to Mr. A. J. Rossi on the evening of January 18th at the Chemists' Club in New York City, a New York Section of the Société de Chimie Industrielle was organized. The Secretary of the parent organization, Lieutenant René Engel, addressed the meeting in terms of grateful appreciation of the coöperation of the American chemists with those of France. He traced interestingly the origin of the new Society.

The following officers for the Section were then unanimously elected:

President, L. H. Baekeland; *Vice-Presidents,* Jerome Alexander; *Secretary,* C. A. Doremus; *Treasurer,* G. F. Kunz; *Executive Committee,* Charles Baskerville, H. Blum, M. T. Bogert, C. F. Chandler, Ellwood Hendrick, W. H. Nichols, R. E. Ortila, G. E. Valabrèque, E. P. V. Verge, Henri Enrique Viteaux.

The constitution and by-laws for the new Section were adopted and after felicitous remarks by Drs. Baekeland, Nichols and Baskerville, the meeting closed with a strong address by Prof. V. Grignard of the French Mission.

NOTES AND CORRESPONDENCE

TWO LETTERS ON THE CHEMICAL CONTROL OF AMMONIA OXIDATION

Editor of the Journal of Industrial and Engineering Chemistry:

In a paper on the "Analytical Control of the Ammonia Oxidation Process"[1] Messrs. Guy B. Taylor and Joseph D. Davis refer to the present writer's article[2] and a brief statement seems necessary by way of reply or further elucidation.

Taylor and Davis assert that the "statements of Schönbein, Weith and Weber are not to be taken to mean that ammonia is oxidized by hydrogen peroxide abundantly under all conditions." But there is nothing in our paper that says they are so to be taken. We said that hydrogen peroxide abundantly oxidizes ammonia—which is true. We did not say that it happened under all conditions. The course of this chemical reaction, and for that matter, all chemical reactions, is determined by the conditions of temperature, concentration, etc. This is a sort of Theorem I of chemical dynamics, and is presumed in any discussion. It may well be true that under the conditions of analysis as used by Taylor and Davis no such oxidation occurs; we should be the last to dispute it as we have no data to dispute it with. It does not appear to us, however, that the evidence brought forward to show absence of oxidation is sufficient to prove the case, under all conditions of analysis.

In the same paper the authors state (p. 1109) that "the reaction $2NO + O_2 = 2NO_2$ occurs in measurable time." That is, it requires a measurable time for the specified equilibrium to be reached. To prove this, they cite five journal articles, most of which are very long and full of data having no relevancy to the issue. They give, however, no particular references; in fact they might as well have cited the literature *en masse*. Let us see what the literature says. In the first paper cited,[3] on p. 2135, we find the statement: "these experiments show that two volumes of NO and one volume of oxygen of different origins (*i. e.*, made by different manufacturing processes) at atmospheric pressure are practically completely transformed into NO_2 and N_2O_4." On p. 2134 is given a curve of time against pressure decrease, which shows that the reaction practically runs its course in half a minute or less. Thus with only the theoretical amount of oxygen (which Holwech used) the reaction is practically complete in less time than would be required to go through our apparatus, but our method of course requires a decided excess of oxygen.

Perhaps the most important paper for the case on hand is that of Foerster and Blich,[4] and the issue amounts to this—when the mixture of air or oxygen and NO is run into a dilute caustic soda solution, does the reaction take place as follows?

$$2NO_2 + 2NaOH = NaNO_2 + NaNO_3 + H_2O$$

The answer is, that it all depends on Theorem I above, and there is nothing in the article bearing on our work because Foerster and Blich did not duplicate our conditions. However the results given in the table on p. 2019 "Versuchsreihe" Experiment 16 (where the gases are diluted) and in Experiment 42 on p. 2021 come as near as any in the paper to being comparable. In both instances the reaction runs practically as specified in the equation above. We do not base anything, however, on these statements from the literature. What is said in our paper was based on the fact that the amount of nitrite found in the first absorber was close enough to the reaction given to justify the calculation. The fact is, that so far from being in the sense of more nitrite as would be presumed from Taylor and Davis's supposition, there was invariably less, *i. e.*, more than half the acid was nitric. The writer thought there might be a little ozone in the oxygen but as the corrections involved were small, he did not think the point worth pursuing. Doubtless the amount of nitrite and nitrate are much influenced by the concentration of the alkaline solution into which they are led. In the writer's apparatus certainly all the NO yielded NO_2 and a little N_2O_5.

However, Taylor and Davis admit that by our procedure all the nitrous gases are absorbed, and all their contention would amount to, even if valid, would be that the formula would have to be modified. One does not adjust his testing to a mathematical formula, but calculates what he wants to know from the data he can get most conveniently and accurately.

Curiously enough, Taylor and Davis in their literature citations overlooked the only paper that could have been cited with any effect. We refer to that by Mandl and Russ[1] who found that with some kinds of oxygen (*e. g.*, that from electrolysis and also that from barium superoxide, bichromate and sulfuric acid, but not that from liquid air) the reaction between NO and O_2 did not go to completion.[2] The objection would apply of course to any methods requiring oxygen, including those of Taylor and Davis. However, we were fortunate enough not to get hold of any such oxygen. Mandl and Russ think that the differences in oxygen of different origin may explain the contradictory statements in the literature on the behavior of NO and oxygen.

Method I of Taylor and Davis amounts substantially to our method in that they have added oxygen to the gases before absorption, the difference being that they omit the precautions to prevent the oxidation of ammonia by the hydrogen peroxide. The main fact is that nitric oxide (NO) is not nearly completely absorbed by alkaline hydrogen peroxide. Sufficient oxygen must be present to convert it into $NO_2(N_2O_4)$. The writer proved this repeatedly, when nitric oxide would go through three absorbers, two of them filled with alkaline peroxide and beads, only to burst into brown fumes on coming into contact with the air. The essential features of our method are to insure by previous addition the presence of the necessary oxygen, and to avoid the oxidation of ammonia which takes place under not well-understood conditions. Now, Taylor and Davis have previously added the oxygen but there is no certainty that it would be enough; this difficulty is avoided by adding an additional dose in the large (1200 cc.) displacement vessel after the absorption is completed. This plan, while not specially appealing to us on account of the double titration and the necessity of getting the acid out of the large container, will doubtless get all the nitrous gases provided the mixture coming from the catalyzer contains enough oxygen already to oxidize practically all the NO to NO_2. In fact, with the saturators at 7 or 8 per cent ammonia (as mentioned in the article) we suspect that little or no oxygen would be necessary. Supposing, however, that the gases from the catalyzer contain all the combined nitrogen as NO, with little or no oxygen, then only limited absorption[3] will take place in K″, and, especially in a cool place, there would be ample opportunity in an hour for part of it to dissolve in the displacement water and get lost. We see then that the method is available only for a highly special manner of operating the catalyzer, and will be satisfactory only so long as there is sufficient excess of oxygen present. The writer was never able to get complete

[1] THIS JOURNAL, **9** (1917), 1106.

[2] *Ibid.*, **9** (1917), 737.

[3] Holwech, "Über die Reaktion zwischen Stickoxyd und Sauerstoff," *Z. angew. Chem.*, **21** (1908), 2131.

[4] *Z. angew. Chem.*, **23** (1910), 2017.

[1] *Z. angew. Chem.*, **21** (1908), 486.

[2] These results have not been confirmed by later workers, without, however, disproving them. Holwech, *Z. angew Chem.*, **21** (1908), 2131.

[3] Probably also irregular. See the reference to Schonbein in the writer's original paper.

absorption with only one absorber, but possibly the absorber K″ is better than his. The use of a manometer is not very convenient.

The same criticism applies to the evacuated bottle method as described. A sufficiency of oxygen is not assured, except under special conditions. Moreover, a pump capable of evacuating to 2 mm. is necessary as well as connections and capillary stopcocks so well ground that they will retain the vacuum mentioned. Fortunately a concession is made in the matter of ground glass connections. What all these mean, it is unnecessary to state. The statement that it is the only method permitting the determination of ammonia escaping oxidation presumably applies only to the procedures described in the paper, for it is perfectly feasible by our method. We are convinced that anyone trying the vacuum bottle method will find it exceedingly elaborate. Presumably the plan could be modified by adding a measured amount of oxygen first to the vacuum bottle, but it then becomes even more complicated. A larger bottle will also be required to cover all cases of gas mixture.

Messrs. Taylor and Davis present a method for eliminating titrations because "the principle involved offers possibilities for development of a rapid method of works control." The essential novelty of the principle however—the running of a gas into a definite volume of liquid stained by an indicator until the indicator turns—had been stated already by the present writer in the second and third paragraphs of his paper. They have added an elaborated glass apparatus which would impress us as being a great deal more troublesome than half a dozen titrations.

Finally, and this a crucial point, catalyzers do not work uniformly and the taking of a sample should extend over considerable time, in fact should be continuous. It seems to the present writer that his is the only process which has this advantage; it is also free from limitations on the composition of the gases. He hopes to publish shortly an account of an improved and more compact form of his apparatus, together with a new method of approximate factory control requiring less skill than any of the proposed methods.

1605 E. Capitol Street
Washington, D. C.
December 11, 1917

Paul J. Fox

Editor of the Journal of Industrial and Engineering Chemistry:

In reply to criticisms of Mr. Paul J. Fox, on our paper "Analytical Control of the Ammonia Oxidation Process."

In regard to the oxidation of ammonia by hydrogen peroxide in alkaline solutions, we are convinced that no such oxidation occurs in any method used by us and would not occur in the method proposed by Mr. Fox, even if hydrogen peroxide were contained in his first absorption vessel. No experimental evidence of such oxidation is presented by Mr. Fox, and certainly none in the reference quoted by him.[1] However, the question is relatively unimportant since little or no ammonia is allowed to pass the oxidizer in commercial operation.

In regard to the second point at issue, the completeness of the oxidation of NO to NO_2, the literature cited by us and confirmed by our own experiments shows that this reaction is not an instantaneous one and has a negative temperature coefficient. The latter is important. If the gas is not cooled to room temperature even with a large excess of oxygen, there is no assurance that the reaction will complete itself unless a large reaction space is provided before the gases enter the alkaline absorbing solution. The apparatus sketched by Mr. Fox shows that the only reaction space provided is the narrow tube conducting the gases to the bottom of the absorption vessel. Since the gases must be kept hot till they enter this tube to prevent moisture condensation, it appears likely to us that the reaction does not complete itself before the acid oxides are absorbed by the alkali. But if Mr. Fox obtained practically equal quantities of nitrate and nitrite in his absorbers from the *hot oxidizer gases*, we withdraw the objection in our original paper.

We quite agree that NO is not absorbed by alkali or alkali containing hydrogen peroxide. But a mixture of NO_2 and NO in any proportions such that NO does not exceed that of NO_2 is more readily absorbed by alkali than NO_2 alone.[1]

In our aspiration method a partial reaction of NO to NO_2 was all that was required. The use of oxygen was to clear absorption vessel K″ of air at the beginning of the test and of the oxidizer gases at the end of the test and *not* to assist in the absorption as assumed by Mr. Fox.

In our opinion no aspiration method is very satisfactory. We do not agree that it is desirable to draw continuous samples or samples over a period of time. In fact, to the authors' knowledge, a commercial plant using an aspiration method similar to that advocated by Mr. Fox, has recently discarded it in favor of the vacuum method which they have recommended. The vacuum bottle method has been in use over a year under all kinds of experimental conditions and in actual plant operation, where it has proved satisfactory. When high concentrations of ammonia are being oxidized it is necessary to introduce a little pure oxygen after taking the sample, but it is not necessary to measure it and is no trouble whatever. One man with a little experience can make a complete efficiency test including calculation of results in half an hour if determination of the free ammonia escaping oxidation be neglected.

Bureau of Mines
Washington, D. C.
January 3, 1918

Guy B. Taylor
J. D. Davis

AVOIDABLE WASTE IN THE PRODUCTION OF SULFURIC ACID BY THE CHAMBER PROCESS

Editor of the Journal of Industrial and Engineering Chemistry:

In connection with the subject of the increased production of sulfuric acid called for on account of explosives requirements, it is interesting to consider one phase which seems to have escaped general observation. In the United States we make some four million tons of acid by the chamber process each year. Very few chamber plants are run on a scientific basis; in fact, most of them operate by rule of thumb, this being particularly true of the acid plants attached to fertilizer factories. While there has never been a survey made of the average operating conditions in the chamber plant acid industry, I am reasonably sure from the data I have gathered during the past five years that the average chamber plant space obtained by combining all the plants in the country would be of the order of 13 cu. ft. per pound of sulfur burned. With proper analytical control of the gases, and with exact control of the volume and temperature of the acid circulated over the towers there is no reason why the chamber space used should not be cut down to 11 ft. per pound of sulfur burned per 24 hours. Suppose, however, the average improvement is no more than a reduction to 12 cu. ft., we would have an increased output, *without the construction of additional plant*, of some 300,000 tons of 50° Bé. sulfuric acid per year.

A questionnaire sent to the acid manufacturers covering chamber acid output and chamber space per pound of sulfur, would soon show the possibilities of increasing our acid production in the way I have indicated, but, of course, such a query to result in answers of real value would have to be sent out by some department of the Government.

A. E. Marshall
Chemical Engineer

Baltimore, Md.
January 4, 1918

[1] *Ber.*, **7**, p. 1745.

[1] Foerster and Blich, *Z. angew. Chem.*, **23** (1910), 2017–25.

BROMINE PROCESS DECISION

According to the *Oil, Paint and Drug Reporter* for December 24, 1917, the case of the Dow Chemical Company *vs.* the American Bromine Company and Arthur E. Schaefer, which has been heard in both Midland and Wayne counties, Michigan, and which was transferred to the Detroit district last June, has been decided in favor of the plaintiff, the Dow Chemical Company, by Circuit Judge Kelly S. Searl.

This case was probably the most striking of recent suits in the chemical industry based upon alleged disclosure of secret processes by former employees, and also involving the ownership of patents covering processes

The plaintiff, the Dow Chemical Company, asked a perma nent injunction restraining the defendants from making use of certain trade secrets, claimed to be the exclusive property of the Dow Company and unfairly obtained from certain of its employees and also asked that a certain patent be transferred to the Dow Company, since through contract with the defendant Schaefer the property right in the patent was held to belong to the Dow Company.

The taking of the testimony has consumed weeks, and in addition to models, marks and charts, the ordinary exhibits numbered several hundred and several thousand pages of testimony were taken.

JUSTICE SEARL'S FINDINGS

The patent and the processes in dispute had to do with the manufacture of bromine and bromides from brine by means of an electrolytic cell and by other combined methods held in strict secrecy by the Dow Company and, according to the ruling of Justice Searl, used and copied by the American Bromine Company in its plant. Justice Searl, in his opinion filed on December 14, 1917, said in conclusion:

"The parties who subsequently incorporated under the name of the American Bromine Company had apparently never heard of the Kossuth cell. They did not undertake to build such a cell for their plant, but instead they copied the Dow cell and are now using one so near like as to require that they be restrained from using the same longer. The fact that a patent had been taken out years ago in Germany for this Kossuth cell is of very little importance in this case, and the same may be said of the other German and American patents. The existence of the majority of these patents was unknown to the defendants until after the commencement of this suit. They did not secure the right to use them nor to build up their business in reliance upon disclosures from them which the public by reason of the expiration of the patents were entitled to use

"On the contrary they set out, as admitted by them, to build a plant as near like the Dow plant as possible and not infringe the Dow patents. Whether they have infringed any of the Dow patents is not a question to be decided in this case. * * * but they did succeed in building and equipping a plant in all essential respects like the Dow plant at a time when the plaintiff was operating the only plant of that kind in this country—or anywhere for that matter.

"Plaintiff, having by reason of the inventions of Dow and others kept its processes secret and built up an extensive and thriving business, is now entitled to the relief prayed for in the bill filed in this cause.

"A decree may be entered accordingly, including a clause requiring defendant Schaefer to assign his said patent to the plaintiff. And inasmuch as the American Bromine Company have under their contract with Schaefer an interest in said patent, such defendant will also be required to relinquish the same.

"The court will not at this time undertake to state the exact terms of the decree, as counsel are better prepared than the court to frame and agree upon the terms thereof. Each party may propose a decree, and if the same cannot be agreed upon or settled by the court without doing so, a day will be set apart for hearing counsel on both sides upon the settlement thereof. Plaintiff will recover costs to be taxed as against the defendant."

COMPLAINT AS FILED

The bill of complaint set forth: That Herbert H. Dow, of Midland, Mich., discovered the presence of bromine in certain brine from natural gas wells, and that after investigations in 1888 and 1889 he discovered a new process by which the bromine was extracted by blowing air through the brine and then recovered by bringing in contact with certain chemicals, resulting in the formation of desired bromides; that during 1889 he manufactured bromide of iron by this process; that on October 28, 1889, he applied for a patent issued September 29, 1891 (No. 460,370), and reissued April 12, 1892 (No. 12,232), and that he began the construction of a plant in Midland, Mich., in August, 1890. That subsequent investigations resulted in the development of an electrolytic process, and that all processes were conveyed to the Midland Chemical Company and kept secret, the works enclosed with a barrier, and specially guarded to prevent the details from becoming public, the manufacture of bromides being carried on in a separate building, also guarded. That the two bromide plants of the plaintiff have a present capacity of 1,500,000 lbs. a year.

That on July 9, 1904, plaintiff employed Arthur E. Schaefer, one of the defendants, as a chemist in its laboratory; that later Schaefer had charge of the plaintiff's bromide plant and its manufacture of bromides and the processes used, and that he continued in that capacity until September 15, 1905; that about February 1, 1908, he returned to the employ of the Dow Company and became the superintendent of the bromide plant and continued in that capacity till July 1, 1910; that the Emerson Drug Company, of Baltimore, and the Dr. Miles Medical Company, of Elkhart, Ind., through their principal stockholders or stockholding interests undertook the organization of the American Bromine Company on December 1, 1915, and bought lands and erected a plant at Midland; that the plaintiff was advised and believes a complete apparatus for the manufacture of bromide identical with that used by the Dow Company and including all the Dow secret devices and apparatus was erected; that to acquire the knowledge of the processes the defendant employed Julius Burow, A. M. Douglas, former employees of the Dow Company, and sought to employ James C. Graves, formerly general superintendent for Dow, but he refused; that afterwards Arthur E. Schaefer was employed by the American Bromine Company as consulting engineer and expert adviser; that while Schaefer left the employ of the Dow Company July 1, 1910, he was continued on the payroll for three months under special agreement; that Schaefer obtained a patent, No. 1,085,944, on a method for the recovery of bromine by the aid and for the use of a solution of ferrous bromide therein, claiming he was the inventor and that the process was in use in the Dow plant at the time Schaefer was employed there.

ANSWER TO COMPLAINT

The American Bromine Company in answer to the bill of complaint filed affidavits to the effect that although it had employed a Dow employee, one Douglas, and he had collaborated on the erection of a cell, the cell was not successful, and that another cell was developed and also a process differing in essentials from the Dow process. An improvement on the Dow process of purifying the bromide brine as it passed through the electrolytic cells was especially commented upon. The defendant denied any intention to appropriate any secret of the Dow process, and denied any effort or steps to do this.

The suit was to compel the disclosure of sums paid by the American Bromine Company or any other person for right to use patent 1,085,944, the assignment of the patent by Schaefer, and perpetual injunction against the use of processes of Dow, or the employment of any of the former or present Dow employees or of disposing of the patent to anyone else, together with an accounting, and that the existing devices and apparatus in the American Bromine plant be ordered destroyed, together with payment to the Dow Company of all sums found due them in accounting as assessed by the court.

OPINION OF JUSTICE SEARL

The court traced the steps taken by Dow in perfecting an improved process of recovering bromine, in place of the old boiling-out process used previously, instancing the use of electricity and

the blowing-out process more fully developed later, and both of which have been in use by the Midland Chemical Company and Dow Chemical Company practically continuously since 1892. The Dow Company had practically no competition in America, and although German manufacturers were shipping some bromine to the United States, these shipments ceased at the outbreak of the European war.

Justice Searl then proceeded: That the Emerson Drug Company and the Dr. Miles Medical Company had purchased bromides in considerable quantities, the former company as high as 100,000 pounds a year on contract. With the increased price demanded a controversy arose, the purchasing concerns alleging that the Dow Company was charging an exorbitant price because having a practical monopoly. In 1915 the Emerson Company considered the advisability of engaging in the manufacture of bromide, and learned of Douglas and of the fact that the Meyer Brothers plant at Midland was for sale. A copartnership was formed by the Emerson Drug Company and the Dr. Miles Medical Company and the American Bromine Company was incorporated under the laws of Michigan in December, 1915, with the Emerson Company holding 60 per cent and the Miles Company 40 per cent of the Bromine Company stock.

The court then reviewed the correspondence between Douglas and the Emerson Drug Company, the discussion of the process to be used and the fact that Dow was using an electrolytic process. After all the correspondence and conferences "in which the founders of the American Bromine Company were practically informed in so many words that the Dow Company were operating under secret processes in addition to its patented processes, Douglas was employed and set to work to build a plant to make bromines and bromides, not by the use of bittern waters as he recommended, but by the electrolytic process."

"The officials of the Emerson Drug Company," asserts the court, "must have had full notice and knowledge that it was proposed to duplicate the plant of the Dow Company in all its essential details, except possibly where it might conflict with the patents held by the Dow Company." Later, Schaefer was employed to take the place of Douglas.

The court also says: "I find that except in some minor details the plant of the American Bromine Company is in its essential characteristics a duplicate of portions of the plant of the Dow Chemical Company and that in the manufacture of bromine and bromides from raw brine the American Bromine Company are now using the same processes as were used by the Dow Company at the time Douglas and Schaefer were employed by the latter company."

UNITED STATES TARIFF COMMISSION INQUIRY IN REGARD TO CHEMICAL INDUSTRIES

The Tariff Commission is undertaking an inquiry into the significant developments that have taken place in the chemical industries since the passage of the tariff act of 1913. Changes which seem likely to alter permanently the conditions of international competition or the course or volume of foreign trade are to be special subjects of study.

All persons having direct knowledge of pertinent facts in regard to any particular industry or product are invited to submit a statement of the Tariff Commission. Among the matters on which the Commission desires as full and complete information as possible are:

1. The manufacture within the United States of articles formerly unavailable or obtained exclusively by importation, for example, phosgene.

2. In the case of industries previously established in the United States, the erection of new plants or increase in capacity of existing plants; for example, the increase in capacity of existing plants for making caustic soda and chlorine and the installation of such plants at textile and paper mills.

3. The future of industries or establishments newly created, or in which productive capacity has been greatly increased to meet a direct war demand. How can these plants be utilized when the war demand disappears? For example, the acetone industry.

4. Any general or significant differences in the prevailing method of manufacture in the United States and abroad, such as the relatively small use of the carbureted water-gas process in England compared to the process in the United States.

5. Differences in the organization of the industry in the United States and abroad.

6. The development or invention in the United States or abroad of new or improved processes which are likely to influence the conditions of international competition; for example, the hydrogenation of fatty oils or the flotation process for concentrating ores.

7. Significant changes in the conditions of international competition caused by the recent law-making patents owned by citizens of enemy countries available to American manufacturers; for example, the patents on salvarsan.

8. Industries which have been seriously hampered in their normal operations or in their development by difficulty in securing materials or supplies formerly imported; for example, the lack of potash for fertilizer or glass. If these difficulties have been met by the introduction of substitutes, it is expected that there will be a return to the old materials and methods when foreign supplies again become available, or will the changes be permanent?

9. Developments or changes in other industries which have created a new or greatly increased demand for chemical products; for example, the manufacture of new varieties of glass in the United States.

10. The discovery of new uses of materials, creating a new demand or furnishing a market for materials formerly wasted; for example, the use of aniline as an accelerator in the vulcanization of rubber.

11. Any governmental hindrances in the United States or abroad, either in manufacture or commerce; such as the export duty on nitrate from Chile.

The Commission will publish only general statements or summaries, which will not reveal the operation or plans of individual companies.

SPECIAL CHEMICALS AND APPARATUS AVAILABLE THROUGH THE CHEMISTRY COMMITTEE OF THE NATIONAL RESEARCH COUNCIL

The Chemistry Committee of the National Research Council will endeavor to locate for our chemical investigators chemicals and apparatus *where the need is definite and urgent, and where the article required is not obtainable in the open market.* Inquiries for chemicals should be addressed to Prof. Roger Adams, University of Illinois, Urbana, Ill., who has already published lists of certain of the products which are obtainable through his office. Requests for aid in locating apparatus should go to Mr. A. H. Thomas, W. Washington Square, Philadelphia, the Chairman of our Sub-Committee on Chemical Apparatus.

As these gentlemen are carrying out this work as a patriotic service for the welfare and security of our country and without any remuneration for the labor involved, it is requested that investigators in need of such supplies make sure that the material required is not available through the ordinary commercial channels before turning to these colleagues for aid, as the burden of correspondence is already heavy. When the desired material is located, the inquirer will be put in direct communication with the owner, so that a loan or sale may be arranged. It will assist these gentlemen in their labors if chemists and physicists having special or unusual chemicals or apparatus available for loan or sale will forward full details concerning the same.

WASHINGTON, D. C. MARSTON TAYLOR BOGERT
January 14, 1918

AS TO PLATINUM

Editor of the Journal of Industrial and Engineering Chemistry:

Much has been written of late, and more said, regarding the use of platinum in jewelry, and it has been broadly intimated that the jewelers are not living up to their agreement of last April with the Government. It is worth while to repeat the terms of this pledge of the Jewelers' Vigilance Committee.

"We pledge ourselves to discontinue and strongly recommend to all manufacturing and retail jewelers of the United States that they in a truly patriotic spirit discourage the manufacture, sale and use of platinum in all bulky and heavy pieces of jewelry.

"During the period of the war, or until the present supplies of platinum shall be materially augmented, we pledge ourselves to discontinue and recommend that the jewelry trade discourage the use of all non-essential platinum findings or parts of jewelry, such as scarfpin stems, pin tongues, joints, catches, swivels, spring rings, ear backs, etc., where gold would satisfactorily serve.

"Be it further resolved that the jewelry trade encourage by all means in its power, the use of gold in combination with platinum, wherever proper artistic results may be obtained."

Having been in close touch with the platinum situation I desire to state from personal knowledge my belief that the jewelers have fully lived up to their pledges and in many cases gone beyond them in efforts to conserve platinum.

It was the manufacturing jewelers who entered into this agreement, and it is not surprising that some retailers have been making great efforts to work off their stock on hand, and have thereby opened themselves to criticism.

Whether a metal, so limited in supply and so invaluable in scientific industry, ought to be used at all in jewelry is a fair question, but it is not the question in point. A large and legitimate platinum jewelry industry has sprung up in recent years, and the question is whether the exigencies of the present platinum situation demand the immediate wrecking of this industry by having the Government commandeer all platinum; personally, I do not believe that at present they do.

I hold no brief for the jewelers, but I think this statement should be made in fairness to them; and I may add that it is my conviction, that, should the Government be placed in straights from lack of platinum for the manufacture of war material, the jewelry trade can be relied on to find a way of furnishing all that is needed.

Jas. Lewis Howe
Special Committee on Platinum,
Chemistry Committee of the National
Research Council

Washington and Lee University
Lexington, Virginia

PLATINUM RESOLUTIONS

At the recent Pittsburgh meeting of Section C (Chemistry) of the American Association for the Advancement of Science, the following resolution was unanimously passed:

Whereas (1) The Government of the United States has purchased from Russia and safely brought to the United States twenty-one thousand (21,000) ounces of platinum, the largest amount that has ever been shipped to this country;

(2) The separation of so great an amount of platinum will offer scientific investigators an opportunity to study the chemical combinations and mineralogical associations of the platinum group of minerals,

Therefore it is *Resolved* (1) That Section C, the Section on Chemistry of the American Association for the Advancement of Science, respectfully *request* that the War Industries Board, the Bureau of Standards, the Bureau of Mines, the American Chemical Society, and others who are interested in chemistry, be offered the opportunity by the United States Government to coöperate with it in the separation of the platinum group of minerals of the above-mentioned material, and that the residue, of which there may be thousands of ounces, be loaned to such scientific investigators who can undoubtedly obtain interesting scientific results, and

(2) If necessary, that one platinum works be commandeered, with proper compensation, for a certain length of time so that the work of separation can be carried on with the greatest care and observation, and

(3) That as much as possible of this platinum be loaned to those who have need of platinum for chemical investigation, the platinum to belong to the Government of the United States and subject to the call of the Government when needed for raw or industrial purposes. As the expense of making crucibles or other utensils is small in comparison to the value of the platinum, this would offer a most unique opportunity to the chemists of the country.

To present this matter to the proper authorities a committee was appointed consisting of Dr. W. A. Noyes, *Chairman*, and Dr. W. F. Hillebrand.

New York City
January 5, 1918

George F. Kunz

FUEL FOR MANUFACTURE OF CHEMICALS

Editor of the Journal of Industrial and Engineering Chemistry:

In view of the shortage in fuel supply and the great demand for large supplies of cheap fuel for the manufacture of chemicals and other products necessary for the war and agricultural purposes, I am bringing to your attention our unusual supply of natural gas at Shreveport, which is available to large industrial consumers on a basis that makes it cheaper than water power or that derived from the use of coal.

There is now available at Shreveport about one billion cubic feet of gas daily, and on the basis of scientific estimate the content of the Shreveport field is two trillion cubic feet, and a very small amount of this gas is now being utilized. This estimate includes only the field as already defined and does not consider other fields which are being opened up near by in drilling for oil. A prominent geologist has recently stated that the Shreveport field has the largest supply of natural gas to be found in the United States.

In addition to our gas supply, we have an abundance of raw materials that are needed for war industries at this time. There is close at hand an abundance of iron, petroleum, lignite, limestone, sulfur, and salt, and generous supplies of asphalt, gypsum, kaolin, sand, gravel, clay, etc. It ought to be especially noted at this time that Louisiana has the largest deposits of sulfur and salt to be found in the United States.

Shreveport, Louisiana
November 21, 1917

Ellis Smith

A STUDY OF THE ESTIMATION OF FAT IN CONDENSED MILK, ETC.—CORRECTION

In our article printed under the above title [This Journal, 9 (1917), 1111] the following changes should be made:

Page 1113, 1st col., line 18—"0.4" should read "0.04;" Table V, 3rd col., No. 8—"2.5005" should read "2.0505."

C. H. Biesterfeld and O. L. Evenson

COMPOSITION OF LOGANBERRY JUICE AND PULP—CORRECTION

In the article under the above title [This Journal, 9 (1917), 1043] note the following rearrangement of 5th line, Table I:

		I	II	III
Per cent Ash	Alkalinity	0.4139	0.5785	0.4226
	K_2CO_3	0.4130	0.5075	0.288

should read:

Per cent Ash	0.4139	0.5785	0.4226
Alkalinity (as K_2CO_3)	0.4130	0.5075	0.288

M. R. Daughters

CHEMISTS AND THE DRAFT

Editor of the Journal of Industrial and Engineering Chemistry:

The information contained in the editorial in the January number of the JOURNAL under the caption "The Chemical Service Section of the National Army" must indeed be gratifying to the members of the Society in that chemistry is now accorded, for the first time, a definite and official place in the organization of the War Department's activities.

Naturally, the organization of such a new branch of service must be at present in its infancy, and subject to such alteration and revision as experience may indicate. At the same time there comes up in the mind of the writer the question—and the same question must present itself to many others—of what will be the status of drafted chemists who may be assigned to this service; that is, whether a drafted chemist will be given the same rank as he might have been given had he sought a commission instead of waiting to be drafted.

Any distinction between the rank assigned a volunteer chemist and a drafted chemist of the same training, who does the same type of work, must be an artificial one. Many chemists have been deterred from seeking commissions by considerations such as were expressed in Dr. Parsons' recent circular letter to the members of the Society; they have had to face the dilemma presented, on the one hand, by the impulse to volunteer their services for work bearing immediately on the prosecution of the war, and, on the other hand, by the obvious desirability of a continuation in their usual work, which, though it did not deal with explosives or poison gases or gun-metal, was yet a necessary contribution to the public welfare.

Is the drafted chemist to be given the rank of private, irrespective of what rank his training might reasonably be expected to entitle him to, merely because he has waited for the draft, the selective principle of which may be expected to utilize his ability most efficiently? The question might appear premature, if not foolish, were it not for the fact that some chemists called in the first draft have been put on chemical research in the capacity of privates. One inevitably draws a comparison to the conditions obtaining with regard to physicians. To the writer's knowledge, physicians drawn in the first draft have been commissioned when they were assigned to medical work. There can be no essential difference between the two cases. To be sure, the term "chemist" (covering as it does everything from a routine analyst to a trained researcher) is a much more flexible one than the term "physician," which in general represents a more uniform, though not always more intensive, degree of training. Yet it seems almost too obvious to say that the Ph. D. (or in many cases a lower degree) in chemistry, with some years of experience in the practice of the profession, represents as high a degree of training as does the M.D., often without any experience to back it up. The raw M.D. has been getting and does get a commission, if he is a capable graduate of a reputable school. May not the chemist expect equal consideration of the value of his services?

The writer believes that some statement on these matters, derived either from information the Editor may have or from additional information from the War Department, would be welcome and illuminating to many readers of THIS JOURNAL.

EDWIN C. WHITE

JAMES BUCHANAN BRADY UROLOGICAL INSTITUTE
BALTIMORE, MD., January 16, 1918

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

The outstanding feature of the month in Washington was the "workless day" order of Dr. H. A. Garfield, the fuel administrator. Many manufacturers of chemicals joined in the protests against the order which descended almost in the volume of an avalanche upon official Washington. Owing to the shortage in most chemicals, reasons were presented why many manufacturers of chemicals should be included in the exemption list. At the time this is written, however, J. T. Lewis Bros. Co., Lafayette Building, Philadelphia, manufacturers of chrome green, C. W. H. Carter, 8 Ferry St., New York, manufacturers of linseed oil, and all manufacturers of optical glass, are the only chemical industries which have been granted exemption. Numerous others were under consideration, however, and it is anticipated that various manufacturing chemists will be added to the exemption list.

During the past two months, decided increases have been attained in the manufacture of many much-needed chemicals. In fact, the achievements in this direction have been so decided that much of the uncertainty expressed as late as two months ago has been dispelled.

Greatest concern just at this time is centered on sulfuric acid, arsenic and ammonia, but the situation in each of these cases has been relieved measurably. Many of the uncertainties, which entered into estimates of the requirements of sulfuric acid for 1918, have been removed, showing that many of the estimates were too high. In addition, it has been possible to increase the productive capacity of existing plants and it has been found that considerable restriction in the use of acid can be practiced without the serious unsettling of the industries affected. These conditions combine to make the immediate situation less serious, while the activities of the War Industries Board looking to the construction of new plants give reassurance for the future. In this latter work, M. F. Chase is prominent. His new duties made it necessary for him to relinquish his work with the chemical division of the Committee on Raw Materials. A. E. Wells, the superintendent of the Salt Lake City experiment station of the Bureau of Mines, has been assigned temporarily to the War Industries Board to look after the work on acids which heretofore has been handled by Mr. Chase. Mr. Wells has been specializing on sulfuric acid for some time and has just completed a personal visit to practically every acid-producing plant in the country.

Special steps have been taken by the Fuel Administration to insure a supply of coal for the sulfuric acid plants. In order that this may be done intelligently, each manufacturer of sulfuric acid has been asked to report the amount of coal on hand, his monthly requirements and the name of the company supplying the plant with coal.

Commendation for Charles W. Merrill has been forthcoming from all concerned in the arsenic industry as a result of the arrangements which he brought about with regard to the regulation of profits and the restriction of use so as to insure ample supplies for noxious gas manufacture and for insecticides.

The licensing system has been extended to all those engaged in importing, manufacturing, storing or distributing ammonia, ammoniacal liquor or ammonium sulfate. The enforcement of the regulations which have been drawn up to cover this trade will be in the hands of an interdepartmental committee headed by Mr. Merrill. The other members of the committee, each of whom is identified, directly or indirectly, with chemical industry, are M. L. Wilkinson and Carl L. Alsberg, Department of Agriculture; Maj. Backus, Bureau of Ordnance; Lieut.-Col. W. H. Walker, Chemical Service Section of the National Army; Maj. M. J. Whitson, Cantonment Division, Quartermaster Corps; Admiral Ralph Earl, Navy Department; Maj. J. T. Crabbs, Interior Department, and L. L. Summers, Council of National Defense.

In the campaign for the conservation of ammonia, a propaganda is being carried on looking to the harvesting of as much natural ice as is possible.

A price of $75.50 per ton has been placed on the Government's supply of nitrate of soda. Approximately 100,000 tons of nitrates were purchased by the Government in Chile and have been transported to several American ports. It is to be sold directly to farmers, who must agree not to re-sell and to use it on their own farms.

Exports of chemicals during the first eleven months of 1917 reached the unusual value of $171,942,221. This is more than

$20,000,000 greater than the value of chemical exports during the corresponding period of 1916. During November, 1917, chemical exports totaled $15,428,809 in value. This was slightly under exports in November of 1916, when they amounted to $17,153,625. Sulfuric acid in November, 1917, amounted to 3,823,898 pounds, as compared with 2,975,602 pounds in November of 1916. For the first eleven months of 1917, exports of sulfuric acid amounted to 57,311,684 pounds, or approximately the same amount exported during the corresponding period of 1916 when exports were 60,361,638 pounds. The more striking increases in exports were in acetate of lime, calcium carbide and glycerine. Increased amounts of chemicals were sent to France, Italy, Spain, United Kingdom, Brazil and Japan. Decreased amounts were sent to Russia, Mexico and Canada.

In order to prevent undue inconvenience to the public and to avoid the handling of large numbers of licenses, a very general rule is being adopted by the Government agency issuing licenses to exclude druggists, wholesalers and dealers handling only secondary products. Persons using prime products solely as ingredients in the manufacture of products not subject to license also are being excluded.

The Bureau of Standards is taking up a study of methods of analysis for molybdenum, tungsten and metallic products derived from them. Samples are being prepared which will be sent out to be analyzed by a number of experts. Thus conclusions will be reached as to the adequacy of the comparative values of metals employed by various analysts. Out of these returns, it is expected to show just where methods should be improved.

The absence of opposition to the Garabed invention was emphasized, when, in the midst of a busy day, no one in the Senate objected when unanimous consent was asked by Senator James for its consideration. The bill had been reported favorably by the committee on patents and was passed without opposition or discussion. The Senate Committee made a few corrections in the phraseology but did not alter the salient features of the measure, which had passed the House. It is believed now that the President will sign the bill. This will put the matter directly up to Franklin K. Lane, the Secretary of the Interior.

While there was some decrease in the amount of iron pyrites imported in 1917, as compared with that brought in in 1916, the general policy with regard to imports remained unchanged. Manganese imports in 1917 were somewhat in excess of those of the year preceding. The shipping question has grown more acute, but still there is no organized effort to promote domestic production of these two important war minerals. In order to meet this situation, it has been found necessary to attempt to secure legislation. As a result, the War Minerals Committee drafted a bill which would place in the hands of the President, for the handling of minerals, the same wide powers with which he already has been vested for the control of food. The bill has been considered by the House Committee on Mines and Mining. Some amendments have been made, but the bill, with its main features, which follow almost exactly those of the Lever Act, is on the point of being introduced by Representative Foster, the chairman of the House Committee on Mines and Mining.

PERSONAL NOTES

Assistant Professor Reston Stevenson, in charge of physical chemistry in the department of chemistry in the College of the City of New York, has been appointed Captain in the Sanitary Corps of the Medical Department of the National Army, and is at present in France.

Mr. Howard Adler, assistant tutor in physical chemistry in the department of chemistry in the College of the City of New York, was detailed to duty in Camp Upton, Yaphank, and subsequently placed in the chemical service of the army.

Mr. Arthur Davidson, assistant tutor in the department of chemistry in the College of the City of New York, has been appointed in the chemical branch of the United States Army.

Dr. Ernest E. Smith, of New York City, has been elected president of the New York Academy of Sciences.

Professor Frederick G. Keyes, of the Massachusetts Institute of Technology, who has been commissioned Captain in the chemical section, has been granted leave of absence and expects to go abroad soon. Dr. Duncan MacInnes, now research associate in physical chemistry, has been appointed to serve in place of Dr. Keyes.

The main laboratory of the United States Fisheries Biological Station at Fairport, Iowa, was destroyed by fire on December 20. The station is the center of most of the scientific work of the Bureau of Fisheries in the Mississippi Basin.

Professor Wilder D. Bancroft, of the department of chemistry of Cornell University, is serving as technical adviser in the U. S. Bureau of Mines, Washington, D. C.

On January 12, 1918, Professor H. C. Sherman, of the department of chemistry of Columbia University, lectured before the Harvey Society at the New York Academy of Medicine on "Food Chemistry in the Service of Human Nutrition."

Dr. R. L. Kahn, pathological chemist of the Montefiore Home and Hospital, New York City, has been commissioned First Lieutenant in the Sanitary Corps, stationed at the Department Laboratory, Southeastern Department, Atlanta, Ga.

Dr. Chas. E. Vanderkleed, formerly director of the chemical laboratories of the H. K. Mulford Company, is now engaged in the manufacture of synthetic chemicals. He is vice president of the Markleed Chemical Corporation, New York and Camden.

Dr. Joseph Price Remington, Dean of the Philadelphia College of Pharmacy since 1893, died on New Year's Day.

Dr. Charles T. P. Fennel, for fifteen years state chemist in Ohio and later professor of chemistry in the Cincinnati College of Pharmacy, has been appointed to the chair of materia medica at the University of Cincinnati, to fill the vacancy created by the death of Dr. Julius Eichberg.

Professor Arthur W. Browne, of the department of chemistry of Cornell University, has been appointed chemical expert of the Ordnance Department. He will continue his work at Cornell University.

A General Science Hall, erected at a cost of $60,000, is under construction at Defiance College, Defiance, Ohio. It is expected that it will be completed next July.

Mr. C. L. Brickman was recently appointed chief chemist by the Rex-Hide Rubber Manufacturing Company, East Brady, Pa. He was formerly in the research laboratories of the United States Rubber Company. He is a graduate of Defiance College and the department of chemical engineering of the Case School of Applied Science.

The Lenz Apparatus Company, New York City, announces that Dr. W. J. Lenz is no longer connected with or in any way interested in that company.

Dr. F. E. Carruth, formerly of the Chemical Division of the North Carolina Experiment Station, is now with the Schaefer Alkaloid Works, Maywood, N. J.

The Hon. Sir Charles Parsons, K.C.B., F.R.S., member of the Council of the Institute of Metals (London), is to give the 8th Annual May Lecture before the Institute this spring. The lecturer will speak on the subject of the formation of diamonds.

Dr. E. P. Wightman, research chemist of Parke, Davis & Co., of Detroit, Michigan, and Windsor, Ontario, has enlisted as a chemist in the Gas and Flame Division of the Thirtieth Engineers of the U. S. A.

Mr. Charles S. Purcell, formerly of the Bureau of Mines, Pittsburgh, Pa., has been transferred to the Boston Station of the Bureau of Chemistry.

Professor Charles H. LaWall delivered, on January 17, an illustrated lecture on "Some New and Interesting Vegetable Foods," at the Wagner Free Institute of Science, Philadelphia.

A society for the furtherance of chemical knowledge and current scientific data has been organized by the technical chemists and chemical engineers of Tacoma, Washington. The president is Paul Van Horst and the secretary, B. H. Bennetts.

The work of the National Research Council has expanded so rapidly that it has outgrown the space available in the Munsey Building, and therefore the Council has rented the entire building at the corner of 16th and L Streets, N. W., Washington, D. C., occupied until recently by the Fuel Administration. The office of the Chemistry Committee will be in Room 24, second floor front.

Dr. H. P. Corliss, former fellow in the Mellon Institute of Industrial Research, Pittsburgh, Pa., is now with the Metals Recovery Co. as research chemist and metallurgist, with headquarters at the General Engineering Co., Salt Lake City, Utah.

Mr. Samuel Ginsburg has resigned from the Drug Laboratory of the New York Station of the United States Bureau of Chemistry to accept a position as chemist in charge of laboratory with the National Gum & Mica Co. of New York City.

Mr. Roy Richard Denslow, assistant tutor in the department of chemistry, College of the City of New York, has been appointed instructor in Smith College.

Miss Grace MacLeod has accepted the position of Assistant Editor of THIS JOURNAL. Miss MacLeod holds the degree of S.B. from the Massachusetts Institute of Technology and of M.A. from Columbia University, and for the past seven years has been instructor in chemistry at Pratt Institute, Brooklyn, N. Y.

In spite of adverse industrial conditions brought about by the war and severe weather conditions which interfered greatly with traveling facilities, the Short Course in Ceramic Engineering is entering upon the second week of its session with a registration of twenty-one men coming from ten different states and representing eight different branches of the ceramic industries, including the manufacture of brick, sewer pipe, drain tile, glass, grinding wheels, terra cotta, and also including representatives in geological surveys and the general engineering firms.

Mr. Robert J. Anderson has resigned as chief chemist and metallurgist of the Cleveland Metal Products Company, Cleveland, Ohio, to take effect February 1, 1918.

Dr. Julius Stieglitz has been elected president of the Institute of Medicine of Chicago.

Mr. W. J. Suer has accepted a position as chemist with the Ault and Wiborg Company of Cincinnati.

The committee on the analysis of commercial fats and oils of the Division of Industrial Chemists and Chemical Engineers of the A. C. S. now consists of W. J. Gascoyne, H. J. Morrison, J. R. Powell, R. J. Quinn, W. D. Richardson, Paul Rudnick, L. M. Tolman and J. J. Vallertsen.

The Powdered Coal and Engineering Company, Chicago, Ill., announce the addition to their engineering staff of Mr. Alex L. Feild, formerly of the Pittsburgh Experiment Station of the Bureau of Mines, and Mr. A. R. Detweiler, formerly with the Tribullion Mining, Smelting and Development Company, at Kelly, New Mexico, from which company he resigned with the purpose of undertaking private investigations with a view to inventing a process of recovering clay and slag from used retorts.

Mr. Benedict Crowell, of the firm of Crowell and Murray, chemists, Cleveland, has been appointed Assistant Secretary of War with the rank of Major in the Engineer Reserve Corps. He has done a great deal of ore analysis work for firms manufacturing and selling Lake Superior ores, and with Mr. Murray he is joint author of "The Iron Ores of Lake Superior." Major Crowell was born in Cleveland in 1869 and was graduated from Yale in 1891. On the completion of his college course he became chemist for the Otis Steel Company of Cleveland. He left that company to engage in business for himself as a chemist and later also took up mining engineering in connection with his other work.

The fifth convention of the National Foreign Trade Council will be held at the Gibson Hotel, Cincinnati, on February 7, 8 and 9, 1918.

Mr. Victor Yngve has been engaged as research chemist by the Oldbury Electrochemical Company of Niagara Falls, N. Y., and will have charge of their research laboratory.

Professor Wilder D. Bancroft, of Cornell University, lectured before the District of Columbia Chapter of the Sigma Xi, December 20, on "Colloid Chemistry."

Mr. H. A. Baker, chief chemist of the American Can Company, has gone to Washington to act on the committee on conservation of tin plate.

Dr. K. L. Mark, head of the chemistry department and of the School of General Science at Simmons College, Boston, has been granted a leave of absence for the duration of the war to accept a commission as Captain in the Sanitary Corps of the Army.

Assistant Professor Frederick E. Breithut, in charge of municipal chemistry in the department of chemistry, College of the City of New York, has been appointed Director of Food Conservation by the United States Government Food Commission to cover the territory of Greater New York City.

Mr. F. F. Beverly, of Sears, Roebuck and Company, has enlisted in the Sanitary Corps, Gas Defense Service. He is now employed at Akron, Ohio, inspecting gas masks.

Mr. Albert King, of the laboratory of Swift and Company, has joined the Gas and Flame Regiment.

Dr. J. W. E. Glattfeld has been appointed a member of the committee on the supply of organic chemicals for research during the war.

The death is announced of Professor G. P. Girdwood, professor of chemistry in McGill University.

Dr. Lawrence J. Henderson, professor of biological chemistry in Harvard University, will give a series of lectures on food conservation at Smith College.

INDUSTRIAL NOTES

Mr. Arthur W. Kinney, Industrial Commissioner, Los Angeles Chamber of Commerce, in the following notes tells of the activity in the development of the mineral and chemical industries of Southern California:

The mineral output for the year 1916 was valued at $22,809,461, petroleum being the largest single product obtained. Second in importance of production was tungsten ore and concentrates which reached the astonishing figure of 1931 tons, valued at $3,915,434. The value of the mineral output for 1917 is not obtainable, but it will undoubtedly show a considerable gain owing to the prevailing high price of petroleum and the important increase in the output of potash products. Potash is now obtained in large quantities in this region from four sources: the Searles Lake deposits, kelp, sugar waste and from the various cement plants. One of the latter now employs a leaching system installed for preparing high-grade potash salts.

In connection with its oil refinery at Fillmore the Ventura Refining Company has expended several hundred thousand dollars in the construction and equipment of a wax extraction plant. Wax will be taken from lubricating stock and handled in large quantities as a by-product.

Oil refineries have shown a greatly increased output. Various refineries, notably the Standard Oil Company and the General Petroleum Company, have spent large sums of money in additions and equipment. The former company has expended over one million dollars at the El Segundo refinery alone and has shown a large increase in its output of lubricants. The latter company has installed furnaces for the cracking of low-grade distillate into synthetic gasoline.

Southern California iron ore deposits have been found to be extensive in quantity and of high quality. Experiments have demonstrated that this ore can be reduced through the medium of natural gas and electric furnaces. Six companies have introduced electric furnaces for various purposes during the year. The Union Tool Company, at Torrance, has installed an open-hearth steel furnace, making a total of three companies thus equipped. There is a great demand for the utilization of Southern Californian resources of iron ore and a great steel industry is promised in the not far distant future.

At Los Angeles harbor the Union Oil Company has commenced construction on the first unit of a two million dollar refinery for the manufacture of lubricating oils, gasoline, kerosene and other petroleum products. This company operates a fleet of tank steamers and not only assists in supplying the industries of the Pacific Coast, but is a large exporter of cargoes of refined and lubricating oils to Australia, New Zealand, and the Hawaiian Islands, and fuel oil to the west coast of Chili.

The Chemical Production Company, Los Angeles, is erecting a fire-proof plant at Owens Lake, Inyo County, for the manufacture of soda ash. This will make the fourth establishment of its kind now operating at this point and the second built there during the present year, the other being the California Alkali Co., at Cartego.

The Stauffer Chemical Co. is erecting a $100,000 plant on a 15-acre tract in Los Angeles. The main buildings will be of reinforced concrete, and hydrochloric acid will be the principal product manufactured.

In addition to the production of molybdic acid salts the Rose Chemical Company, Los Angeles, has made commercially during the year in its electric furnaces, ferrotungsten, ferromolybdenum and ferrochrome. This company will be soon operating three furnaces using electricity in the reduction on a large scale of California and Arizona ores. The American Alloy and Chemical Company has also installed an electric furnace for the making of ferrotungsten.

The Palau Metals Co. has erected a refinery in Los Angeles. Machinery has been installed for the reduction, by a new process, of platinum, palladium and other metals, the ore being brought from Nevada. This plant is said to be the only palladium refinery in America, and the only one in the world handling this ore in the rock.

The Pacific Refractories Company, at Vernon, is now manufacturing magnesite brick from magnesite produced in this region. For a long time California magnesite has been shipped east for the making of brick.

Another new chemical plant in the Vernon district is the California Chemical Company. This company, operating its own oil refinery, is manufacturing a full line of orchard sprays.

At Long Beach the Western Chemical Co. is successfully manufacturing strontium nitrate from celestite, a mineral found in Imperial County. F. G. Mortimer, of Imperial County, is also engaged in the making of this product, which is largely used by manufacturers of fireworks and railroad fuses.

At Searles Lake two potash companies, the American Trona Company and Solvay Process Company, have continued to produce large quantities of chloride of potash. The former company has made additions to its refinery at Los Angeles harbor, costing several hundreds of thousands of dollars, and is now shipping potash, soda and borax in large quantities.

The Western Calcium Chloride Syndicate has equipped buildings at 2472 Hunter Street, Los Angeles, and is producing calcium chloride.

The Southern Reduction Co. at Vernon is making chloride of lime and caustic soda.

At Santa Barbara the U. S. Department of Agriculture, under the direction of Dr. J. W. Turrentine, has erected at an expenditure of one hundred thousand dollars an experimental kelp potash plant. The principal product manufactured thus far is kelp ash.

White oxide of antimony, said to be the best product ever offered in this country and exceeding in solubility the highest grade of the French product, is now being made by the Western Metals Company at Harbor City.

The Crystal Hills Mine, Inc., has just completed a plant at Huntington Park for the making of salts of aluminum and magnesium sulfate, drawing on the extensive salt beds of Inyo County for raw material.

The oxygen plant of the Linde Air Products Company, completed early this year, is now in full operation. The California-Burdett Oxygen Company, making the same product at Vernon, has erected new buildings and greatly enlarged its facilities. The shipbuilding industry calls for a large supply of oxyacetylene gas.

An important industry, the manufacture of oil from soya beans, has been inaugurated at Vernon by the Globe Oil Mills Company. This company has recently received, direct from Russia, a cargo of 9,300 tons of these beans and is grinding the same at the rate of 120 tons a day. The oil is refined, washed, bleached and filtered and the material left after its extraction is made into oil meal cake. This industry in connection with the manufacture of cottonseed oil and cocoanut oil will enable the Globe Company to keep its plant busy every working day in the year and thereby give employment to a large number of people.

At San Diego the Lower California Chemical Co. is making orcein dyes, using as raw material the orchilla, a moss found growing in vast quantities along the western coast of lower California.

The Western Aniline Products Co. is installing machinery and equipment in a fire-proof building at Tropico for the purpose of manufacturing photographic developers and kindred coal-tar products. The former are to be used as a substitute for the metol which is no longer obtainable in the market. The new product has already been used satisfactorily by the motion picture film laboratories and others in Los Angeles.

At Pasadena the Rare Metals Refining Co. has erected a modern plant and is engaged in the refining of various precious metals.

The N. C. Ward Co., Los Angeles, has installed and is operating a complete plant for the manufacture of permanganate of potash.

At Inglewood the Graphite Products Company is equipping a factory for the making of crucibles and carbon electrodes.

At Corona, the United Chemical Company, recently organized, is equipping a factory for the manufacture of citric acid and other citrus by-products. This will be the second concern engaged in this business at this place, the Citrus By-Products Company, a coöperative organization composed of various members of the California Fruit Growers' Exchange, having opened a plant last year to handle cull lemons in that district.

We learn from the *Journal of Commerce* that the development of the quicksilver deposits and the sulfur beds of the upper border region of Texas has been greatly stimulated by the existing high prices of these minerals.

It is reported from Washington that the Federal plant at Summerland, Cal., started as an experiment to demonstrate the possibility of salvaging potash from giant kelp on a commercial scale, has already proved a success. Dr. F. W. Brown, in charge of the office of fertilizer investigations, who is father of the project, has returned from an inspection trip much pleased with the way the plant is working. As a result of the success attained in California, an effort will be made to establish a similar industry on the Atlantic coast. Mr. Brown expects to start preliminary work soon on the Florida coast, where the conditions are nearly the same as on the California coast.

A statement by the Bureau of Foreign and Domestic Commerce says the United States is now producing enough aniline dyes to meet all domestic demand and leave a surplus for export.

Announcement has been made of the formation of the Dixie Gas Company at Anniston, Alabama, under the laws of Delaware, with a capital stock of $2,500,000. This company will develop the oil and gas possibilities of Alabama on a huge scale.

The International Coal Products Corporation of Trenton has been incorporated under the laws of New Jersey with a capital of $11,000,000, by G. W. Bacon, C. L. Blair and J. B. Dennis, of New York.

It is reported from Germany that Prof. Thoms, of Berlin, has been making extensive experiments in poppy cultivation. It is stated that he has succeeded in obtaining from poppies opium containing no less than 22 per cent of morphine, and greatly superior to the Turkish and Bulgarian opium in morphine content.

Merck & Company have increased their capital from $250,000 to $1,000,000.

A company has been formed in Japan for the manufacture of fish grease used in the manufacture of soap and glycerin.

The U. S. Potash Products Company, capital $5,500,000, has filed a charter under the laws of Delaware. The company is organized to produce and market potash and alum. The incorporators are Dormann T. Connet, White Plains, N. Y., John F. Roach and Clarence E. Bohn, of New York City.

Amalgamated Dyestuff and Chemical Works of Manhattan has increased its capital from $50,000 to $500,000.

We learn from the *Textile World Journal* that the paper industry has found a new use for sulfonated castor or Turkey-red oil. This commodity is extensively used in cotton finishing and dyeing. It has been found in a practical application that a small quantity of an alcoholic solution of this oil prevents the formation of foam in the beaters.

A method of determining manila fiber in rope and twine has been discovered in the research department of Arthur D. Little, Inc., Cambridge, Mass. The method has been adopted by the United States Bureau of Standards. Briefly, it consists of freeing the rope from oil, soaking it for twenty seconds in a solution of bleaching powder acidulated with acetic acid, rinsing in water, then in alcohol, and finally exposing it for a minute to the fumes of ammonia. Manila fiber turns russet-brown while all other rope fibers turn cherry-red.

The Mallinckrodt Chemical Works of St. Louis on December 19 celebrated the fiftieth anniversary of the founding of its business by giving a banquet at the Mercantile Club, St. Louis. About one hundred and fifty guests were present, including the representatives of the various branches. An important feature of the evening was the presentation to Edward Mallinckrodt, Sr., president of the company, by the employees, of a beautiful bronze tablet or medallion prepared from one of his recent photographs.

An explosives manufacturing plant to require an investment of $60,000,000 will be built by the Government at Hadley's Bend, on the Cumberland River, near Nashville, Tennessee. From 4000 to 5000 acres of land will be utilized for the site and the buildings will cover about 2000 acres. It is planned to begin explosives manufacturing within ten months. This factory is one of the several big explosives manufacturing plants which the Government has decided to build in connection with its $90,000,000 expenditure for this purpose.

Secretary Lane has recommended to Congress an appropriation of $100,000 to investigate the commercial and economic practicability of utilizing lignite coal for producing fuel oil, gasoline substitutes, ammonia, coal tar and gas for power. There are immense quantities of lignite deposits in public land but the coal is of such character that it does not stand transportation in its natural state and is of small value for fuel except in the immediate vicinity of the mines.

The Carbo-Hydrogen Company of America, with offices at Pittsburgh, has increased its capital from $3,500,000 to $5,000,000.

Castor oil used in dyehouse preparations and for lubricating airplane engines has become so scarce that the Government, in view of the latter requirement, is arranging for the planting of 100,000 acres, 40,000 of which lie in Florida, with the India castor bean. Contracts will be made with farmers in suitable sections who will plant not less than 1000 acres, the Government undertaking to purchase the beans at a fixed price.

The United Chemical Company, Wilmington, Del., has been incorporated to manufacture chemicals and allied products. The capital is $3,000,000. Incorporators: M. M. Clancy, C. L. Rimlinger and C. M. Egner, Wilmington.

According to estimates of the U. S. Geological Survey, Department of the Interior, the production of magnesite in California in 1917 exceeded that of all former years, being estimated at 215,000 tons. This quantity and the magnesite produced in the recently discovered field in Stevens County, Washington, estimated at close to 100,000 tons, makes an output of 315,000 tons in 1917, or 15,000 tons more than the normal domestic demand.

Regarding the explosion at the extensive Griesheim-Electron chemical works in Germany recently, "Lloyd's List," in an article on the explosion, attributed to an authoritative source, says:

"It will be remembered that on November 22 it was reported that the large chemical factory of Griesheim-Electron, near Frankfort, had been destroyed as the result of an explosion. No details were obtainable at that time, and no great attention was paid to the report in this country, no doubt from desire to avoid exaggeration of what might after all prove to have been an affair of no great importance.

"But the extreme care taken to prevent fuller accounts from leaking out from Germany and the enforced silence of the German press on the subject are the best proof of the German Government's anxiety to conceal a very serious loss. The first telegram which managed to escape from Frankfort made a significant admission, which the subsequent silence only confirms. It announced that the excitement in Frankfort caused by the explosion was tremendous. Information which has since been obtained from perfectly trustworthy sources makes it clear that there was good reason for excitement. For it is now certain that the explosion caused the complete destruction of one of the greatest munition factories in the world, by which Germany has suffered a disaster comparable to a very serious military defeat in its effect on the issue of the war.

"Under these circumstances it is a matter of supreme interest to understand precisely to what extent German military equipment was dependent on the source of supply which was wiped out of existence a few weeks ago.

"The Griesheim factory was situated in the neighborhood of Frankfort with an extensive frontage on the river Main. It consisted of an enormous group of buildings covering an area of over 54 acres. Twenty-eight large chimneys, one of them over 200 feet high, gave the impression more of an industrial town than a single factory; and numerous piers abutting on the river, combined with an extensive railway system, enabled this huge concern to distribute its products among the world's markets economically and quickly. Before the war it ranked as fourth in importance of the great German chemical works, and was always a flourishing company, paving a pre-war dividend of 14 per cent, and worth, as a going concern, well over 60,000,000 marks.

"Its commanding position in the chemical world rested not only on its huge output, but on the extensive variety of its manufactures. These comprised, among other things, aniline dyes of every description, nitric, sulfuric and other acids, phosphorus, and alkali, with liquid chlorine, hydrogen and oxygen as important by-products. What it meant to Germany as a source of munitions of war can thus be readily understood. Moreover, as one of the uncommon instances among German chemical works possessing installations for electrochemical production, it was of prime importance as a source of synthetic nitrates; and its splendidly organized research laboratory enabled it to play a leading part in the production of poison gas, and the other more refined forms of frightfulness which Germany has introduced in the course of the war. That the Imperial Government has taken the fullest advantage of these facilities is shown by the rapid increase of the works both in extent and output since the beginning of the war, and by the fact that the company has recently decided to increase its share capital by 50 per cent, an increase in which the German Government is more than suspected of having a financial interest.

"With regard to the productive capacity of Griesheim some authoritative facts are available which cast an interesting light on the war activities of this concern. It has been producing saltpeter for the manufacture of black powders at the rate of 1,000 tons a day, and it is reputed to be the only factory turning out this article. To such an extent has its already impressive output of soda nitrate and concentrated sulfuric acid been developed that it supplied the whole demand of five nitroglycerine and dynamite factories, as well as two powder works, including that of Rottweil, one of the most important in Germany. Another explosive, which it manufactured in large quantities, was tonite, through its facilities for making synthetic phenol and consequently picric acid, from which acid this explosive is derived.

"Another circumstance of special interest to us is the fact that this factory supplied large quantities of electrolytic hydrogen for the inflation of Zeppelins, and possessed by way of a reserve three gasometers with a total capacity of over 300,000 cubic feet. So important was it in this respect that a Zeppelin shed, usually containing two or three airships, was erected in close proximity to the works. For the kite balloons at the front the gas was supplied in steel tubes in the liquefied state. Moreover, the extensive electrolytic plant was further utilized to produce asphyxiating gas and lachrymatory and poisonous shells. Indeed it was the greatest center of this manufacture in Germany, and in 1916 the output of poison gases reached the colossal figure of nearly 600,000 cu. ft. a day.

"The extent of the material loss which Germany has suffered by the destruction of the Griesheim factory can thus be easily comprehended. But the disaster is of still wider significance. The variety of the materials formerly produced means, in such a closely interlocking industry as chemical manufacture, that every concern in Germany is affected, both from the cutting off of supplies which many of them formerly drew from Griesheim and from the necessity of making the loss of these supplies good from plants already working to their maximum. The deaths of scores of trained workmen and specialists in the factory itself, and in the dwellings within its confines, will make the task of coping with this deficit all the more difficult.

"Even if the material loss can be successfully replaced, the problem of collecting miscellaneous quantities of explosives and acids from various quarters and conveying them over the greater distances thus made necessary is bound to complicate further the transport difficulty, already regarded as exceedingly pressing in Germany. It is impossible that the works can be reconstituted during the war, and sooner or later Germany must show on her fighting fronts the effects of this staggering blow which she has suffered within her own territory."

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

GEOLOGICAL SURVEY

Gypsum in 1916. R. W. Stone. Separate from Mineral Resources of the United States, 1916, Part II. 7 pp. Published October 30. In 1916 for the first time the total value of the gypsum products of the United States in a single year exceeded $7,000,000. Since 1912, inclusive, the annual output has been approximately 2,500,000 tons of raw material, but in 1916 the total production was over 2,750,000 short tons.

As might be expected from the general tendency of the times, the average price per ton for gypsum and most gypsum products shows a large increase over the price in 1915. The increase is least for crude gypsum sold to Portland cement mills and greatest for dental plaster. Dental plaster is reported as produced in six states and at prices ranging from $6 to $23.50 per ton, with an average price of $13.26 per ton. In former years it has ranged from $3 to $15, with an average price of about $5. This greatly increased average price in 1916 is due to the fact that the higher-priced material largely predominated in the output.

The increased average price per ton of all calcined plaster in 1916, due to higher wages and cost of all supplies, will doubtless be greatly exceeded in 1917.

Gypsum imported into the United States comes almost wholly from Nova Scotia and New Brunswick and enters the ports of the New England and North Atlantic States. The proportionate value of imports to domestic production is very small and decreasing. It was about one-seventeenth in 1915 and one-twenty-second in 1916.

Peat in 1916. J. S. Turp. Separate from Mineral Resources of the United States, 1916, Part II. 2 pp. Published November 19.

Peat was used in the United States in 1916 mainly for fertilizer, soil builder and as stock food. Small quantities were used for peat litter and fuel, and, as was predicted in the report for 1915, very little peat fuel was produced in this country in 1916.

During 1916, as in 1915, no new processes or machinery for preparing peat were reported to have been commercially tried in the United States, but several firms reported additions and improvements to their plants. The total number of firms reporting production in 1916 was 13, all but one of which sold peat for fertilizer. Two also sold peat for stock food. One sold a small quantity for fuel. The 9 firms that furnished data for 1915 furnished data also for 1916, and 4 firms reported that were not represented in 1915.

Peat Produced, Imported and Consumed in the United States in 1916

Use	Production Quantity Short Tons	Production Value	Imports Quantity Short Tons	Imports Value	Consumption Quantity Short Tons	Consumption Value
Fertilizer and fertilizer filler	48,106	$336,004	...	.....	48,106	$336,004
Stock food	4,300	32,250	...	.....	4,300	32,250
Miscellaneous	100	850	...	.....	100	850
Peat moss litter	....	.....	3,042	$27,859	3,042	27,859
	52,506	$369,104	3,042	$27,859	55,548	$396,963

Hydraulic Conversion Tables and Convenient Equivalents. Anonymous. Water Supply Paper 426-*C*, from Contributions to the Hydrology of the United States, 1917. 24 pp. Published October 31.

The Alaskan Mining Industry in 1916. A. H. Brooks. Bulletin 662-*A*, from Mineral Resources of Alaska, 1916-*A*. 62 pp. "This volume is the thirteenth of a series of annual bulletins treating of the mining industry of Alaska and summarizing the results achieved during the year in the investigation of the mineral resources of the Territory. In preparing these reports the aim is prompt publication of the most important economic results of the year.

"This volume, like those previously issued, contains both preliminary statements on investigations made during the year and summaries of the conditions of the mining industry, including statistics of mineral production. It is intended that this series of reports shall serve as convenient reference works on the mining industry for the years which they cover."

Mining in the Lower Copper River Basin and the Prince William Sound Region, Alaska. F. H. Moffit and B. L. Johnson. Bulletin 662-*C*, from Mineral Resources of Alaska, 1916-*C*. 66 pp.

Manganiferous Iron Ores. E. C. Harder. Bulletin 666-*EE*. 13 pp. The dependence of the United States on imported high-grade manganese ore and ferromanganese is well known to steel makers and other users of manganese. Normally the high-grade manganese ore produced in this country constitutes less than 2 per cent of the total amount of manganese ore consumed, not including the ore represented by the manganese imported in the form of the alloys—ferromanganese and spiegeleisen. During 1916 the domestic production was about three times that of 1915, largely on account of the high prices paid for ore. The exploration for new deposits has also been stimulated, and many discoveries of manganese ore are being reported. Even with this outlook for increased production, however, it is not unduly pessimistic to say that the deposits of high-grade manganese ore in the United States will probably never be able to supply the manganese consumed in domestic industries. If, therefore, the importation of high-grade manganese ore were discontinued, numerous industries would be vitally affected. Of these the steel industry consumes by far the largest quantity of manganese.

There are in the United States large quantities of manganiferous ores containing varying amounts of manganese. A very small proportion of these can be used in the production of high-grade iron-manganese alloys, but a large proportion can be used for lower-grade alloys, and nearly all can be used in making high-manganese pig iron. Compared with the manganiferous ores, the reserves of high-grade manganese ores in this country are insignificant. Hence, although a search for manganese ore is desirable, a more promising solution of the manganese problem would seem to lie in the direction of the utilization of low-grade manganiferous ores. Up to the present time the use of these ores has been very slight. Until a few years ago they were considered to have little value and were mined only incidentally. In the West manganiferous ores would not be mined were it not for their association with ores of other metals.

There are several ways in which the utilization of manganiferous ores may be brought about: (1) It has been suggested that by methods of concentration resulting in the elimination of iron, silica, or other constituents a product high in manganese might be derived from them. Such concentration has been attempted locally but with very little success, owing mainly to

the intimate mixture which manganese generally forms with associated materials: (2) The steel-making practice might be changed so that more spiegeleisen and less ferromanganese would be used for deoxidizing. By the addition of small quantities of high-grade manganese ore much of the manganiferous iron ore could be used in the manufacture of spiegeleisen; (3) The most effective solution, however, as has previously been suggested, seems to be to so change the practice in the manufacture of basic open-hearth steel as to make possible the use of high-manganese pig iron. Experimentation along this line is extremely desirable. The successful application of such a change would make large reserves of manganiferous iron ore commercially available and would greatly decrease the quantity of high-grade manganese ore consumed.

BUREAU OF FISHERIES

The Menhaden Industry of the Atlantic Coast. R. L. GREER. Document 811, 30 pp. Issued October 18. Paper, 10 cents. "Descriptions of methods of conducting the fishery, vessels, factories, apparatus, and methods employed in converting the fish into oil and scrap, and includes statistics of the fishery for 1912 and selected bibliography of papers relating to the subject."

BUREAU OF STANDARDS

The Latent Heat of Pressure Variation of Liquid Ammonia. N. S. OSBORNE AND M. S. VAN DUSEN. Scientific Paper 314, 6 pp. Issued November 16. Paper, 5 cents.

COMMERCE REPORTS—DECEMBER, 1917

Lubricating oil is being made from the liquid rosin obtained in sulfite paper pulp factories in Sweden. (P. 849.)

Efforts are being made to develop **salt** beds in Holland, to replace salt hitherto imported. Salt brine and solid salt have been encountered in exploration work. (P. 853.)

Copper pyrites mines in Norway, formerly German owned, have been purchased by Swedish firms. (P. 871.)

A new type of hard **porcelain** has been developed at Stoke-on-Trent (England). It is made entirely of British materials, is cheaper than ordinary earthenware, and the glaze (which is leadless) is very satisfactory, and can be readily decorated. The ware can be fired in either oxidizing or reducing atmospheres, preferably the latter. (P. 872.)

American exports of **aniline dyes** are constantly increasing, being now equivalent to about $4,700,000 annually, *i. e.*, about twice the domestic production in 1914. A similar increase has occurred in the exports of vegetable colors. (P. 903.)

Efforts are being made to produce **paper** in Australia from native grasses. Newsprint paper is now very scarce, and costs four times the pre-war price. (P. 918.)

The **tin plate** situation in the United States is improving, as shown by increased imports of pig tin and palm oil (used in tinning), and by decreased exports of tin plate and terneplate. (P. 947.)

It is proposed to subsidize for three years any organization that will establish a **paper** factory in the Philippines. (P. 965.)

Exports of **manganese ore** from Brazil to the United States are five times those of 1913, and could be still more increased if the rich regions could be made more accessible. (Pp. 971 and 1155.)

The Japanese **steel** industry shows an increase of over 50 per cent above last year's production. (P. 975.)

To provide **steel** for shipbuilding and other industries, a large modern steel plant is to be erected in Holland at the entrance to the North Sea Canal; and will use imported iron ores. (P. 978.)

The conditions and methods in use in the Scottish **shale oil** industry are described in some detail. The principal products are naphtha, burning oil, gas oil (used as fuel and for enriching gas), lubricating oils, paraffin, coke, gas (illuminating), and sulfate of ammonia. (Pp. 990–1.)

The British Government has assumed control of all **vegetable oils** and oil seeds, and hydrogenated oils. (P. 993.)

Imports of **chemicals** into Great Britain in October showed a slight increase, while exports showed a marked decrease. (P. 1031.)

The **iron ore** and **steel** industry of the Biscayan Provinces of Spain is described in some detail. (P. 1128.)

Proposed **substitutes for gasoline** as motor fuel in England include denatured alcohol, coal gas and kerosene. The first is not possible with the present demand for alcohol, though efforts are being made to increase the cultivation of potatoes to be used for industrial alcohol. The use of coal gas, especially in busses, etc., is increasing. Containers are usually made of fabric made gas-tight by various coatings. Kerosene is not extensively used, as it requires special fittings, etc., and involves the use of gasoline for starting. (Pp. 1132–5.)

Experiments were performed in India upon three new **paper-making** materials: *E. monostachya* leaves from Western Australia, wood of the *N. macrocalyx* from East Africa, and bark of *brachyotegia* from Rhodesia, all with encouraging results. (Pp. 1203–5.)

Efforts are being made to increase the output of **asbestos** from Russia, in view of increased demands, especially from Japan. (P. 1139.)

Most of the **mineral products** of India show an increased output, the most important being coal, gold, manganese ore, petroleum, salt, saltpeter, tungsten ore, lead ore, mica, silver, tin ore, iron ore, and monazite. (P. 1175.)

To meet increased demands for **aluminum**, especially in the aircraft industry, large extensions of the plants in Scotland are planned. (P. 1191.)

Further exploration of the **manganese** mines in Mysore, India, has shown that the richness of the ore increases with the depth. Manufacture of ferromanganese in India is being considered. (P. 1192.)

Experiments are being conducted in the West Indies upon the concentration of **lime juice** by freezing, to reduce the cost of transportation. (P. 1219.)

Soya bean oil is obtained in Manchuria principally by the "expression" process, only one plant using the benzene extraction process. The oil by the latter process is inferior. (P. 1227.)

A firm in Scotland, experienced in the manufacture of gauge glasses, has extended its plant and force to include **chemical glassware** of high quality, including apparatus for HNO_3 condensation, miners' safety lamp globes, and special glass for airplanes and marine mines. Prohibition of imports of chemical and scientific glassware for seven years is urged as a necessary step for the establishment of a permanent industry in Great Britain.

SPECIAL SUPPLEMENTS ISSUED IN DECEMBER

SPAIN—15*d*	STRAITS SETTLEMENTS—56*a*
IRELAND—19*c*	MOROCCO—75*a*
CHINA—52*f* and *g*	

STATISTICS OF EXPORTS TO THE UNITED STATES

HONGKONG—925	SINGAPORE—Sup. 56*a*	JAMAICA—1127
Antimony	Cassia	Annatto
Chemicals	Cubebs	Hides
Hides	Cutch	Kola nuts
Leather	Dragon's blood	Logwood extract
Peanut oil	Gamber	Sugar
Aniseed oil	Gamboge	Fustic
Cassia oil	Gum	Logwood
Paper	Gum benjamin	
Sugar	Gum copal	LONDON—1137
Tin	Gum damar	Rubber
DARIEN, CHINA—Sup. 83*g*	Gutta isolatong	Tin
Albumen	Gutta percha	Hides
Bean oil	Gutta stak	Indigo
Bean cake	Hides	
Linseed	Mangrove bark	CANARY ISLANDS—Sup. 15*d*
TSINGTAU—Sup. 52*g*	Cocoanut oil	Cochineal
Hides	Paraffin	Copper matte
Peanuts	Rubber	Pumice
Peanut oil	Tin	

BOOK REVIEWS

Chemical Patents and Allied Patent Problems. By EDWARD THOMAS. John Byrne & Co., Washington, D. C. Price, $2.50.

Patent law is a wilderness of decisions, a jungle of entangled and interlacing precedents which, like most jungle vegetation, can be found running almost any old way. However, still pursuing the analogy, most of the main lianas pursue something the same general direction with only occasional divagations. Our usual legal custom, from which we have not departed in patent matters, is to enact statutes in a few brief paragraphs; and then leave it to the courts to find out what those paragraphs mean as applied to any individual case. And in the patent field, our judges have been reasoning from parallel case to parallel case for something over a century now, with awe-inspiring results considered volumetrically.

Every chemist is interested in patents at one time or another, whether it be because he wants one or is afraid of one or for both reasons together. Chiefly, he wants to know the law governing compositions and processes; and for his purpose the ordinary text books on patent law are more irritating than instructive. Naturally, such books seek to cover the whole field and do not specialize in these matters; the more so since in the United States invention and litigation have been much more concerned with matters of mechanics than with matters of chemistry.

Mr. Thomas' book is a specialization; it is, practically, confined to the law of process and composition. It is hardly a treatise on patent law; it is more what Mr. Thomas terms a "finding list" of the decisions relating to chemical things. In a way it is an attempt to do for chemical patent law what Beilstein or Richter did for organic chemistry, *viz.*, classify the literature with just enough running text to give the classification. The difference, and the difficulty, arise in that while Beilstein's running text can give facts and avoid theory or controversial matter, Mr. Thomas, in the nature of things, can only give opinions. And opinions do not lend themselves to verbal condensation as do boiling points and reactions. Any law suit represents a difference in opinion which generally spreads itself over many pages of testimony and argument with the court's opinion coming as a lengthy equilibration of the difference. This equilibration cannot well be compressed into a paragraph or a sentence; in most instances, anyhow.

As a finding list, Mr. Thomas' book is extremely good. The running text, considered purely as a classification, is also good. It is so short and compressed that little difficulty is found in glancing over it to catch a key word.

But because it is short and compressed, the running text is open to more objection if it is to be considered a "statement of the patent law." It says too positively that which is oftentimes a matter of opinion. This is something Mr. Thomas could not altogether avoid in a summary. To state the upshot of any decision in a single sentence, a world of qualifications and limitations must be omitted unless that sentence is to be, as Mark Twain said of Germanic wording, "long enough to have perspective." Nevertheless, Mr. Thomas might perhaps, with advantage, have hedged a little in some of his statements. The law is proverbially a thing of glorious uncertainty; and where its conclusions are stated too categorically, the casual reader is apt to receive fixed impressions which may afterwards have to be unfixed. Or, Mr. Thomas might have inserted a brief warning that in general the dicta given are merely his opinion of what the courts' opinions were: and that wherever the matter is of importance the original decision should be consulted.

Sometimes, Mr. Thomas uses language which is a little confusing. It is not meant in the discussion in page 31, for example, that the courts and Patent Office are coming to the view that a thing demonstrably old can be re-patented merely because it is made by a new process; but that there are some things, like a fried egg, which can best be defined by a recital of the process of making. See also the reference to "fusible tubes of water" (page 6). And the collocation of sentences in the running text is often just a little bewildering; like the dictionary, the text changes the subject a bit too abruptly sometimes. For instance, in pages 24 and 25, one sentence is talking about new matter in re-issues while the next is devoted to infringement of an adrenalin patent.

But of course it is easier to criticize than to do things; and the fact is that Mr. Thomas has produced a very useful book; and one which represents a vast amount of labor. It fills, and fills well, a vacant place on the reference book shelf.

K. P MCELROY

Explosives. By ARTHUR MARSHALL. Second Edition, Vol. II, Properties and Tests. 8vo, 386 pp. and 80 illustrations. P. Blakiston's Son & Co., Philadelphia, 1917. Price, $8.00 net.

The author's work, as evidenced in this second volume, is of the same high character as set forth in the review of Vol. I.[1] The extent of the revision is to a degree shown by the fact that Part IX, devoted to "Properties of Explosives," has been enlarged by twenty pages; Part X, "Special Explosives," by thirty-eight pages; Part XI, "Stability, etc.," by eleven pages; and Part XII, "Materials and Their Analysis," by twenty-two pages. Besides the enlargement of each of the former chapters there have been added one, of seventeen pages, on "Naval and Military Explosives" and another of twelve pages, on "Commercial High Explosives," while to the "Thermo-Chemical Tables" in Appendix II have been added tables of heats of formation of "Fulminates and Azides" and of "Aliphatic Nitrates and Nitro-Compounds." Novelties are found in the change of the legend for Chapter 35 from "Safety Explosives" to "Coal-Mine Explosives" which latter is a much more accurate title, and in Part XII, by placing in full-face type at the bottom of each page, in addition to the marginal legends, the name of the substance described and for which the methods of analysis are given on that page. This section of the book will be much used and this addition will undoubtedly prove very convenient and helpful.

The same degree of sensible frankness in treatment of devices and materials now used for war purposes is noticeable in this as in the first volume, and particularly in the chapter on "Naval and Military Explosives" introduced into this edition. As this information is without question already in the hands of the enemy it would be foolish to withhold it from friends who might be able to render useful service if supplied with the information. In the first edition the author gave the composition of the chlorate priming used by the U. S. in its small-arms ammunition. In this edition he says of potassium chlorate: "If made by the electrolytic method it always contains at least 0.05 per cent of potassium bromate, and may contain as much as 0.6 per cent. That manufactured by the old process does not contain this impurity. As bromate may have a deleterious effect on the stability of explosives made with it, especially if the explosive also contains sulfur, an official order has been passed in Germany that chlorate for the manufacture of blasting explosives must not contain more than 0.15 per cent of bromate, for fireworks not more than 0.10 per cent, and for cap composition none at all," and he gives methods for the detection and determination of the bromate.

As a rule, the author has covered each topic with fullness and has cited the original authority with accuracy. A notable

[1] THIS JOURNAL, 9 (1917), 822.

exception, which therefore attracts attention, is that of the perforation of plates by hollow cartridges of detonating explosives which is referred to Neumann under dates of 1911 and 1914, though these cartridges were devised in this country, the method applied, and the results published so long ago as 1888 and repeatedly later. Also it is noted that the Bureau of Mines' Sand Test for detonators is attributed to Storm and Cope, though these authors, in Technical Paper No. 125 cited by Marshall, state that it had been devised by W. O. Snelling. These are, however, but minor defects in a very valuable work.

Unfortunately, the printers' work is more open to criticism and this is the more to be regretted as the author was so far distant from his publisher. Two flagrant errors are the numbering of chapter thirty-six in full-faced Roman as Chapter XXX, and the omission of a legend from the newly added table for the heats of formation of the fulminates and azides. In addition dropped letters, imperfect impressions, and uncouth formulas, due to wrong case type or signs, are not uncommon.

CHARLES E. MUNROE

Tube Milling. A treatise on the practical application of the tube mill to metallurgical problems. By ALGERNON DEL MAR. x + 159 pp. Illustrated. McGraw-Hill Book Co., New York, 1917. Price, $2.00 net.

This book is of what may be called the standard dimensions of page, the binding is good and the paper, type and illustrations excellent. The latter are numerous and are in general clear and well selected for their purposes.

The object of the work is shown in the statement in the author's preface that "it is important that the principles involved in their [tube mills] operation should be made common property. It is for this purpose that the author has compiled the present volume, hoping that it will meet the requirements of the engineer and millman."

Chapter I is headed "General Description," and in addition treats fully, more or less, what are called the essential factors governing capacity, together with feeding devices, power requirements, costs and foundations. Chapter II is entitled "Amalgamating with the Tube Mill," Chapter III "Grinding Ores with the Tube Mill for Flotation," Chapter IV "Crushing Efficiencies," and Chapter V "The Use of Wrought Iron and Alloy Steel."

There is also an appendix of six pages giving some useful data, tables and notes on slime density relations, and some information on assay methods, etc., for a cyanide mill laboratory.

There are a few evident typographical errors, among which are the following:

Page 13. "0.5316 tons of dry feed" should be "0.5297 tons of dry feed."
Page 32. "Guanajuanto" for "Guanajuato."
Page 51. In the formula $m = \frac{Sv(a-d)}{(s-d)}$ "s" should be "S"
Page 120. "Fig. 50" should be "Fig. 64."
Page 147. "Excising" should be "existing."

Criticism might be made as to some of the details of arrangement. For example, on pages 104 and 105 the figures given as "Cement Data" might have been more properly placed in the appendix. Also in the chapter headed "Crushing Efficiencies" there is a page and a half only on this subject, while the remainder of the chapter, six pages, treats of screen gauges, screen openings, etc.

In the reviewer's opinion the notes on "Cyanide Chemistry" in the appendix should either have been made very much fuller or else omitted altogether and replaced by references to the several complete treatises on the subject. These notes are condensed to such a degree that it would be very difficult for anyone not a chemist familiar with cyanide laboratory practice to use them to advantage.

These are all minor criticisms, of course. The main objection to the author's treatment of the subject is his insufficiently full and adequate handling of important divisions, with a resulting lack of balance. As referred to above, barely two pages are given to the very important subject of crushing efficiencies, although references are given to the literature. Over thirteen pages are given to a discussion of the use of wrought iron and alloy steels, with tables and diagrams. This chapter is not to be objected to in itself, but, in comparison, the three pages of text devoted to grinding ores with the tube mill for flotation are certainly very meagre. A considerable volume of very valuable data on this subject has either been published or could be secured easily.

For a treatise the complete collection and arrangement of important published information and data is always a very valuable feature. The danger usually is that very often this results in what is practically a compilation only. The author is to be congratulated in that the proportion of pure compilation in the present volume is so decidedly less than the average that the book is not open to this objection, nevertheless this proportion could have been considerably increased to advantage in some of the chapters.

G. D. VANARSDALE

Everyman's Chemistry. By ELLWOOD HENDRICK. Harper & Bros., Philadelphia. Price, $2.00.

During the past few years the public has come to realize, in a vague way, the tremendous importance of chemistry in its application to daily life. No book, however, that the average reader could comprehend has been written on this subject, and it is gratifying indeed to welcome such a volume.

In his book Mr. Hendrick discusses the great problems of the day in an interesting, instructive, and lucid manner, setting forth the general principles underlying the subject of chemistry in a language which is simple, direct and intelligible to all. The delightful manner in which the subject is presented makes the reader feel almost a personal contact with the author. The keen wit and sense of humor displayed throughout the text relieves the monotony of dry scientific facts. Thus like a sugar-coated pill one swallows the information without noticing the bitter taste.

ALLEN ROGERS

Lubricating Engineer's Handbook. A reference book of data, tables and general information for the use of lubricating engineers, oil salesmen, operating engineers, mill and power plant superintendents and machinery designers, etc. By JOHN ROME BATTLE, B.S. in Mechanical Engineering. 8vo. Pp. 333. J. B. Lippincott Co., Philadelphia and London, 1916. Second Impression. Price, $4.00.

After a careful perusal of the book, the reviewer has failed to find any phase of the oil business that has not been discussed: history, manufacture, tests, the varied uses, storage, oil house methods, specifications, etc., etc.

Two statements made are very interesting, one that the oil supply of this country is about one-third used up (in about fifty years), and, second, that the annual friction loss in the United States is nearly 200 million dollars. If the book helps to bring about a diminution of this, it will have served a useful purpose. This statement is made on p. 69, "The so-called gumming test for lubricating oils is of little practical value * * * * * and the same may be said of evaporation tests." On the other hand (p. 138), the statement is found, that "a lubricating oil for forced feed in a steam turbine should have a low gumming test." Speaking from an experience of more than thirty years, the reviewer has found both tests of great value: the first is an admirable sorting test, particularly for automobile oils, and the second is of cardinal importance to the insurance companies, having to do with textile mills.

The book was very much needed, and is eminently satisfactory, in fact, about as nearly perfect as is humanly possible to produce—but this might have been expected from the engineer of the Atlantic Refining Company, "the largest manufacturers of lubricants in the world."

A. H. GILL

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Antiseptics: A Handbook on Antiseptics. H. D. DAKIN AND E. K. DUNHAM. 129 pp. Price, $1.25. The Macmillan Co., New York.

Biochemical Catalysts in Life and Industry. JEAN EFFRONT. 8vo. 752 pp. Price, $5.00. John Wiley & Sons, New York.

Chemistry: A Course of Instruction in the General Principles of Chemistry. A. A. NOYES AND M. S. SHERRILL. 8vo. Price, $2.25. T. Todd Co., Boston.

Chemistry: An Elementary Study of Chemistry. W. MCPHERSON AND W. E. HENDERSON. 12mo. 576 pp. Price, $1.60. John Wiley & Sons, New York.

Colloids: The Chemistry of Colloids. R. ZSIGMONDY AND E. B. SPEAR. 8vo. 288 pp. Price, $3.00. John Wiley & Sons, New York

Flotation: Testing for the Flotation Process. A. W. FAHRENWALD. 16mo. 173 pp. Price, $1.50. John Wiley & Sons, New York.

Foods and Their Adulteration. H. W. WILEY. 3rd Ed. 8vo. 646 pp. Price, $4.00. P. Blakiston's Son & Co., Philadelphia.

Hydro-Electric Power Stations. E. A. LOF AND D. B. RUSHMORE. 8vo. 822 pp. Price, $6.00. John Wiley & Sons, New York.

Metallurgy: A Practice Book in Elementary Metallurgy. E. E. THUM. 8vo. 313 pp. Price, $2.75. John Wiley & Sons, New York.

Minerals: Practical Instruction in the Search for and the Determination of the Useful Minerals, Including the Rare Ones. ALEX. MCLEOD. 16mo. 254 pp. Price, $1.75. John Wiley & Sons, New York.

Non-Metals: Elementary Experiments on the Non-Metals. J. S. LONG AND D. S. CHAMBERLIN. 8vo. 78 pp. Price, $1.25. W. S. Rhode Co., Kutztown, Pa.

Ore Mining Methods. W. R. CRANE. 8vo. 277 pp. Price, $3.50. John Wiley & Sons, New York.

Refrigeration: Mechanical Refrigeration. H. WILLIAMS. 12mo. 406 pp. Price, $3.00. The Macmillan Co., New York.

Science: Experimental General Science. W. N. CLUTE. 12mo. 303 pp. Price, $1.00. P. Blakiston's Son & Co., Philadelphia.

Science: A Short History of Science. W. T. SEDGWICK AND H. W. TYLER. 8vo. 474 pp. Price, $2.50. The Macmillan Co., New York.

Soil Conditions and Plant Growth. E. J. RUSSELL. 3rd Ed. 8vo. 243 pp. Price, $2.00. Longmans, Green & Co., New York.

Steam Power Plant Engineering. G. F. GEBHARDT. 8vo. 347 pp. Price, $4.00. John Wiley & Sons, New York.

Sugar: A Handbook for Cane-Sugar Manufacturers and Their Chemists. G. L. SPENCER. 6th Ed. 16mo. 561 pp. Price, $3.50. John Wiley & Sons, New York.

Technical Periodicals. NATIONAL CARBON CO. 12mo. 22 pp. Gratis. National Carbon Co., Cleveland.

Wood: The Preservation of Wood. A. J. WALLIS-TAYLOR. 8vo. 363 pp. Price, 10s. 6d. William Rider & Sons, London.

RECENT JOURNAL ARTICLES

Acetylene: New Exploits of Acetylene. J. M. MORSHEAD. *Journal of Acetylene Lighting*, Vol. 19 (1918), No. 1, pp. 240–243.

Actinochemistry: Studies in Actinochemistry. H. H. CUSTIS. *Journal of the Franklin Institute*, Vol. 184 (1917), No. 6, pp. 849–884.

Alcohol: Waste Sulfite Liquor and Its Conversion into Alcohol. ERIK HAEGGLUND. *Pulp and Paper Magazine*, Vol. 15 (1917), No. 51, pp. 1185–1192.

Babbitt: Physical Properties of Babbitts. W. G. HARRIS. *Pulp and Paper Magazine*, Vol. 15 (1917), No. 51, pp. 1183–1184.

Blast Furnace: Prevention of Blast Furnace Slips. F. H. WILLCOX. *The Iron Trade Review*, Vol. 61 (1917), No. 25, pp. 1332–1334.

Boiler Plant Management. E. MATHESON. *Paper*, Vol. 21 (1917), No. 14, pp. 11–13.

By-Product Coke Oven Pressure Regulation. F. W. ELLS. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 1, pp. 21–22.

Carbonizing: Limitations of Carbonizing Process. E. F. LAKE. *The Iron Trade Review*, Vol. 61 (1917), No. 26, pp. 1385–1386.

Chemist in the Textile Mill. *Textile World Journal*, Vol. 53 (1917), No. 26, pp. 21–23

Coal: General Utilization of Pulverized Coal. H. G. BARNHURST. *Journal of the Cleveland Engineering Society*, Vol. 10 (1917), No. 3, pp. 145–163.

Compressed Air: Using Compressed Air in Forge Shops. C. A. HIRSCHBERG. *The American Drop Forger*, Vol. 3 (1917), No. 12, pp. 391–397.

Cyaniding a Small Gold-Tailings Dump. A. W. ALLEN. *Engineering and Mining Journal*, Vol. 104 (1917), No. 24, pp. 1032–1039.

Displacement-Tanks. W. S. WEEKS. *Mining and Scientific Press*, Vol. 115 (1917), No. 24, pp. 855–856.

Electrical Cleaning of Blast Furnace Gas. H. D. EGBERT. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 1, pp. 39–43.

Enzymes of Milk and Butter. R. W. THATCHER AND A. C. DAHLBERG. *Journal of Agricultural Research*, Vol. 11 (1917), No. 9, pp. 437–450.

Evaporation: New Method of Increasing the Evaporation in Boilers. CARL HERING. *Power*, Vol. 47 (1918), No. 1, pp. 10–13.

Flotation: The Effect of Addition Agents in Flotation. M. H. THORNBERRY AND H. T. MANN. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 12, pp. 709–713.

Flotation at Cobalt, Ontario. W. E. SIMPSON. *Mining and Scientific Press*, Vol. 115 (1917), No. 23, pp. 819–824.

Forestry: A Financial Analysis of Forestry and Reforestation. ELLWOOD WILSON. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 1, pp. 5–7.

Fuel Briquettes: Utilization of City Garbage for Fuel Briquettes and Other Products. W. B. PHILLIPS. *Manufacturers Record*, Vol. 73 (1918), No. 1, p. 85.

Furnaces: The Action of Flame in Furnaces. A. D. WILLIAMS. *The Iron Trade Review*, Vol. 61 (1917), No. 25, pp. 1319–1323.

Fusion: Some Notes on Fusion Apparatus. FREDERICK POPE. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 12, pp. 704–709.

Gas Circulation in Regenerator Checkers. A. D. WILLIAMS. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 1, pp. 29–33.

Gas Explosions at Blast Furnaces. F. H. WILLCOX. *The Iron Trade Review*, Vol. 61 (1917), No. 26, pp. 1377–1380.

Gels: The Formation of Crystals in Gels. H. N. HOLMES. *Journal of Physical Chemistry*, Vol. 21 (1917), No. 9, pp. 709–733.

Heat Hazards—An Industrial Waste. J. A. WATKINS. *The Iron Trade Review*, Vol. 61 (1917), No. 26, pp. 1387–1388.

Hydrocyanic-Acid Gas as a Soil Fumigant. E. R. DE ONG. *Journal of Agricultural Research*, Vol. 11 (1917), No. 9, pp. 421–436.

Hydrosulfite of Soda: Preparing Hydrosulfite of Soda. *Textile World Journal*, Vol. 53 (1917), No. 26, pp. 23–25.

Iron and Steel Technology, 1917. R. J. ANDERSON. *The Iron Trade Review*, Vol. 62 (1918), No. 2, pp. 156–161.

Microscopic Features in Silver-Deposition. F. N. GUILD. *Mining and Scientific Press*, Vol. 115 (1917), No. 24, pp. 857–864.

Platinum: Recovery of Platinum in Gold Dredging. J. W. NEILL. *Mining and Scientific Press*, Vol. 115 (1917), No. 23, pp. 825–827.

Potash: The Nebraska Potash Industry. E. E. THUM. *Metallurgical and Chemical Engineering*, Vol. 17 (1917), No. 12, pp. 693–698.

Potash in 1916. H. S. GALE. *The American Fertilizer*, Vol. 46 (1918), No. 1, pp. 37–40.

Pulp Mills: The Chemical Development of Pulp Mills at Berlin, N. H. ELLWOOD HENDRICK. *Pulp and Paper Magazine*, Vol. 15 (1918), No. 52, pp. 1209–1213.

Pulpwood: Factors Influencing the Value of Pulpwood. S. D. WELLS. *Paper*, Vol. 21 (1918), No. 17, pp. 11–15.

Pulpwood Handling and Storage Systems. E. R. LOW. *Paper*, Vol. 21 (1917), No. 15, pp. 11–13.

Redredging—Will It Pay? W. H. GARDNER. *Engineering and Mining Journal*, Vol. 105 (1918), No. 1, pp. 1–3.

Soils: Movement of Soluble Salts through Soils. M. M. MCCOOL AND L. C. WHEETING. *Journal of Agricultural Research*, Vol. 11 (1917), No. 11, pp. 531–547.

Steel Production by the Duplex Process. J. K. FURST. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 1, pp. 25–28.

Textile Mill Organization and Costs. EUGENE SZEPESI. *Textile World Journal*, Vol. 53 (1917), No. 25, pp. 23 and 48.

Tin Dredging in Portugal. F. W. FOOTE AND R. S. RANSOM, JR. *Engineering and Mining Journal*, Vol. 104 (1917), No. 26, pp. 1109–1110.

Ultraviolet Light. VIII. Types of Apparatus Used for Sterilization and Other Purposes. C. ELLIS AND A. A. WELLS. *The Chemical Engineer*, Vol. 26 (1918), No. 1, pp. 28–34.

Wood: Economical Wood Splitting. H. G. SARCKER. *Paper*, Vol. 21 (1917), No. 14, pp. 16–17.

MARKET REPORT—JANUARY, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JAN. 15

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lbs.	4.00	@	4.50
Aluminum Sulfate, high-grade	Lb.	2¾	@	3
Ammonium Carbonate, domestic	Lb.	11	@	11¼
Ammonium Chloride, white	Lb.	15	@	17
Aqua Ammonia, 26°, drums	Lb.	20	@	21
Arsenic, white	Lb.	16½	@	17
Barium Chloride	Ton	75	@	85
Barium Nitrate	Lb.	9½	@	11
Barytes, prime white, foreign	Ton	40.00	@	45.00
Bleaching Powder, 35 per cent	100 Lbs.	2.50	@	3.00
Blue Vitriol	Lb.	9	@	9½
Borax, crystals, in bags	Lb.	7¼	@	8
Boric Acid, powdered crystals	Lb.	13¼	@	15
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	85
Calcium Chloride, lump, 70 to 75% fused	Ton	30.00	@	32.00
Caustic Soda, 76 per cent	100 Lbs.	6.00	@	6.25
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	18.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20	@	30
Glauber's Salt, in bbls	100 Lbs.	1.00	@	1.50
Green Vitriol, bulk	100 Lbs.	1.15	@	1.25
Hydrochloric Acid, commercial, 20°	Lb.	3½	@	4
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	19
Lead Nitrate	Lb.	nominal		
Litharge, American	Lb	9½	@	10
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	18	@	20
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	9	@	10
Nitric Acid, 42°	Lb.	9	@	10
Phosphoric Acid, 48/50%	Lb.	7½	@	8
Phosphorus, yellow	Lb.	1.70	@	1.90
Plaster of Paris	Bbl.	1.50	@	1.70
Potassium Bichromate, casks	Lb.	43	@	44
Potassium Bromide, granular	Lb.	1.45	@	1.46
Potassium Carbonate, calcined, 80 @ 85%	Lb.	45	@	55
Potassium Chlorate, crystals, spot	Lb.	40	@	42½
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	83½	@	84
Potassium Iodine, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	28	@	30
Potassium Permanganate, bulk	Lb.	4.10	@	4.15
Quicksilver, flask	75 Lbs.	135.00	@	140.00
Red Lead, American, dry	Lb.	10	@	10½
Salt Cake, glass makers'	Ton	30.00	@	35.00
Silver Nitrate	Oz.	53	@	56
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	3.00	@	3.10
Sodium Acetate	Lb.	17	@	18
Sodium Bicarbonate, domestic	100 Lbs.	2.65	@	2.75
Sodium Bichromate	Lb.	20	@	22
Sodium Chlorate	Lb.	20	@	22
Sodium Cyanide	Lb.	44	@	45
Sodium Fluoride, commercial	Lb.	18	@	19
Sodium Hyposulfite	100 Lbs.	2.50	@	3.00
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.50	@	4.60
Sodium Silicate, liquid, 40° Bé	100 Lbs.	1.75	@	2.00
Sodium Sulfide, 60%, fused, in bbls	Lb.	4⅞	@	5
Sodium Bisulfite, powdered	Lb.	6¾	@	7
Strontium Nitrate	Lb.	22	@	30
Sulfur, flowers, sublimed	100 Lbs.	nominal		
Sulfur, roll	100 Lbs.	nominal		
Sulfuric Acid, chamber, 66° Bé	Ton	nominal		
Sulfuric Acid, oleum (fuming)	Ton	75.00	@	80.00
Talc, American white	Ton	15.00	@	18.00
Terra Alba, American, No. 1	100 Lbs.	85	@	90
Tin Bichloride, 50°	Lb.	55	@	56
Tin Oxide	Lb.	80	@	85
White Lead, American, dry	Lb.	9	@	9½
Zinc Carbonate	Lb.	25	@	30
Zinc Chloride, commercial	Lb	10½	@	11
Zinc Oxide, American process XX	Lb.	13	@	14

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	75	@	80
Acetic Acid, 56 per cent, in bbls	Lb.	11	@	11½
Acetic Acid, glacial, 99½%, in carboys	Lb	34	@	35
Acetone, drums	Lb.	nominal		
Alcohol, denatured, 180 proof	Gal.	72	@	75
Alcohol, sugar cane, 188 proof	Gal.	5.05	@	5.25
Alcohol, wood, 95 per cent, refined	Gal.	nominal		
Amyl Acetate	Gal.	5.10	@	5.25
Aniline Oil, drums extra	Lb.	26	@	28
Benzoic Acid, ex-toluol	Lb.	5.25	@	5.50
Benzol, Pure	Gal.	35	@	40
Camphor, refined in bulk, bbls	Lb.	85	@	86
Carbolic Acid, U. S. P., crystals, drums	Lb.	52	@	54
Carbon Bisulfide	Lb.	7½	@	8
Carbon Tetrachloride, drums, 100 gals	Lb.	15½	@	16
Chloroform	Lb.	63	@	65
Citric Acid, domestic, crystals	Lb.	75	@	78
Creosote, beechwood	Lb.	1.90	@	2.00
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	7	@	8
Dextrine, imported potato	Lb.	18	@	20
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	19½	@	20
Glycerine, dynamite, drums included	Lb.	64	@	65
Oxalic Acid, in casks	Lb.	45	@	46
Pyrogallic Acid, resublimed, bulk	Lb.	3.15	@	3.25
Salicylic Acid, U. S. P.	Lb.	1.10	@	1.15
Starch, cassava	Lb.	—		
Starch, corn (carloads, bags) pearl	100 Lbs.	6.30	@	6.45
Starch, potato, Japanese	Lb.	10½	@	11
Starch, rice	Lb.	10	@	12
Starch : sago flour	Lb.	6½	@	7½
Starch, wheat	Lb.	5¾	@	6½
Tannic Acid, commercial	Lb.	50	@	[illegible]
Tartaric Acid, crystals	Lb.	78½	@	79

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	55	@	60
Black Mineral Oil, 29 gravity	Gal.	19	@	20
Castor Oil, No. 3	Lb.	29	@	29½
Ceresin, yellow	Lb.	nominal		
Corn Oil, crude	100 Lbs.	18.65	@	18.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	
Cottonseed Oil, p. s. y.	100 Lbs.	20.25		
Menhaden Oil, crude (southern)	Gal.	—	@	—
Neat's-foot Oil, 20°	Gal.	2.70	@	2.80
Paraffin, crude, 118 to 120 m. p.	Lb.	11	@	11½
Paraffin Oil, high viscosity	Gal.	36	@	37
Rosin, "F" Grade, 280 lbs.	Bbl.	7.05	@	7.10
Rosin Oil, first run	Gal.	41	@	42
Shellac, T. N.	Lb.	58	@	59
Spermaceti, cake	Lb.	25		
Sperm Oil, bleached winter, 38°	Gal.	2.08	@	2.10
Spindle Oil, No 200	Gal.	35	@	36
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.57	@	1.62
Tar Oil, distilled	Gal.	30	@	35
Turpentine, spirits of	Gal.	50	@	50½

METALS

Aluminum, No. 1, ingots	Lb.	36	@	38
Antimony, ordinary	Lb.	14	@	14¼
Bismuth, N. Y.	Lb.	2.85	@	2.90
Copper, electrolytic	Lb.	23½	@	—
Copper, lake	Lb.	23½	@	—
Lead, N. Y.	Lb.	6¾	@	7
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	105.00		
Silver	Oz.	85¾	@	90
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	23.00	@	25.00
Zinc, N. Y.	Lb.	8	@	8¼

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.25	@	7.30
Blood, dried, f. o. b. Chicago	Unit	6.50	@	6.55
Bone, 3 and 50, ground raw	Ton	31.00	@	33.00
Calcium Cyanamid	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	nominal		
Phosphate, acid, 16 per cent	Ton	16.00	@	16.50
Phosphate rock, f. o. b. mine:		5.50	@	6.50
Florida land pebble, 68 per cent	Ton	2.25	@	2.50
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	350.00	@	355.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.50	&	10

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | MARCH 1, 1918 | No. 3

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD | *Advertising Manager:* G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY, M. C. WHITAKER

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- Where Are the Leaders? ... 172
- A Long Step in the Right Direction ... 172
- Facts for the Tariff Commission ... 173
- A Patent Abuse ... 173
- Wasting Waters ... 174
- Spruce Turpentine to the Fore ... 174
- Sugar and Soap ... 175
- The Naval Consulting Board ... 175

ORIGINAL PAPERS:
- American Sources of Supply for the Various Sugars. C. S. Hudson ... 176
- The Deterioration of Raw Cane Sugar: A Problem in Food Conservation. C. A. Browne ... 178
- Theory and Practice in the Design of Multiple Evaporators for Sugar Factories. A. L. Webre ... 191
- Notes on the Analysis of Molasses. Herbert S. Walker. 198
- Relation between Efficiency of Refrigerating Plants and the Purity of Their Ammonia Charge. F. W. Frerichs ... 202
- Testing Natural Gas for Gasoline. G. G. Oberfell ... 211
- The Valuation of Lime for Various Purposes. Richard K. Meade ... 214
- A Study of the DeRoode Method for the Determination of Potash in Fertilizer Materials. T. E. Keitt and H. E. Shiver ... 219

LABORATORY AND PLANT:
- Blue and Brown Print Paper: Characteristics, Tests and Specifications. F. P. Veitch, C. Frank Sammet and E. O. Reed ... 222
- A Hydrogen Sulfide Generator. Louis Sattler ... 226
- Distinguishing Manila from All Other "Hard" Rope Fibers. Charles E. Swett ... 227

CURRENT INDUSTRIAL NEWS:
- Diesel Engine Blast Pressure Control; Hides and Skins from Venezuela; Germany's Commercial Methods; Coal-Mining Machinery for Argentina; Utilization of Nitre Cake; Electro-Technical Industry in Japan; Tannin and Timber; Aluminum Goods for Brazil; Wiring Supplies; Pure Bismuth; Chromium Steel for Magnets; An Automatic Controller for Electrical Heating Apparatus; Machinery for Korea; Autoclaves and High Pressure Problems; South African Industrial Developments; Utilization of Waste Boots; Vegetable Wax from Colombia; Zinc Refining in Japan; British Board of Trade ... 228

TRADE ASSOCIATIONS:
- The Chemical Alliance; Dyestuff Convention; American Drug Manufacturers Association ... 231

CHEMISTS IN WAR SERVICE:
- Government Recognizes the Importance of Chemistry in the War ... 234

NOTES AND CORRESPONDENCE:
- Spring Meeting of the American Chemical Society; War Risk Insurance for Chemists in Military Service; Ramsay Memorial Fund; Chemical Research in the Various Countries before the War and in 1917; Licenses Required for Explosives and Their Ingredients; The Indexes to Chemical Abstracts; The Utilization of Niter Cake; Readjustments at the Massachusetts Institute of Technology to Meet War Conditions; Directions for Assistant Editors and Abstractors; Estimation of Phenol in the Presence of the Three Cresols—Correction; Electric Furnace Smelting of Phosphate Rock, etc.—Correction ... 236

WASHINGTON LETTER ... 239

OBITUARIES:
- Charles Caspari, Jr.; Joseph Price Remington ... 240

PERSONAL NOTES ... 241

INDUSTRIAL NOTES ... 243

GOVERNMENT PUBLICATIONS ... 245

BOOK REVIEWS:
- The Distillation of Resins; The Chemistry of Farm Practice; An Introduction to Theoretical and Applied Colloid Chemistry; The Chemistry of Colloids; Allen's Commercial Organic Analysis; Standard Methods of Chemical Analysis. A Manual of Analytical Methods and General Reference for the Analytical Chemist and the Advanced Student; Laboratory Guide of Industrial Chemistry ... 249

NEW PUBLICATIONS ... 251

MARKET REPORT ... 252

EDITORIALS

WHERE ARE THE LEADERS?

To back the man power of our military forces the enormous industrial resources of the country are being assembled. Chemistry permeates every fiber of our national economic body. It is but logical, therefore, that intense chemical activity should prevail in Washington at the present moment. Chemists from every quarter have been called to this center of war preparations. These men are giving all of their talent and energy in loyal devotion to the interests of America.

With characteristic foresightedness the Director of the Bureau of Mines early began the development of a great organization of research chemists to investigate the various problems connected with gas warfare—offensive and defensive. The War Department, particularly the Ordnance Bureau, has added largely to its staff of chemists for test, inspection and supply of material vital to the successful prosecution of the war. The Navy Department, always "on the job," is relying upon the applications of chemical principles. The War Industries Board is confronted constantly with chemical questions of the first magnitude. The Chemical Service Section of the National Army, attached directly to General Pershing's Staff, functions as a field service, and is prepared to advise him directly on pressing problems arising from day to day in the manifold activities of a continually growing army on French soil. The Sanitary Corps depends upon its chemical experts for safe guidance in measures to protect the physical well-being of the men in camp and in field. The government chemical bureaus have expanded their normal activities. Chemistry everywhere! So it should be, if the best results are to be obtained.

The greater part of the work up to the present time has been research. This has been well done, and carried out with the utmost despatch. Now we are entering upon—indeed, are already getting well into—a new phase, namely, the production of materials on an immense scale. Laboratory results must be translated quickly into terms of plant operation. The requisites now are rapid plant construction and a never-failing yield of abundant finished product.

As we view fairly and honestly the inauguration of this phase of the work, candor compels the statement that the feeling of pride in the accomplishments of the initial stage has given way to grave apprehension over the ultimate outcome of this all-important second stage, for mistakes here will be measured in the blood of young Americans now being trained for the heart-rending days that are just before us.

A great chemical industry must be developed immediately. Through some strange concatenation of circumstances men are now charged with the responsibility of vast chemical developments who, in times of peace and by those best qualified to judge, would never have been thought of; others are daily called upon to decide gravest questions of supplies of chemicals who, it is commonly reported, know not even the names of these substances save as they have become familiar in the routine of the new duties; much less is there full understanding of the interdependence of these products and their relative values. It is a serious situation and one which calls for wise and courageous treatment. Where are the leaders, the men who in peace times have made this country what it is, so far as chemistry has affected its fashioning? They are not in Washington. There they should be, giving of their very best in talent, in experience, and in executive ability. Furthermore, now is the time for the appointment of a man preëminent among these leaders to act as a coördinating agent for the multifarious chemical activities; to have at his command the highest specialized talent in the land for projecting into being the plants whose output bears so directly on the future welfare of the world; and to adjust the requirements of the various Departments as supply steadily increases: a man with chemical experience, with knowledge of chemical personnel, with executive ability of the highest order, and blessed with vision. Such a man can be found. A sure road to his discovery would lie in the request from President Wilson for a joint recommendation from the Directors of the American Chemical Society, the Chemical Alliance, the American Institute of Chemical Engineers and the American Electrochemical Society.

Give such a man the power to do things, and hold him responsible to the nation for the use of that power. The days for preparation are passing!

A LONG STEP IN THE RIGHT DIRECTION

The last number of THIS JOURNAL contained an editorial entitled "Somebody Please Cut the Tape." It develops that on January 26, after we had gone to press, the Adjutant General issued an order correcting radical defects in the method of securing the transfer of chemists to positions in which their training can best be utilized. On page 234 of this issue statements from the Chemical Service Section of the National Army are published, outlining the measures initiated to put this new order into effect. These communications are followed by important announcements from Secretary Parsons. It is of particular interest to note that the War Department is making no narrow and strictly technical definition of the term "chemical engineer" in its attitude toward the return for graduation of drafted chemical engineering students. The red tape which bound those cards of information on file in the office of Secretary Parsons has been cut, and it is gratifying to learn that common sense is prevailing. Careful reading of these statements is urged upon all.

There is one issue, however, which still deserves most serious consideration by the authorities, namely, the question of deferred classification of university

instructors. Among others, Secretary Baker, General Wood, and, more recently, Mr. Hoover have publicly urged all students to remain in college unless actually drafted. In orders promulgated by the War Department, official recognition has been given of the necessity for continued preparation of students in engineering and in medicine. The successful training of both of these groups of men involves fundamental instruction in chemistry. Yet it seems that the Local Draft Boards throughout the country are declining to give any deferred classification to instructors in chemistry.

In practically every institution, members of the teaching staffs have been assigned by the Local Boards to Class 1-*A*. In a few isolated cases, and only as the result of strenuous effort on the part of university administrators, District Boards have transferred these men to Class 3-*K*. Yet upon the instructors, for the most part of draft age, must fall a large part of the burden of instructional work, for already the staffs of these same institutions have been seriously crippled by the withdrawal of many professors for war investigations in Washington, and for the Chemical Service Section of the National Army, while many important government researches are being prosecuted within university laboratories. The candle is being burned at both ends.

If it be considered necessary for the country's welfare that students should continue their university training, surely it is logical that these men should have competent and adequate instruction. Otherwise the entire program falls through.

The action of the Adjutant General in clarifying the industrial situation warrants the hope that the Provost Marshal General will likewise issue orders to prevent the decimation of the instructional staffs of the institutions where, at the direction of the War Department, young men are to be trained in order eventually to give to this country the greatest service of which they are capable.

FACTS FOR THE TARIFF COMMISSION

From the Chairman of the Tariff Commission we have received a copy of the letter and accompanying questionnaire as to production and consumption recently sent out to all manufacturers of intermediates, dyes, medicinals, photographic chemicals, flavors, synthetic phenol resins, and to those plants other than coke plants and gas houses, manufacturing crudes.

In conducting this census the Commission is accumulating the evidence by which the President, under the law as it now stands, will eventually be guided in the matter of the possible repeal of the special duties. We are confident that manufacturers, regardless of the time and labor involved, will promptly and in fullest detail furnish the Commission the information desired. And it is directly to the manufacturer's own interest to do so. The published summary of this census will furnish facts which will prove the vindication and glory of the American manufacturer and constitute the certain basis upon which a repeal of the sixty per cent clause can be recommended and urged.

Furthermore, this publication should serve as an accurate and illuminating gude for the future coördination and intelligent diversification of the dyestuff industry.

We have been especially interested in reading one portion of the questionnaire and quote herewith from the second footnote on page 7:

"The term 'indigoids' has not yet been defined by the courts. It is, therefore, urged that special care be taken to explain the chemical nature of all dyes which might be regarded as indigoids. Such explanation will enable the Commission to make classifications in accordance with future judicial interpretation of this word."

Congress can relieve the courts of the necessity of making any such "judicial interpretatioh" by striking out the word.

It is altogether pleasant and assuring as we approach the day of further legislation concerning tariffs and especially tariffs on dyestuffs to sense a new standard of action. The log-rolling spirit of previous years has been put in the background and in its place appears a desire for facts as a guide for action. For this change we are largely indebted to the able and comprehensive manner in which the Tariff Commission has begun its labors. Then, too, the spirit of the times precludes excessive partisanship; more and more, selfish and purely local considerations are yielding to whole-hearted devotion to national interests. Such an atmosphere justifies the utmost confidence as to the character of future legislation.

A PATENT ABUSE

The exigencies of the war period have led to feverish activity in many laboratories in attempts to carry out processes described in the literature and in patent specifications, chiefly in the field of organic chemistry. Within the past year we have frequently been apprised by chemists of the lack of success in the preparation of compounds by following directions, even by most careful attention to the minutest details, in the official records. Men who have experienced this difficulty stand so high that no question of lack of skill and technique can be involved, and we are forced to the conclusion that deliberate misrepresentation has been made, especially in the case of certain foreign patents. If this is true it is extremely regrettable that the literature of chemistry is clogged with such deceit; in the case of patent specifications, it is reprehensible, in that a matter of perjury is involved. The demonstration of such falsity would immediately invalidate the patent, but this is a tedious process, necessitating a great amount of laboratory work and expense and loss of time in litigation.

Our patent system should be protected against impositions. This might be accomplished in one of at least three ways: *First*, the Patent Office might test the good faith of all applicants for chemical patents by making greater use of existing government laboratories. It is doubtful, however, in view of the work already engaging the attention of these federal laboratories, whether a further tax upon their courtesy would

be justifiable. *Second*, the Patent Office might be provided with a control laboratory of its own. The varied character of the applications for patents covering all fields of chemistry would necessitate a large, efficiently manned laboratory. This would entail considerable expense, nevertheless it would be an expenditure operating for the benefit of the entire country. *Third*, the Patent Office might require of the applicant a laboratory demonstration of the correctness of the specifications. This would place the burden of the proof upon the inventor, but would work no hardship upon organizations having extensive laboratories, though it might affect the man of small means.

Perhaps there are other practicable remedies. Certain it is that the abuse should be eliminated, and the first step toward this end is the demonstration of the correctness of the original premise, namely, that the Patent Office files have been befouled with false declarations. If evidence can be brought together, we are fortunately in position to place it where it will do most good, and we therefore urge all chemists who have been led up a blind alley by following the directions outlined in patents, to communicate that fact to this office, designating by number and subject the misleading patent, and supplementing this by a brief exposition of the difficulties encountered. This is more than an invitation, it is an appeal, for nothing can be more vital to the future of the chemical industries than the establishment upon a firm basis of the patent system, whose *raison d'être* is the stimulation of the inventive genius of the Nation by affording full protection of the law to those who record with it the truth concerning their discoveries.

WASTING WATERS

An anomalous situation presents itself at Washington and at Niagara Falls. At Washington, under the authority of the President, the power produced by the several American companies at Niagara Falls, together with that imported from the Canadian side, has been requisitioned. The War Industries Board is now engaged in the task of redistributing this power in a manner "to assure the adequate supply of electric power for the establishments engaged in war work at Niagara Falls and Buffalo." There can be no difference of opinion as to the wisdom of this step, regardless of the fact that about one hundred and ten plants at Buffalo, hitherto dependent solely upon this power, may now use it only when it is not needed for war work, or else must resort to steam plants requiring that form of carbon which at present is, if anything, more difficult to obtain than the crystalline variety.

Also at Washington legislation has been enacted for the express purpose of relieving the power shortage at Niagara Falls by authorizing the diversion of the full amount of water permitted under treaty stipulations. All this sounds hopeful and helpful. Such is the state of affairs at the Washington end.

On the other hand, at Niagara Falls water sufficient for generating 65,000 horse power, the diversion of which has been duly authorized by Act of Congress, is to-day flowing over the falls, serving no other purpose, while the Nation's life is at stake, than the delectation of bridal couples having the temerity to journey in such unseasonable weather to this classic resort of newly-weds. Of the 80,000 horse power capable of being produced under the legally increased take-off of water only 15,000 has been developed.

The explanation is simple: the terms of the Act are so restrictive that private capital will not risk the necessary increased investment. To make this clear, we quote from the joint resolution approved January 19, 1917, which resolution on June 30, 1917, was "continued and in full force and effect, and under the same conditions, restrictions and limitations until July 1st, nineteen hundred and eighteen."

"Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized to issue permits, *revocable at will*, for the diversion of water in the United States from the Niagara River above the Falls for the creation of power to individuals, companies, or corporations which *are now* actually producing power from the waters of said river, in additional quantities which, with present diversions, shall in no case exceed the capacity of the generating machinery of the permittee and tenant companies *now* installed and ready for operation, nor an amount sufficient to enable the permittee to supply the now existing hydroelectric demands of the individuals, companies, or corporations which said permittee and tenant companies are now supplying, *but not in excess of the capacity of power-using appliances of said consumers now installed and ready for operation* * *"* (Italics are ours.)

We hold no brief for the power companies at Niagara Falls, nor on the other hand can they be blamed for failure to develop this power, under the restrictions the law now imposes. We do, however, feel the same impatient interest as would be aroused by the sight of trainloads of coal controlled by the Government burning on the railroad tracks, while the fire department sat knitting sweaters for the boys at the front.

Sixteen and a half pages of the *Congressional Record* devoted to the debate in the House of Representatives on the reintroduced Garabed resolution which offers to produce something from nothing, while water sufficient for 65,000 horse power glides uninterruptedly over the Falls! It may be that the bill of Representative Waldow, recently introduced (H. R. 8491), "empowering the President to take possession and assume control of projects for the generation of hydroelectric power from the waters of Niagara River, etc.," will prove the salvation of this situation, but it is too often a long time between the introduction of a bill in Congress and its ultimate signature by the President

Divert those wasting waters into channels where, to the uttermost drop, their energy will turn the wheels of the munitions plants of the Nation!

SPRUCE TURPENTINE TO THE FORE

The scene shifts rapidly nowadays. Two months ago we pointed out to sulfite pulp manufacturers the necessity of recovering spruce turpentine for the purpose of increasing the toluol supply of the Army. On

February 6 we were shown a letter from the president of one of the largest paper concerns, waving aside the whole matter of spruce turpentine as being not worth consideration. In spite of the judgment of this high official we had the boldness on the same evening to urge the members of the Technical Association of the Pulp and Paper Industry to devote the full energies of their research laboratories and engineering departments to this subject, on the ground that in times like the present manufacturing problems involving the supply of material needed for our army in France pass beyond the realm of the cold-blooded calculations of peace times—that business must be conducted, where war material is concerned, on a higher basis than one of mere profits. An interesting confirmation of the soundness of that contention was furnished on the following day, when, at a conference of representatives of the War Department and of the Association, a strong committee was appointed to ascertain what supplies of spruce turpentine may be available, and to coöperate with the War Department in procuring the installation at mills of suitable apparatus for its recovery. The committee from the Association consists of Henry E. Fletcher, Alpena, Mich., chairman; F. M. Williams, Watertown, N. Y.; W. E. Byron Baker, York Haven, Pa.; P. A. Paulson, Kimberly, Wis.; Henry F. Obermanns, Erie, Pa.; Morris W. Hedden, 736 Pittock Block, Portland, Ore.; George K. Spence, Johnsonburg, Pa.; E. R. Barker, 79 Milk St., Boston, Mass.; A. W. Nickerson, 501 Fifth Ave., New York.

It is not a hard tax upon the imagination to believe that when peace has come again the availability of so large a quantity of pure cymene will, through the work of research laboratories, open a new chapter in chemical industry.

SUGAR AND SOAP

We are fortunate in presenting in this issue four distinct and important contributions bearing upon various aspects of the sugar industry. It may be well in this connection to call attention to the use of sugar in the manufacture of soap, to produce transparency. For this purpose from five to ten per cent of sugar is added. Its function is purely an aesthetic one; a transparent soap delights the eye, but how pleasing to the palate would have been that extra lump of sugar, without which we have gone for months. This is a day of demarcation of essentials and non-essentials, and surely the transparent quality of soap is not essential in attaining that cleanliness which, according to the proverb, is next to godliness.

THE NAVAL CONSULTING BOARD

The first of the many war boards organized for the purpose of civilian coöperation with the regularly constituted authorities was the Naval Consulting Board. It is unique in that its members were nominated by the chemical and engineering societies upon invitation of the Secretary of the Navy. For this reason chemists will be particularly interested in that portion of the concise and impressive report of Secretary Daniels referring to the work of this Board.

"During the year the work of the Naval Consulting Board, organized and approved by Congress in 1915, has increased very materially in importance and volume, its meetings have been frequent and the work of the individual members has been such in some cases as to occupy almost their entire time in the service of the Government.

"Some time before the active entry of this country into war the Board called a special meeting to which were invited some 50 of the leading scientists and industrial managers, whose special study fitted them to advise on the methods of meeting the submarine problem.

"Plans were immediately made to investigate every field to develop a means of preventing destruction of vessels and of defeating the U-boat. The investigation was divided according to the experience of the different members and associated scientists and with the coöperation and valuable assistance of the various manufacturing companies interested a highly developed system of team work has been attained and results accomplished not dreamed of at the beginning of the war.

"The services of the Board were offered to the Council of National Defense and accepted by that body for the investigation of all inventions submitted. Its services were also accepted by the War Department in an advisory capacity.

"Valuable assistance has been rendered merchant shipping by the Board's activities. * * * In this field the Board's work has resulted in materially reducing the shipping risk, with a consequent lowering of marine insurance rates.

"Not the least result of its work has been the stimulation of interest, in the problems brought up by the war, throughout the country by the general invitation to submit ideas for investigation. Early in the calendar year 1917 this interest manifested itself in the receipt of thousands of ideas weekly, and to care for this the department's connecting office has been greatly enlarged, the office of the Board in New York has been organized on a working basis with a large force, and the whole movement has received the approval and hearty assistance of the great national engineering societies. The president of the Board, Mr. Thomas A. Edison, has been giving his entire time to the work of the Board in the service of his country, and has called to his assistance a capable staff who are working diligently upon naval problems.

"With war conditions increasing the need for labor and building materials, it was believed to be a wise policy to defer for a time the building of the new experimental and research laboratory. Such experiments as have been warranted have been made in private laboratories generously offered and at the Bureau of Standards. The need for this establishment, however, is more clearly shown than ever, and its support is urgently advised.

"The valuable results obtained by the work of this Board are of too confidential a nature to make them the subject of a public document. The members have given freely of their time and scientific ability to the service of the Nation and have earned the gratitude of all who know their unselfish and patriotic service. I wish to express my sense of obligation for the cheerful coöperation, wise counsel, loyal devotion, and personal sacrifice which have characterized the membership of the Board of distinguished civilians who responded, long before war was declared, to the selective draft with all the enthusiasm and efficiency of youthful volunteers."

Drs. L. H. Baekeland and W. R. Whitney, the representatives of the American Chemical Society, have given generously of their time, energy and talents to this service, and it will be gratifying to all to read these words of appreciation of their ability and patriotic spirit.

ORIGINAL PAPERS

AMERICAN SOURCES OF SUPPLY FOR THE VARIOUS SUGARS

By C. S. Hudson[1]

Received January 16, 1918

The annual consumption of sugar in the United States is approximately 4,300,000 short tons or nearly 86 lbs. per capita. The sources of this sugar are:

Cane Sugar from Cuba	49 per cent
Domestic Beet Sugar	21 per cent
Cane Sugar from Hawaii	13 per cent
Cane Sugar from Porto Rico	8 per cent
Cane Sugar from Louisiana	6 per cent
Cane Sugar from the Philippines	3 per cent

It will be noticed that 73 per cent of the sugar comes from over the sea. The domestic beet sugar is produced principally in the states of Colorado, California, Utah, Michigan, Idaho and Ohio, with smaller quantities from several others.[2] The growth of beet sugar production in the United States has been phenomenal, the output having increased from 2,000 tons in 1888 to 430,000 tons in 1908 and 800,000 tons in 1915. The further extension of sugar production in the continental United States will probably come from increased plantings of sugar beets, and possibly also from the growth of sugar cane in the drained lands of southern Florida, though it must be added that the commercial production of cane sugar in that locality is not yet demonstrated and may not prove possible. It will be borne in mind by those investigators who may be seeking new sources for sugar that many plants yield sweet sirups which might be used for sweetening purposes if the natural accompanying colors and flavors could be removed. In recent years this removal has become a possibility through the use of active decolorizing carbons that may be prepared from wood in a variety of ways.[3]

Crystalline *dextrose* (corn sugar) is produced in the United States in very large quantities by the acid hydrolysis of corn starch, and is used in commercial baking, in tanning, in the production of wines in the Middle West, and to some extent in the manufacture of a type of vinegar. Commercial corn sugar is somewhat yellow in color, a fact which will be readily understood by chemists when it is recalled that dextrose forms small crystals that are in consequence difficult to free from adhering mother liquors.[4]

The third sugar of commercial importance is *milk-sugar*, which was produced in the United States from milk to the extent of about 3,500,000 pounds in 1914, at 16 factories, the supply being increased by the importation of nearly 600,000 pounds.

Crystalline *levulose* was imported from Germany before the present war for use by diabetics as a sweetening agent, but it does not appear to have been manufactured at any time in the United States. It is not difficult to prepare levulose, either as a sirup or in crystals, by forming from inverted cane sugar and lime the crystalline calcium levulosate that Dubrunfaut discovered early in the last century and breaking up this compound into levulose and calcium carbonate by the use of carbon dioxide. Indeed this very old process is quite worthy of consideration as a possible method of preparing a sweet sirup from plants that yield inulin, since the latter is readily hydrolyzed by dilute acids to levulose. Levulose is the sweetest of all the sugars. Chicory, the Jerusalem artichoke (*Helianthus tuberosus*), and the sotol plant,[1] a species of Agave (*Dasylirion*) that grows abundantly in the wild state in Texas, contain much inulin or inulin-like substance.

The *lactone of α-glucoheptonic acid*, which may be prepared from dextrose by the cyanhydrin synthesis, is rather sweet and apparently has been manufactured to some extent in Germany for use by diabetics.[2]

Many sugars that are of much interest to scientists, particularly chemists and bacteriologists, are almost wholly unknown to the general public, even though some of them are consumed in large quantities as natural components of foods for man and domestic animals. Thus *raffinose* is contained in cottonseed meal to the extent of nearly 8 per cent; this portion of the weight of the cottonseed cake that is produced annually in the United States amounts to about 100,000 tons. Cottonseed meal offers the best source for the preparation of crystalline raffinose,[3] which is used in bacteriology to some extent. From raffinose the disaccharide *melibiose* may be prepared in good yield;[4] the latter has never been upon the chemical market and the raffinose that has been used by scientists was imported from Germany, where it was made from cottonseed meal that came from the United States.

Many industrial chemists have sought to prepare from starch by the action of malt the very palatable sugar *maltose*, and the field of possible uses of this sugar, either in crystalline form or as a syrup, is a large one.[5] Most maltose sirups carry a flavor of the malt and do not quite represent the pleasing sweetness of a solution of pure maltose; possibly this objection could be overcome by the use of decolorizing carbon since it readily removes many flavors as well as coloring matters. Maltose forms small crystals that are difficult to wash by commercial processes, but there has always been a small market for C. P. maltose among chemists and bacteriologists. The whole supply for such scientific uses has always been imported

[1] Presidential Address delivered before the Washington Section of the American Chemical Society, January 10, 1918.

[2] Sugar statistics are available from the annual *Yearbook of the U. S. Department of Agriculture* and from Willett & Gray's *Weekly Statistical Sugar Trade Reports*.

[3] For a summary of work on decolorizing carbon, see Schneller *Louisiana Planter*, **59** (1917), 154.

[4] Directions for the laboratory preparation of C. P. dextrose have been published by Hudson and Dale, *J. Am. Chem. Soc.*, **39** (1917), 320.

[1] Hudson THIS JOURNAL, **3** (1911), 145.

[2] See Abderhalden's *Biochemisches Handlexikon*, First Supplementary Volume to Vol. **8** (1914), 253.

[3] Hudson and Harding, *J. Am. Chem. Soc.*, **36** (1914), 2110.

[4] *Ibid.*, **37** (1915), 2734.

[5] For a description of the principal steps in making a maltose sirup, see an early article by Cuisinier, *Sucr. ind.*, **20**, No. 14. German translation in *Z. Ver. Zuckerind.*, **19** (1882), 908.

Mannose, a sugar of much interest to scientists on account of its close kinship to dextrose and levulose, has usually been prepared from the hydrolysis of vegetable ivory, the seed of a palm (*Phytelephas macrocarpa*) that is native to South America. A large industry in the United States has been built upon the manufacture of buttons from vegetable ivory; the waste from these button factories, amounting to twenty-five or more tons a day, offers a very cheap source for the production of mannose. Since the sugar crystallizes only with difficulty it has been customary to prepare that small quantity of it which was used in research by chemists and bacteriologists by separating from the solution of the hydrolyzed vegetable ivory waste a crystalline phenylhydrazone of mannose, regenerating the sugar from this compound, and crystallizing it. Germany has been the source of the marketed product, and little has been imported by the United States, partly because the cost of nearly $200 per lb. has restricted its use even in research. But we now know a process for crystallizing mannose directly from the hydrolyzed vegetable ivory with a large yield,[1] and this interesting sugar should come into more extended use in research chemistry and bacteriology at a relatively low cost. Indeed the possible commercial production of derivatives from mannose, such as *mannite* (by its reduction) or the crystalline *dilactone of mannosaccharic acid* (by its oxidation) should not be lost sight of by chemists. It is very surprising that perfectly pure mannose has a slightly sweet taste that is followed by a distinctly bitter one. Its very close relatives by structure, dextrose and levulose, are both of a pure sweetness, the latter being the sweetest sugar known.

The disaccharide *trehalose*, which is composed of two molecules of dextrose, has always been a very rare sugar. It is of very crystalline habit, resembling cane sugar superficially. It might be useful to have a supply of trehalose available for bacteriological and chemical research. The older sources of it, such as ergot, mushrooms, or trehala manna, have been supplanted by Anselmino and Gilg's[2] discovery that the resurrection plant (*Selaginella lepidophylla*), a native of our own arid Southwest, obtainable in large quantities, contains 2 per cent of trehalose which may readily be crystallized.

Galactose may of course be prepared from the hydrolysis of milk sugar and this is a good source for the production of such supplies of it as are needed by scientists. It has recently been shown by Schorger and Smith[3] that a native species of larch (*Larix occidentalis*), a lumber tree of our Northwest, contains a considerable quantity of a gum that is easily hydrolyzed by acids to yield galactose. This source seems to offer a way for the economical production on a commercial scale of useful derivatives of galactose such as its oxidation product, crystalline *mucic acid*, and possibly *dulcite* from its reduction. The last substance is very useful in bacteriological work, and its price has heretofore been about $400 per lb. The supply of dulcite for scientific research has come from Germany.

Arabinose may be prepared readily by the hydrolysis of beet pulp, the insoluble residue from the technical extraction of sugar beets with water. It has been used by bacteriologists only to a slight extent on account of its cost, but the expense of its production from beet pulp is small. Its reduction product, *arabite*, is also needed in the same field of science. Beet pulp is a much better source for arabinose than the cherry gum that is usually recommended by the textbooks.

An excellent source for the methyl pentose sugar, *rhamnose*, is the bark of the American black oak tree (*Quercus tinctoria*) which is extensively used in dyeing. Its aqueous infusion is known as quercitron extract. Since the early part of the last century, when Chevreul isolated from it the glucoside *quercitrin* (a compound of rhamnose with quercetin), it has been the natural source of the commercial glucoside. There is needed at the present time, however, a description of a dependable process for preparing rhamnose from black oak bark.

The octacetate of cellose is readily obtainable from the action of acetic anhydride and sulfuric acid upon cotton, and the sugar *cellose*, a disaccharide composed of two molecules of dextrose, may be prepared without difficulty by the saponification of the octacetate.

During the last year two new sugars have been added to the group by the work of LaForge.[1] Both of these are members of the seven carbon series of sugars, and their occurrence in natural products indicates that the heptoses are by no means restricted to the fields of synthetic sugars from the chemist's laboratory, but are important natural substances. *Manno-keto-heptose* was found to occur free in the avocado (*Persea gratissima*), a native American fruit that is used extensively as human food. The name avocado is the Spaniard's equivalent for the Aztec ahuacatl. *Sedoheptose* was found in the free state in the stonecrop (*Sedum spectabile*), an ornamental European plant that is now domesticated throughout the world.

The pentose sugar *xylose*, isomeric with arabinose, was first found by Koch in the gummy portion of various woods, but its isolation from such sources is rather difficult and the yield low. Two much better sources of American origin have recently come into notice, namely, cottonseed hulls[2] and corn cobs. In unpublished experiments by Mr. T. S. Harding and myself, yields of about 10 per cent of crystalline xylose were obtained from the acid hydrolysis of corn cobs. While it has long been known that xylose occurs in corn cobs, the yields of crystalline xylose that have been reported have never been as high as one per cent. The yield from corn cobs is much larger than from cottonseed hulls. If industrial uses could be found for xylose, either in the pure state, through derivatives, or in the form of the sirup that results from the hydrolysis of

[1] Hudson and Sawyer, *J. Am. Chem. Soc.*, **39** (1917), 470.
[2] *Ber. pharm. Ges.*, **23** (1913), 326.
[3] THIS JOURNAL, **8** (1916), 495.

[1] *J. Biol. Chem.*, **28** (1917), 511; LaForge and Hudson, *Ibid.*, **30** (1917), 61.
[2] Euler *Grundlagen und Ergebnisse der Pflanzenchemie*, **1** (1908), 44; Hudson and Harding, *J. Am. Chem. Soc.*, **39** (1917), 1038

corn cobs, a way would be open for the use of a very cheap and abundant waste product.

When one realizes that the best sources for nearly all the sugars are to be found among raw products and plants that occur abundantly in America, most of them being of distinctly American origin, the poet's lines,

"My Country 'tis of Thee
Sweet land of liberty,"

seem peculiarly appropriate in a novel sense.

DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

THE DETERIORATION OF RAW CANE SUGAR: A PROBLEM IN FOOD CONSERVATION

By C. A. BROWNE

Received January 4, 1918

INTRODUCTION

The changes in composition of food products between manufacture and consumption involve some of the most interesting problems of agricultural-chemical research. The problems are also of great economic importance, the financial losses, which result from deterioration of food materials during transportation or storage, amounting each year to many millions of dollars. In the case of cane sugar, of which there is at present so serious a shortage, calculations based upon careful analytical and statistical data show that the losses from the deterioration of Cuban sugars alone probably exceed one million dollars per year.

The chief ingredient responsible for the deterioration of sugars is moisture. As far back as three centuries ago, when sugars began to be shipped from the West Indies to Europe, it was observed that moist sugars reached their destination in a much damaged condition. The need of excluding moisture was quickly recognized. Ligon,[1] one of the earliest writers upon the subject, in 1673 pointed out the necessity of keeping sugar "drie in good casks, that no wet or moist aire come to it."

But while early observers were agreed that moisture played an important part in deterioration, the actual cause of the phenomenon was for centuries unknown. It was believed by some that the trouble was due to a deliquescence produced by the action of chlorides and other saline impurities upon the sugar; as late as 1848 Wray[2] stated that in his belief it was possible for "this deliquescence to continue, until the whole mass of sugar is decomposed" and suggested as a possible remedy for deterioration the precipitation of chlorides from cane juices by means of silver nitrate. A more common belief was that deterioration resulted from the action of a glutinous fecula or ferment which occurred naturally in the cane and, if clarification was imperfect, passed into the sugar. The true explanation was not forthcoming until after the work of Pasteur, when Dubrunfaut[1] about 1869 discovered in a deteriorating sugar microörganisms similar to the alcohol and lactic acid producing organisms of Pasteur. After this the deterioration of sugars began to be studied with increasing interest from the standpoint of infection by germs, until the subject has now become one of the most important fields of research in industrial mycology.

After the invention of the polariscope, some three-quarters of a century ago, it became possible to determine the keeping power of sugars with an exactness undreamed of by earlier observers. The refiners of sugar, who were the first to put the polariscope to practical use, employed this instrument not only for determining the value of purchases and for controlling factory operations, but they also used it for following the keeping power of stored sugars. With the accumulation of analytical data, which all such establishments acquire, it was soon observed that other factors beside moisture played an important rôle in the keeping of sugars. It was noticed that impure molasses sugars of high moisture content might keep perfectly when high-grade white sugars of much lower moisture content would rapidly deteriorate. In other words, it became evident that the impurities or non-sucrose constituents of raw sugars must be considered in connection with the moisture content before a reliable forecast could be formed as to keeping power. Various tables and rules were devised, in fact, towards this end, although but little of the valuable information thus gathered was published. The best known of these rules is the so-called "factor-of-safety" of the Colonial Sugar Refining Company of Australia, according to which the moisture of a sugar must not be more than half the non-sugar if the product is to keep. In other words, if W is the percentage of water and S the percentage of sucrose, the quantity $\frac{W}{100 - S - W}$ must not exceed 0.5; or simplified, the quantity $\frac{W}{100 - S}$ must not exceed 0.333.

EXPERIMENTAL PART

A—CHEMICAL OBSERVATIONS

In a report published two years ago the author[2] called attention to the value of the "factor-of-safety" of the Colonial Sugar Refining Company, and his more recent investigations show that the rule is one which can be relied upon in the great majority of cases. The

[1] "History of the Island of Barbadoes," London, **1673**, 111.

[2] "The Practical Sugar Planter," London, **1848**, 342–343. It is interesting to note that Pekelharing (*International Sugar Journal*, **3**, 434) as late as 1900 found it necessary to combat the idea that deterioration was due to the salts contained in sugars.

[1] *Compt. rend.*, **68** (1869), 663. The classic observation of Dubrunfaut upon the deterioration of sugars is worth translating. In commenting upon the fact noted so many times since that raw beet sugars, which were not made by an alkaline clarification, failed to keep, Dubrunfaut wrote as follows:

"By means of the microscope we were able to detect in impure beet sugars the presence of those lower organisms, so accurately described by M. Pasteur, and which are the living causes of the alcoholic and lactic fermentations. Nothing can be more simple, therefore, than to arrive at an immediate understanding of the formation of the glucoses and of the acid reaction in sugars which were not made by the old traditional sugar-house process known under the name of the alkaline process."

Dubrunfaut attributed the deterioration of refined sugars to the impurities, ferments, etc., introduced into the factory by the raw sugar.

It is remarkable how here, as in so many other instances, the opinions of this great French investigator (to whom the sugar industry is indebted for more discoveries than to any other chemist) have been confirmed by subsequent workers.

[2] "The Deterioration of Raw Sugar Samples," *Louisiana Planter*, **54** (1915), 281–2.

author's experiments indicate, however, that, for Cuban and Porto Rican sugars at least, the constant 0.333 is a little too high, the value 0.3 for $\frac{W}{100 - S}$ being more nearly correct.

This is shown by the following series of experiments begun in 1915: Eight sugars were selected of the average Cuban and Porto Rican type with factors of safety ranging between 0.25 and 0.35. Forty glass-stoppered bottles of 8 oz. capacity were then filled with the well mixed samples (making eight sets of five bottles each) and the stoppers sealed hermetically with wax. Periodic analyses were then made, one set of eight bottles being analyzed at the beginning and the other sets put aside for future comparison. The four sugars whose factors ranged from 0.313 to 0.346 deteriorated, while the four samples whose factors ranged from 0.253 to 0.289 suffered no appreciable loss in sucrose. The results obtained upon the four deteriorating samples are given in Table I.

TABLE I—PERIODIC ANALYSES OF BAD-KEEPING SUGARS

Date of Analysis	Sample	Polarization	Water (W) Per cent	Sucrose (S) by Clerget Per cent	Invert Sugar Per cent	Ash Per cent	Undetermined Per cent	W / 100 − S
May 1915	A	96.15	1.25	96.39	0.91	0.47	0.98	0.346
	B	94.85	1.65	95.18	1.22	0.62	1.33	0.343
	C	95.85	1.18	96.34	1.13	0.56	0.79	0.322
	D	95.55	1.31	95.82	0.86	0.70	1.31	0.313
	AVERAGE	95.60	1.35	95.93	1.03	0.59	1.10	0.331
October 1915	A	95.55	1.27	95.75	1.61	0.45	0.92	0.298
	B	94.35	1.65	94.70	2.01	0.61	1.03	0.311
	C	95.15	1.09	95.54	2.04	0.54	0.79	0.244
	D	94.65	1.41	95.09	1.83	0.65	1.02	0.287
	AVERAGE	94.93	1.35	95.27	1.87	0.56	0.95	0.285
January 1916	A	95.55	1.34	95.92	1.64	0.46	0.64	0.328
	B	94.10	1.55	94.65	2.12	0.61	1.07	0.289
	C	94.95	1.12	95.59	2.02	0.55	0.72	0.254
	D	94.55	1.39	95.10	1.90	0.67	0.94	0.284
	AVERAGE	94.79	1.35	95.31	1.92	0.57	0.85	0.288
August 1917	A	94.30	1.40	94.61	2.30	0.43	1.26	0.260
	B	93.10	1.58	93.72	2.61	0.67	1.42	0.252
	C	93.85	1.23	94.80	2.65	0.57	0.75	0.237
	D	93.05	1.59	94.06	2.69	0.68	0.98	0.268
	AVERAGE	93.58	1.45	94.30	2.56	0.59	1.10	0.254

The results obtained upon the four samples which did not deteriorate are given in Table II. As there was but little change in composition only two of the periods are given.

The results indicate that the limiting factor for good-keeping is about $\frac{W}{100 - S} = 0.3$.

Anyone who has studied the keeping quality of sugars can no doubt report numerous exceptions to such a rule as the above. Examples can be cited of sugars with a factor far beyond the limit for safe-keeping which keep perfectly well and of sugars with a factor well within the safety limit which deteriorate rapidly. The exceptions of the first class need not detain us long

TABLE II—PERIODIC ANALYSES OF GOOD-KEEPING SUGARS

Date of Analysis	Sample	Polarization	Water (W) Per cent	Sucrose (S) by Clerget Per cent	Invert Sugar Per cent	Ash Per cent	Undetermined Per cent	W / 100 − S
May 1915	E	96.70	0.88	96.96	0.66	0.55	0.95	0.289
	F	96.15	1.02	96.42	1.40	0.50	0.66	0.285
	G	96.35	0.94	96.53	0.92	0.78	0.83	0.271
	H	96.45	0.81	96.80	1.05	0.51	0.83	0.253
	AVERAGE	96.41	0.91	96.68	1.01	0.59	0.82	0.274
January 1916	E	96.75	0.85	97.12	0.65	0.53	0.85	0.295
	F	96.15	0.99	96.71	1.12	0.50	0.68	0.300
	G	96.05	0.92	96.37	0.94	0.79	0.98	0.253
	H	96.45	0.75	96.98	1.05	0.50	0.72	0.248
	AVERAGE	96.35	0.88	96.80	0.94	0.58	0.81	0.275

for the probabilities in the case of moist sugars which keep are that the organisms which produce deterioration are either absent or that the conditions of temperature, alkalinity, etc., are unfavorable for their development.

INFLUENCE OF TEMPERATURE UPON DETERIORATION—The author has noted moist sugars which kept perfectly well in the climate of New York from October to May. The organisms producing deterioration, however, were present and with the approach of warm weather in May, the conditions became favorable for their development and the sugars suddenly began to undergo a rapid decrease in polarization. As an example of such an influence of temperature upon deterioration the following analyses are given of a soft refined sugar with high factor.

	Polarization	Moisture Per cent	Sucrose by Clerget Per cent	W / 100 − S
January 17	94.35	3.90	94.42	0.699
March 18	94.35	...	94.42	...
June 10	92.70	4.07	93.10	0.590

In the cool season between January and March there was no deterioration, but sometime between March and June a very rapid destruction of sucrose began.

Cool weather may not only retard the commencement of deterioration, but it may also check the process after it has once begun. This can be seen from Table I, which shows an average loss of 0.66 per cent sucrose between May and October of 1915. In January 1916 the sucrose had undergone no further diminution and the process of deterioration had apparently come to a standstill. But the organisms producing the destruction of sucrose resumed their activity in the following summers so that we find in August 1917 a further loss of 1.00 per cent sucrose. A correlation of analytical and meteorological data shows that the destruction of cane sugars by microörganisms does not usually take place until the daily maximum temperature exceeds 20° C., which for the climate of New York is from about the middle of May to the first of October. Raw cane sugars of any class can be stored without serious risk when the maximum temperature in the warehouse is below 20° C. But if sugars are to be kept for the season when the temperature maximum exceeds 20° C., then only such sugars should be selected as have a factor of safety below 0.3.

DETERIORATION WITHOUT LOSS IN POLARIZATION—Attention should be called at this point to a condition of not infrequent occurrence, where a sugar during storage in a warehouse undergoes no loss in polarization and yet is steadily deteriorating. This circumstance arises from the fact that the sugar during storage is losing moisture and that the loss in polarization from destruction of sucrose is counterbalanced by the drying out of the product. The custom of making spot tests from time to time in order to see if stored sugar is holding up is therefore of little value unless such polarizations are controlled by moisture or invert sugar determinations. The author has found the periodic analysis of sealed samples to be a most useful criterion of what is taking place in the warehouse. He has had excellent opportunity of making such comparisons in connection with the analysis of sugars for the New York Coffee Exchange where the same lots of sugar in the warehouse

are resampled and retested with every change of ownership. In every case where sugars in the sealed bottle lost in polarization, deterioration was observed in the stored sugar. Although the polarization of the latter frequently showed no falling off, yet deterioration was advancing as was indicated by the steady increase in invert sugar.

The case of Sugar B in Table I is an illustration of this. This sugar was part of a large lot that was stored in a New York warehouse in May 1915. A sample taken from the bags in the warehouse the following October polarized 94.80 as compared with 94.85 when the sugar was stored. This was taken by the owner as an evidence that the sugar was undergoing no deterioration, although a sealed sample of this sugar, kept from the previous May, polarized only 94.35. A complete analysis of the October warehouse sample showed, however, that inversion was taking place.

	Polarization	Water (W) Per cent	Sucrose (S) by Clerget Per cent	Invert Sugar Per cent	Ash Per cent	Undetermined Per cent	W / 100−S
Sealed Sample, May.....	94.85	1.65	95.18	1.22	0.62	1.33	0.343
Sealed Sample, Oct.....	94.35	1.65	94.70	2.01	0.61	1.03	0.311
Warehouse Sample, Oct..	94.80	1.21	95.19	1.76	0.66	1.18	0.251

The October warehouse sample shows an increase of 0.54 per cent invert sugar: deterioration is thus plainly indicated, but is concealed, when only a polarization or sucrose determination is made, owing to the loss of 0.44 per cent water through drying out of the sugar. Shrinkage in weight, without the attendant increase in test, caused the owner of the sugar a considerable financial loss.

UNEVEN DISTRIBUTION OF MOISTURE—The exceptions of the second class, where sugars of low factor deteriorate, are usually found upon examination to confirm rather than to nullify the factor-of-safety rule. The deterioration of a raw sugar is confined entirely to the thin films of molasses which adhere to the crystals of sucrose. The cases of low-moisture sugars which deteriorate result nearly always from uneven distribution of moisture; the average percentage of moisture is low but there are zones of sugar in the bag whose percentage of moisture is relatively high. Uneven distribution of moisture in the bag may result from mixing together sugars of varying moisture content at the factory, but it seems to be produced more commonly by the migration of moisture after the sugar is bagged, with the result that the liquid films become more concentrated on some grains of sucrose and more dilute upon others. Fermentation will then set in where the films are more dilute, the result being that the average mixed sample of the lot shows deterioration, although the average moisture content may appear to be well within the limit for good keeping.

SWEATING—The sweating of raw sugar due to warm packing or to unfavorable storage conditions is one of the chief causes of moisture migration. The danger of bagging sugar as soon as it is emptied from the centrifugals has long been recognized. It is very evident that when warm sugar is packed in a bag, there will be an expulsion of water from the center towards the cooler surface. Zones of high moisture content are formed which, with the favoring warmth from the interior of the bag, become exceedingly favorable for the development of microörganisms. An examination of such sugars when the bags are opened shows that deterioration is not evenly distributed but is confined to zones, the polarization of sugar from different parts of the bag showing variations sometimes of several per cent. If such sugar be imperfectly mixed, extremely wide variations may be noted in the composition of duplicate samples. The following is an actual case of three samples of a deteriorated sugar taken from the same mix, drawn from 2420 bags of one mark in a New York warehouse in December 1910.

	Polarization	Moisture
Sample No. 1.....	92.75	1.80
Sample No. 2	93.65	1.46
Sample No. 3.....	94.50	1.18

Migration of moisture may take place not only within the bag but may proceed from one bag to another. In the case of sweat-damaged sugars in the hold of a ship or in a warehouse, the moisture from the lower tiers may condense upon the ceiling overhead and fall back in a shower upon the upper layer of sacks. A careful manufacturer, who makes sugars that conform to the rules of safe keeping, may thus have his product deteriorate through the negligence of other people.

DEDUCTIONS FROM THE "FACTOR-OF-SAFETY" RULE—If a fixed ratio between moisture and non-sucrose is the governing factor in the keeping quality of raw cane sugars, there are a number of deductions or corollaries which must follow from such a proposition.

The first corollary which we will consider is that slight fluctuations in moisture content have a much greater influence upon the keeping quality of high-grade than of low-grade sugars. Thus 0.1 per cent increase in moisture will raise the factor of a 90° sugar with 0.28 per cent moisture from 0.28 to 0.35, but will raise the factor of a 90° sugar of 2.80 per cent moisture from 0.28 to only 0.29. In other words, a high-grade sugar of good-keeping quality can be made unfit for storage by the absorption of only 0.1 per cent moisture, while the keeping quality of a low-grade sugar having the same factor will not be sensibly affected. This conclusion is abundantly confirmed not only by laboratory tests but by practical experience. The storage of high-grade raw sugars or of moist refined sugars has always been regarded as hazardous. Even white granulated sugar has been found to deteriorate in a humid atmosphere, owing to the absorption of moisture. Low purity sugars, on the other hand, can be subjected to considerable variations in moisture content without loss of keeping quality.

A second deduction, which results from the factor-of-safety rule, is that displacement or saturation of moisture by non-sucrose constituents should render a questionable sugar fit for storage. This conclusion has also been confirmed by practical experience. It is customary with some factories to wash the sugars in the centrifugals with low-grade molasses instead of with water. A superintendent, who had long followed molasses washing, upon being asked why he did this replied that sugars thus treated never went back in

storage. This superintendent, who knew and cared nothing about "factors-of-safety," was yet unconsciously making a practical application of the rule.

LIMIT OF DETERIORATION—A third corollary, to which the author called attention a few years ago, is that sugars which are prevented from absorbing moisture, as in a sealed container, can deteriorate only to a certain limit. In other words deterioration will continue until the quantity $\frac{W}{100 - S}$ becomes less than 0.3 when the process must come automatically to a standstill. This deduction has been repeatedly confirmed by making periodic analyses of deteriorating samples that were contained in sealed bottles. The deterioration, after a few months or years, depending upon the moisture content of the sample, came gradually to a stop and subsequent analyses, even after several years, showed no change in composition. The value of $\frac{W}{100 - S}$ at which a deteriorating sugar ceased to lose in polarization was found usually to be nearer 0.25 than 0.30. This would seem to indicate that although the destructive organisms might not multiply under conditions when the safety factor was 0.3, yet if a sufficient number of organisms were already present in a state of great activity they might continue for a time to exert an inverting action upon the sucrose dissolved in the liquid films.

It will be noted, for example, in Table I that the average factor of 0.331 in May 1915, after remaining the following winter at 0.288, underwent a further decrease to 0.254. The average factor of 16 sugars at the end of deterioration, determined by the writer[1] in 1914, was 0.251.

The fact that a sugar in an active state of deterioration may continue to undergo inversion, even though its factor of safety be under 0.3, helps to explain why many sugars of apparently good keeping quality fail to hold up. A sugar may have been made with a factor of 0.33 and, beginning at once to deteriorate, have had a factor of 0.29 at the time of its arrival in New York. The purchaser of this sugar, unaware of previous conditions, might therefore be misled as to its keeping quality, for the sugar being in an active state of fermentation had not yet reached the limit of deterioration.

That there is a certain limit of deterioration has been intimated by previous investigators. L. Lewton-Brain and Noel Deerr[2] make the following statement:

"Another point of interest that requires further investigation is whether there is a definite maximum of deterioration for each bacillus, for each percentage of water or whether the deterioration will go on indefinitely merely varying in rapidity according to temperature and moisture conditions. The probability is that it will go on indefinitely, but there is also a possibility that an accumulation of by-products might inhibit further activity when a certain point has been reached."

[1] "The Deterioration of Raw Sugar Samples," *Louisiana Planter*, **54**, 282.

[2] Hawaiian Sugar Planters' Association, Division of Pathology, *Bulletin* **9** (1909), 32–3.

In answer to a letter requesting his present opinion upon the subject, Mr. Deerr makes the following additional statement:

"I now think there is a final maximum of deterioration for a percentage of water, but if the sugar is free to absorb water, deterioration will continue to far limits. If the sugar is in a stoppered bottle, I think the deterioration is limited."

This opinion of Mr. Deerr coincides with the results of the author's experience.

In 1915 the writer[1] suggested the explanation that the limit of deterioration in a sealed sample was reached when the liquid films were saturated with non-sucrose ingredients, at which limit "the dissolved sucrose is practically all inverted and no more sucrose can pass into solution from the underlying crystal." Subsequent studies of the liquid films at the end-point of deterioration show them, however, to contain a considerable amount of uninverted sucrose. Experiments made to reproduce the conditions in a deteriorating sugar by coating fine glass beads with films of a molasses undergoing deterioration likewise showed that all the sucrose could not be destroyed under such conditions. Unless, therefore, a sugar can absorb moisture from the outside or produce moisture during fermentation, deterioration never destroys the whole of the sucrose originally present in the liquid films.

The possibility, suggested by Lewton-Brain and Deerr, that an accumulation of by-products may inhibit the activity of the organisms which produce deterioration, derives considerable support from the fact that after a few years fermented samples of sugar in many cases fail to produce colonies upon agar or gelatine plates. It was only in cases where deterioration was produced by organisms which formed resistant spores or where water seemed to be formed as a fermentation by-product that the author was able to obtain colonies from old fermented sugars. The death of the organisms in old sugars may be due to the formation of substances actually toxic or to a concentration of invert sugar which by its plasmolytic action[2] causes the destruction of life.

ABNORMAL FERMENTATIONS—Over 90 per cent of the cases of deterioration of sugars studied by the author correspond to the examples given in Table I, in which the polarization and sucrose regularly diminish and the invert sugar increases until the limit of deterioration is reached, the percentage of moisture remaining practically constant throughout. A number of cases have been noted, however, in which the fermentation followed a different course. In some instances an increase in polarization was observed which might afterwards be followed by a progressive decrease in test. Examples of this type of fermentation have been

[1] "The Deterioration of Raw Sugar Samples," *Louisiana Planter*, **54** (1915), 281–2.

[2] Prof. W. L. Owen, Bacteriologist of the Louisiana Sugar Experiment Station, in a recent conversation with the author, suggests that the degree of osmotic pressure necessary to produce plasmolysis in the cells of the organisms which inhabit the sirupy films, may represent the limit to which sugars can deteriorate. Osmotic pressure may, perhaps, be the basis of the factor-of-safety rule.

previously reported by Watts and Tempany[1] in the West Indies, by Deerr and Norris[2] in Hawaii, and by other observers.

INCREASE OF POLARIZATION IN ABNORMAL FERMENTATIONS—An initial increase in the polarization of stored sugars is usually due to a partial drying out of the product. This increase, however, may take place without the sugar losing moisture, in which case there must be either a production of some new dextrorotatory substance such as dextran or a destruction of some levorotatory constituent of the sugar such as fructose. The author[3] has studied the production of dextran in fermenting sugar-cane juice but has not been able to observe its formation in raw sugars in any instance among the several hundred cases of deterioration which he has investigated. It seems more probable that the increase in polarization of stored sugars, where loss of moisture does not occur, is due to the fermentation of fructose as suggested by Watts and Tempany.[4] The destruction of reducing sugars in stored samples of sugar is in fact not unusual.

Watts and Tempany[4] report an instance where a muscovado sugar between May 6 and June 21 underwent a decrease in reducing sugars from 3.58 per cent to 0.65 per cent and an increase in polarization from 88.8 to 91.0. Deerr and Norris[4] also report the case of a sugar which, after four months storage, underwent a decrease in reducing sugars from 1.65 to 0.22 per cent and an increase in polarization from 93.7 to 95.2.

In a case observed by the author a sugar on June 15, 1915, polarized 94.05 and contained 1.90 per cent invert sugar and 1.54 per cent water; on January 10, 1916, a duplicate sample of the same sugar, which had been hermetically sealed, polarized 95.55 and contained 0.89 per cent invert sugar and 1.73 per cent water. One part of fructose conceals the rotation of 1.4 parts of sucrose, and if we assume that the loss of 1.01 per cent invert sugar was due to fermentation of fructose there should be an increase in polarization of 1.41, which agrees fairly well with the 1.5 increase observed.

ABNORMAL CLERGET VALUES—If the fructose be fermented away from a mixture of sucrose and invert sugar, the residue of sucrose and glucose should give a Clerget value lower than the direct polarization instead of higher as is usually the case. The above sample which polarized 95.55 gave a Clerget value of 95.26. An independent analysis, performed at the author's request by Mr. A. H. Bryan, gave a polarization of 95.60 and a Clerget value of 95.36. The results indicate a destruction of fructose in this sample by fermentation.

FORMATION OF WATER (VOLATILE MATTER) IN ABNORMAL FERMENTATIONS—In the case of abnormal fermentation previously cited, the water, or volatile matter, increased from 1.54 per cent to 1.73 per cent. This difference of 0.19 per cent may have been due partly to some experimental error and partly to the formation of alcohols, esters, or other volatile products. The increase in water, or volatile matter, seems to be associated in some way with this type of fermentation.

As another example the following case of a Cuban sugar is given. Four jars of the well-mixed sample were filled and hermetically sealed in April 1915. Periodic analyses of the samples showed the following:

Date of Analysis	Polarization	Water (W) Per cent	Sucrose (S) by Clerget Per cent	Invert Sugar Per cent	Ash Per cent	Undetermined Per cent	W 100 — S
Apr. 6, 1915.....	96.00	1.14	96.43	1.17	0.51	0.75	0.316
Jan. 10, 1916.....	96.05	1.11	96.36	1.05	0.54	0.94	0.304
Aug. 1, 1917.....	95.85	1.51	95.47	0.87	0.54	1.56	0.338

But little change is noted between the April and January tests. The August 1917 analysis, however, shows an increase of 0.37 per cent in water, or volatile matter, a decrease of 0.30 per cent in invert sugar, a decrease of 0.15 in polarization, and a decrease of 0.96 per cent in sucrose. In the case of the first two tests the Clerget value is higher than the polarization, while in the August analysis it is lower, as is usually the case with this type of fermentation. The undetermined matter shows a marked increase, as does also the factor of safety.

The fact that a raw sugar can undergo a serious loss in its sucrose content with but little change in polarization is only an additional illustration of the inadequacy of an uncontrolled polariscope test.

VOLATILE DECOMPOSITION PRODUCTS OF STORED SUGARS. *Alcohols and Esters*—As shown by Table I the chief chemical change in the deterioration of sugars is the inversion of a part of the sucrose. With an average loss of 1.63 per cent sucrose there was an average gain of 1.53 per cent invert sugar which is only 0.18 per cent below the theoretical. This unknown loss may be taken as the average amount of sucrose converted into gums, acids, alcohols, esters, and other fermentation products. The inversion of 1.63 per cent sucrose involves the loss of 0.08 per cent water; the results of Table I, however, show an average increase of 0.10 per cent water, or volatile matter, so that the unknown loss of 0.18 per cent must consist almost wholly of volatile constituents. The quantity of samples was not sufficient to determine whether the latter were of an alcohol, aldehyde or acid nature. Nearly all the samples, upon opening, gave off a perceptible rum-like odor, so that it seems safe to assume that alcohols and esters make up a certain part of the volatile decomposition products of stored sugars. The strong odor of esters, which is noticed upon entering a warehouse or the hold of a ship, where raw sugar is stored, is sometimes regarded as an evidence of deterioration, but this is not necessarily the case. Sealed samples of raw sugar may develop an intense rum-like odor without showing the slightest loss in sucrose.

Carbon Dioxide—The volatile decomposition product which is given off in greatest quantity by stored sugars is carbon dioxide. This gas seems always to be produced, whether or not the sugar is undergoing deterio-

[1] "Fermentation Changes Occurring in Muscovado Sugars," *West Indian Bulletin* No. 11, 7 (1906), 226-36.

[2] "The Deterioration of Sugars on Storage," Experiment Station of the Hawaiian Sugar Planters' Association, *Bulletin* 24.

[3] "The Fermentation of Sugar Cane Products," *J. Am. Chem. Soc.*, 28, 453-469.

[4] *Loc. cit.*

ration. While the quantity of carbon dioxide in sealed bottles of raw sugars is usually highest where the loss of sucrose is greatest, this is not always true. In the case of six samples of raw sugar which had undergone deterioration the carbon dioxide content of the air in the bottle after two years was found to be 625, 274, 310, 33, 102 and 494 times the amount present in the laboratory air. In the case of five samples of raw sugar which had undergone no loss in sucrose similar figures for carbon dioxide after one year were 226, 51, 26, 171 and 309.

In several instances where the air was drawn off from bottles of deteriorating sugar the oxygen was found to be almost completely displaced by carbon dioxide. It was thought at first that the exhaustion of the oxygen supply might be the cause of the death of the organisms in the old samples of sugar but this condition of oxygen exhaustion was observed in only a few cases and there seemed to be no connection between the phenomenon and the limit of deterioration. In the case of a soft refined sugar undergoing deterioration the oxygen of the air in the bottle was 91 per cent consumed after 8 months and 95 per cent consumed after 19 months. The number of microörganisms per gram after 19 months was 550,000 and the sugar was still undergoing inversion. The evolution of carbon dioxide from sugar in the hold of a ship is sometimes so great that workmen have been overcome upon removing the hatches.

SPONTANEOUS COMBUSTION OF SUGARS—The absorption of oxygen and the evolution of carbon dioxide by a stored sugar resemble the process of respiration which fruits, vegetables, grains, tobacco and other products undergo in storage. Under certain unusual conditions, which are not perfectly understood, this absorption of oxygen may proceed with sufficient intensity to cause spontaneous combustion of the product. There are, in fact, well authenticated cases where this has happened to sugar in bulk. Schöne[1] mentions an instance where 1000 tons of raw beet sugar in a German factory underwent spontaneous combustion with almost explosive violence. Wasilieff[2] also mentions a similar occurrence with raw beet sugar in a Russian factory. Many of the cases where cargoes of raw cane sugar have mysteriously caught fire no doubt resulted from spontaneous combustion. Certain sugar-containing products, such as molasses feeds, are particularly susceptible to this phenomenon.[3] That the heating of a mass of moist sugar is produced by yeasts or other organisms is well known, but how these organisms can elevate the temperature far above the point at which they can exist has seemed a contradiction. It has been held by some physiologists that in the fermentation of sugar to alcohol or lactic acid, certain unsaturated intermediate products are produced. In the interior of a fermenting mass of sugar, when the supply of oxygen is used up, these unstable unsaturated products may possibly be formed in considerable amount. If outside air suddenly gained access to the interior of such a mass, the intense absorption of atmospheric oxygen might easily elevate the temperature to the point of combustion.

The conditions of moisture, air supply, etc., which favor the spontaneous combustion of sugars are, however, of very unusual occurrence, and the financial losses from this cause are slight in comparison with the slower and less spectacular process of inversion which, after all has been said, is responsible for the greater part of the losses from deterioration of the Cuban crop.

B—MYCOLOGICAL OBSERVATIONS

PREVIOUS INVESTIGATIONS—Since the time of the first observation by Dubrunfaut, fifty years ago, various writers have referred to the action of microörganisms in producing the deterioration of sugars. It is only, however, within the last twenty years that the specific behavior of these organisms and the method of preventing their action upon sugars have been subjected to serious study.

In 1898 Shorey[1] detected the mould *Penicillium glaucum* in samples of deteriorated Hawaiian sugars and suggested that the inverting action of this fungus was a common cause of deterioration. Shorey believed infection to take place through spores drawn into the sugar by the current of air in the centrifugals, and made the observation that the sugars which showed most deterioration were usually made in dusty localities where such spores would be most easily scattered. As a protection against infection Shorey recommended that the sugar in the centrifugal, during the process of curing, be sterilized by a current of dry steam.

In 1902 Greig-Smith and Steel[2] in Australia discovered a sugar-destroying organism, related to the heat-resisting so-called "potato" bacilli, which was found to occur in raw sugar from Australia, Java, Mauritius, Egypt, Peru, Fiji, France, Germany and Russia. From its conversion of sucrose into the levorotatory gum levan, Greig-Smith and Steel named their organism *Bacillus levaniformans* and from its wide distribution expressed the belief that it, and not the mould of Shorey, was "responsible for the bulk of the deterioration of sugar during transit and in store, which has been noted from various parts of the world." As a remedy against the infection of sugars by this organism, Greig-Smith and Steel recommended thorough cleanliness of apparatus at all stages of manufacture and steam sterilization in the centrifugals.

In 1909 Lewton-Brain and Deerr[3] made a study of the "Bacterial Flora of Hawaiian Sugars" and came to the same conclusion as Greig-Smith and Steel that moulds are not to be considered as a cause of deterioration. Lewton-Brain and Deerr isolated five different kinds of sugar-destroying bacteria, two of which produced a gum similar to levan: these authorities came, therefore, to the conclusion that the production of levan cannot be held as characteristic of one particular

[1] *Deut. Zuckerind.*, **36** (1911), 608.

[2] *Z. Ver. Zuckerind.*, **1902**, 864.

[3] Report of the Chief Inspector, Bureau for the Safe Transportation of Explosives, etc., B. E. Report No. 7, p. 47, discusses the spontaneous combustion of alfalfa-molasses mixtures. Spontaneous combustion of bagasse-molasses feeds has occurred in ships.

[1] "The Deterioration of Raw Cane Sugar in Transit or Storage," *J. Soc. Chem. Ind.*, **17** (1898), 555.

[2] "Levan: A New Bacterial Gum from Sugar," *J. Soc. Chem. Ind.*, **21** (1902), 1381.

[3] Experiment Station of the Hawaiian Sugar Planters' Assoc., Division of Pathology and Physiology, *Bulletin* **9**.

bacterium. According to Lewton-Brain and Deerr "the best safeguard against deterioration is the maintenance of the factory itself in as aseptic condition as possible, the avoidance of the introduction of bacteria, as for instance in the use of unclean water at or about the centrifugals, and the disinfection of the factory during the off season."

In 1911 Owen,[1] in Louisiana, came to the conclusion that the deterioration of sugars is not due to inversion but to a gum fermentation which is formed by a slightly alkaline reaction. This gum fermentation, according to Owen, is produced by a group of bacteria, comprising the so-called potato bacilli, that cause the destruction of sucrose by an enzyme *levanase*,[2] which is extracellular in its action and breaks down sucrose according to the equation:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} = \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Levan}}{C_6H_{10}O_5}$$

The potato bacilli, which occur widely distributed in the soil, can easily be introduced into the sugar factory by dirt adhering to the cane, and the great resistance of the spores of these organisms to heat offers a means of their passing through all the stages of manufacture into the sugar. Owen in fact showed by experiments in Louisiana that while 98 per cent of the organisms occurring in cane juice are destroyed in the process of clarification, in no stage of the manufacture is the product entirely free from microörganisms and that there is a remaining 2 per cent of heat-resisting spores, which escape destruction and find their way into the final sugar. As a remedy against deterioration Owen recommends the use of antiseptic washes for the mills and tanks of the sugar house and the exercise of greater care in drying the sugars.

While the observations of the authorities just mentioned may in large measure be true for the respective countries where their work was performed, it has seemed to the author entirely too sweeping to assert that the deterioration of sugar is never due to moulds or that it is nearly always produced by one specific bacillus or specific class of bacilli. Table I, which is typical, shows that the deterioration of Cuban sugars, at least, is mainly a process of inversion and that the formation of levan and other gums is not of usual occurrence. According to cultural experiments carried out by the author, the organisms most prevalent in Cuban raw sugars are not bacteria but certain organisms belonging to the budding fungi. The occurrence of such fungi in deteriorating sugars has in fact been previously indicated by Schöne.

In a sample of "farine" (powdered sugar) which had undergone a loss of nearly 8 per cent sucrose, Schöne[3] observed a large number of yeast-like cells mixed together with the spores and mycelia of moulds. The deterioration, in Schöne's opinion, was started by a budding fungus of the *Monilia* class and then continued by the moulds. In a second sample of deteriorated "farine" Schöne isolated another budding fungus of the *Torula* class.

[1] "The Bacterial Deterioration of Sugar," *Louisiana Bulletin* **125**; "A Recently Discovered Bacterial Decomposition of Sucrose," THIS JOURNAL, **3** (1911), 481.

[2] It should be noted in passing that levan is a polysaccharide ($C_6H_{10}O_5$)$_n$ and, therefore, could not be formed from sucrose by the hydrolytic action of any such enzyme.

[3] "Garungserscheinungen in Farinzuckern," *Deut. Zuckerind.*, **33** (1908), 638.

PRESENT INVESTIGATIONS

PREPARATION OF CULTURE MEDIA—In the experiments performed by the author a medium was prepared by boiling a 30 per cent solution of raw cane sugar of the ordinary 96° type with a little salt-free alumina cream, filtering, and diluting the cold filtrate to a concentration of 20° Brix. This stock raw sugar solution was sterilized and kept, with the usual precautions against infection, in a large flask.

The agar medium for plating was prepared by dissolving 15 g. of agar-agar in 1000 cc. of the stock raw sugar solution in a sterilizer and filtering through a hot water funnel. The sterilized agar medium was kept in test tubes and flasks, with the usual precautions against infection.

METHOD OF PLATING—1 g. of raw sugar was dissolved in 10 cc. of sterile distilled water and 0.5 cc. of the solution was mixed with 10 cc. of the agar medium, previously liquefied at about 55° C., and poured into a warm petri dish. After the agar had set, the petri dish was placed in an incubator at about 30° C. At the end of three or four days the colonies were counted and examined under the microscope. If the colonies were too numerous, a new plate was prepared from a raw sugar solution of lower concentration. Typical growths were selected from the agar plates and inoculated into measured amounts of the stock raw-sugar solution in order to study the specific action of each organism. The behavior of the latter was also tested upon concentrated raw sugar syrups and upon sterile sugars. It is not possible in a chemical paper to give in detail the results of all experiments and only a few of the more typical observations are described.

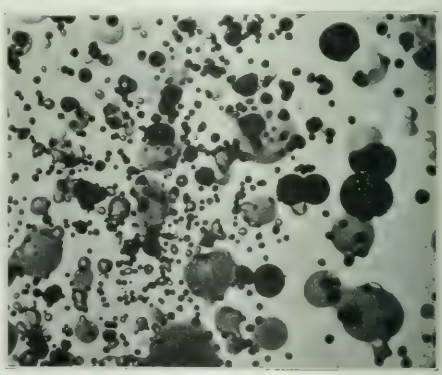


FIG. 1 × 2

Colonies of microörganisms from a Cuban raw sugar. The dark colonies belong to *Torula communis*, which although white, appear black by transmitted light. The large light-colored globular masses belong to *Bacterium inversians*. In the lower left-hand corner is a growth of *Monilia nigra*.

NUMBER OF ORGANISMS—The average number of colonies produced upon raw sugar-agar plates by the method just described was 144,000 per gram for Cuban sugars as delivered in New York, the number varying

from 3,500 to 571,000. During storage this number of organisms might increase for a time if the sugar was in a state of deterioration, and samples have been noted which produced over 1,000,000 colonies per gram of sugar. On very long storage, however, the number of microörganisms undergoes a decrease; samples of raw sugar after two years are frequently found to be almost sterile.

An example of the colonies obtained from 0.05 g. of a Cuban raw sugar upon an agar plate is shown in Fig. 1.

KINDS OF MICROÖRGANISMS. *Torula communis*—The most abundant organism observed in Cuban raw sugars was a non-inverting *Torula*. A similar organism was also found in raw sugars from the British West Indies and in soft refined sugars. It appears to be one of the most widely distributed of the microscopic flora which thrive in cane sugar factories, and for this reason has been named by the author *Torula communis*.[1]

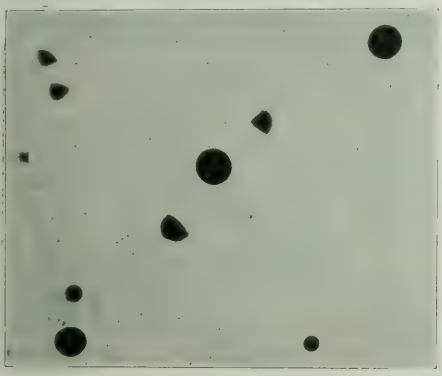


FIG. 2 × 2

Colonies of *Torula communis* in different stages of growth. On the left is a small star-shaped cyst, the nucleus of the future colony; above it are two colonies forming around their nuclear cysts. The large circles are fully developed colonies. The colonies are white but appear black by transmitted light.

FORM OF COLONIES—The colonies upon raw sugar-agar at the beginning have the appearance of minute white cysts which under the microscope show an angular contour of boat-shape or arrow-head form. The cysts increase in size to a diameter of 0.2–0.5 mm. until the surface of the agar is reached, when the organisms spread out in all directions from the point of emergence. The colony gradually assumes a circular or heart-shaped form of grayish white color, varying in diameter from 3 to 10 mm. and retaining the original cyst as a dense white nucleus (Fig. 2). With very old colonies a brownish color appears.

MICROSCOPIC APPEARANCE—Under a high power of the microscope *Torula communis* is seen to consist of single cells, yeast-like in appearance and without mycelium (Fig. 3).

[1] Owen (*Louisiana Planter*, **56**, 173) mentions among the microörganisms of unrefined sugars a non-inverting *Torula*, which is no doubt the same organism as the one described by the author as *Torula communis*. The specific names, *communis*, *nigra*, *fusca*, etc., employed by the author in this and the following cases are used provisionally until the exact relationship of the organisms to their genera can be determined.

GROWTH IN RAW SUGAR SOLUTIONS—*Torula communis* grows readily in raw cane-sugar solutions from the most dilute to the most concentrated. It forms a granular sediment of cells and, at later stages of growth, a thin



FIG. 3 × 1000

Magnified cells of *Torula communis*.

marginal film. A slight evolution of gas takes place, but never with froth or foam as with yeast. A strong, fruity, ester-like odor is also characteristic.

ACTION UPON RAW SUGAR SOLUTIONS—The action of *Torula communis* upon raw cane-sugar solutions consists principally in a destruction of invert sugar, fructose being the ingredient mostly affected. Sucrose is not inverted. The following fermentation experiment upon 50 cc. of a solution of 64° Brix was conducted for 21 days at 28° C.

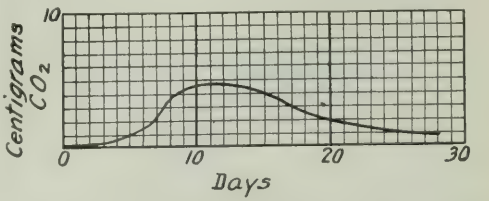
	Solution Diluted to 200 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Gram
Blank.....	+76.60	76.78	39.9256	0.8085
Torula communis..	+76.85	76.56	39.8112	0.2338

In the above experiment the blank solution lost 0.3458 g. in weight and the *Torula*-inoculated solution 0.7535 g., the difference of 0.4077 g. representing the loss due to evolution of carbon dioxide and other volatile products.

A second fermentation experiment was conducted upon 50 cc. of a clarified supersaturated raw sugar solution of 78° Brix for 27 days at 30° C. The excess of sucrose crystallized out during the experiment, leaving a solution of about 69° Brix.

	Solution Diluted to 200 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank.....	+98.70	98.86	51.4072	1.1576
Torula communis..	+98.95	98.27	51.1104	0.1462

In the second experiment the loss due to evolution of carbon dioxide, alcohols, esters, etc., after correcting for the loss in weight of the blank solution, was 0.6118 g. The distribution of this loss over the 27-day period is shown in the following diagram. It will be



seen that the greatest intensity of fermentation was between the 9th and 15th days.

The two experiments show a marked destruction of invert sugar. The selective action of *Torula communis* upon fructose is seen by the increase in polarization and

by the lowering of the Clerget value below the polarization. The changes of this character, previously noted in the case of certain stored sugars, are no doubt due to this organism.

The inability to invert sucrose is characteristic of many *Torulae*,[1] although such inability does not prevent these varieties from subsisting at the expense of sucrose. A destructive action of this kind is shown in the previous results, where there was a loss of 0.1144 g. sucrose in the first experiment and a loss of 0.2968 g. sucrose in the second. The experiments show how a raw sugar may gain in polarization and yet undergo an actual loss in sucrose.

Although relatively harmless, in comparison with the organisms which invert sucrose, the non-inverting *Torulae* may become deleterious in the case of sugar stored for a considerable period.

Among the most destructive organisms found by the author in Cuban raw sugars were two varieties of *Moniliae*, which from the difference in color of their colonies upon agar have been named *Monilia nigra* and *Monilia fusca*.

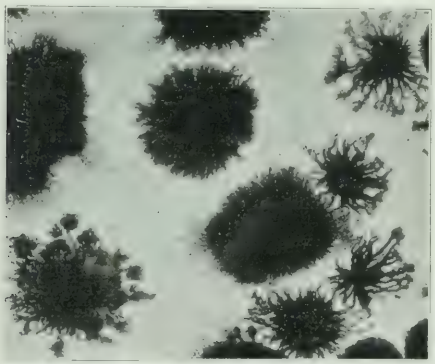


FIG. 4 × 2
Large colonies of *Monilia nigra*. The radiating growths consist of hyphae covered with bud-cells. The tufted terminal growths are conidia.

Monilia nigra—Some of the raw sugars examined by the author, when plated out, gave practically pure cultures of this organism. In the case of one fermented sample (A, Table I) which had been sealed over two years, 1500 colonies of this *Monilia* were produced from 1 g. of sugar (Fig. 4).

FORM OF COLONIES—The colonies upon raw sugar-agar have at first the appearance of small star-shaped white dots, which under the microscope are seen to consist of radial hyphae. The latter throw off a conglomerate of bud-cells, the mass of which increasing in thickness soon gives the colony a starfish appearance. This primary growth of the colony is usually succeeded by a secondary growth, due to the propagation of the bud-cells, which, without the formation of hyphae, germinate like yeast and cover the center of the colony with a white amoeba-like film. When the colony attains a diameter varying from 1 mm. to 15 mm. the ends of the hyphae projecting beyond the bud-cell conglomerate and yeast films usually break up into clusters of dark conidia (frequently of branched tree-like form) which give the colony a jet-black color.

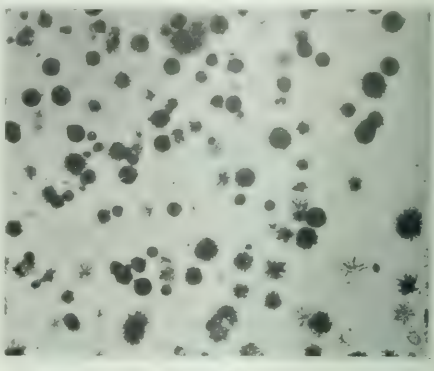


FIG. 5 × 2
Small colonies of *Monilia nigra* in various stages of growth.

From the latter circumstance the organism has been named *Monilia nigra*. Sometimes the colony stops growing before the conidia stage is reached, in which case the white color remains unchanged. The latter is particularly apt to occur when the colonies are so numerous as to coalesce; the surface of the agar may then be covered with a dense white growth of bud-cells which at first glance might be mistaken for yeast colonies. Variations in composition of the agar and in temperature of incubation cause such difference in the shape and appearance of the colonies that the latter might appear due to different organisms. The appearance of the colonies is shown in Figs. 4, 5 and 6.

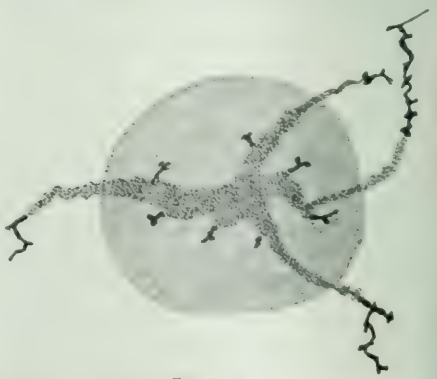


FIG. 6 × 50
Magnified colony of *Monilia nigra*. The radiating growths consist of hyphae, covered with bud-cells. The black terminal growths are conidia. The secondary growth of bud-cells forms the circular film.

MICROSCOPIC APPEARANCE—The polymorphic characteristics of *Monilia nigra* are also shown under the microscope. The hyphae are sometimes smooth, of

[1] For further particulars as to the action of the *Torulaceae* upon sucrose and other sugars see Lafar's *Technische Mykologie*, **2** (1907), 717, or Salter's Translation, **2** (1911), 296.

the ordinary branched type, but are more often studded with clusters of bud-cells. The latter are irregularly elliptical in shape and when detached, depending upon conditions, produce new hyphae or propagate like yeast. When the mycelium approaches its maximum growth the hyphae begin to break up at the ends into dark thick-walled conidia. The latter often occur as twin spores in which case they are produced by a process of cell division. The disintegration of the hyphae into thick-walled cells may also occur at other points than the ends in which case they often have the appearance of oidia. The various cell forms of *Monilia nigra* contain large numbers of oil globules. The microscopic appearance of the various cells is shown in Fig. 7.

GROWTH IN RAW SUGAR SOLUTIONS—*Monilia nigra* grows readily in raw cane sugar solutions excepting the most concentrated. The solution becomes turbid with a growth of fibrous mycelia while the walls of the flask about 2 mm. above the liquid often become coated, after several days, with a margin of dark conidia 1 cm. or more in width. There is a very slight formation of gas; a mild, ester-like odor is also perceptible.

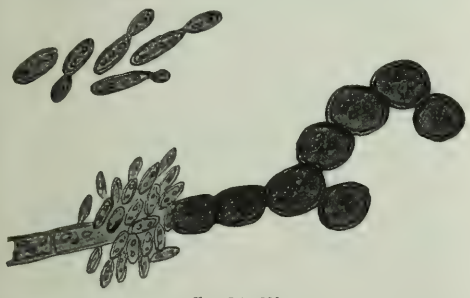


FIG. 7 × 500

Magnified cells of *Monilia nigra*. Below is the end of one of the hyphae, covered with bud-cells and terminating in a cluster of dark conidia. Above are a number of bud-cells germinating into a film.

ACTION UPON RAW SUGAR SOLUTIONS—The action of *Monilia nigra* upon raw cane-sugar solutions consists principally in an inversion of sucrose. The following fermentation experiment upon 50 cc. of a solution of 21° Brix was conducted for three weeks at 28° C.

	Solution Diluted to 100 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank	+40.55	40.94	10.6444	0.2952
Monilia nigra	+ 7.15	15.54	4.0304	5.8965

A second fermentation experiment, conducted upon 50 cc. of a solution of 64° Brix for three weeks at 28° C. showed the following results:

	Solution Diluted to 200 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank	+76.60	76.78	39.9256	0.8085
Monilia nigra	+72.65	73.83	38.3916	2.1932

In the second fermentation experiment the solution inoculated with *Monilia nigra* lost 0.0454 g. more in weight than the blank, which shows only a very slight evolution of carbon dioxide.

The experiments show that the inverting action of *Monilia nigra* is considerably restrained by increasing the concentration of sugar.

A third fermentation experiment was attempted with a saturated raw sugar solution of 69° Brix, but the organism was unable to thrive in a solution of this concentration and no change in composition could be detected after four weeks incubation at 30° C.

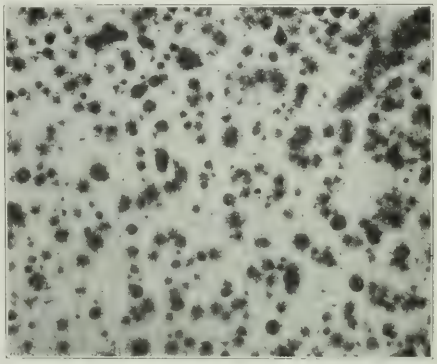


FIG. 8 × 2

Colonies of *Monilia fusca* in various stages of growth.

Monilia fusca—Besides the preceding form a second more strongly inverting variety of *Monilia* has been observed by the author in Cuban sugars. The colonies upon raw sugar-agar (Figs. 8 and 9) resemble those of *Monilia nigra* in some characteristics, but are distinguished from the latter by a much greater length of hyphae, by a less pronounced tendency to form secondary yeast films, and by a greenish brown color in the conidia stage instead of black. Owing to this difference in color the organism has been named *Monilia fusca*. The principal microscopic features are shown in Fig. 10.

GROWTH IN RAW SUGAR SOLUTIONS—*Monilia fusca* grows in raw cane sugar solutions excepting the most concentrated. The solutions become turbid and there is a deposit of mycelia and cells. The walls of the flask, to a distance of 3 cm. or more above the liquid, become coated with a growth of dark conidia. There is a very slight evolution of gas; a pronounced fruity odor is also developed.



FIG. 9 × 50

Magnified colony of *Monilia fusca*. The radiating hyphae are covered with bud-cells and dark conidia.

ACTION UPON RAW SUGAR SOLUTIONS—The following fermentation experiment upon 50 cc. of a solution of 21° Brix was conducted for three weeks at 28° C.

	Solution Diluted to 100 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank.....	+41.30	41.81	10.8706	0.6368
Monilia fusca.....	+3.15	12.60	3.2760	7.1869

A second fermentation experiment conducted upon 50 cc. of a solution of 64° Brix for three weeks at 28° C. showed the following results:

	Solution Diluted to 200 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank.....	+76.60	76.78	39.9256	0.8085
Monilia fusca.....	+43.75	52.01	27.0452	10.9880

In the second fermentation experiment the solution inoculated with *Monilia fusca* lost 0.0346 g. more in weight than the blank, which shows only a very slight evolution of carbon dioxide.

The experiments show that *Monilia fusca* has a much stronger inverting action than *Monilia nigra* and that the activity of the organism is less restrained by increasing the concentration of sugar.

A third fermentation experiment was attempted with a saturated raw sugar solution of 69° Brix, but the organism was unable to thrive in a solution of this concentration and no change in composition could be detected after four weeks incubation at 30° C.

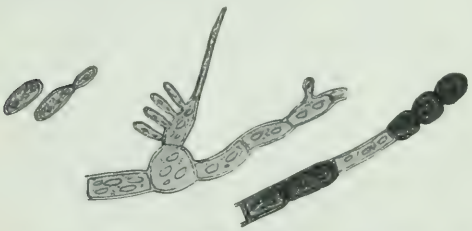


FIG. 10 × 500

Magnified cells of *Monilia fusca*. In the middle is a branched part of the mycelium bearing 4 bud-cells; two of the latter (one germinating) are shown at the left. At the right is the end of one of the hyphae, breaking up at the end into 3 conidia and in the middle into 2 oidia.

The great variability of the *Moniliae* in habits of growth renders them exceedingly adaptable to conditions of environment, and for this reason they are to be counted among the most destructive organisms which thrive in raw sugars.

Bacterium invertens—In addition to the *Torula* and *Monilia* forms just described, plate cultures of Cuban raw sugars frequently exhibit a different type of colony. The surface of the agar becomes covered with an exudation of clear colorless drops (Fig. 11) which sometimes run together and cover a considerable part of the plate. The organism producing this appearance is a bacterium which under the high power of the microscope appears as rod-like cells, detached or in chains, surrounded by a capsule (Fig. 12).

GROWTH IN RAW SUGAR SOLUTION—*Bacterium invertens* grows best in raw cane sugar solutions of low concentration. The solution acquires a milky turbidity, a little sediment is formed and there is a slight evolution of gas. A disagreeable putrid odor is also perceptible.

ACTION UPON RAW SUGAR SOLUTIONS—The action of the bacterium upon raw cane-sugar solutions consists for the most part in an inversion of sucrose, from which circumstance the organism has been named *Bacterium invertens*. The following fermentation experiment upon

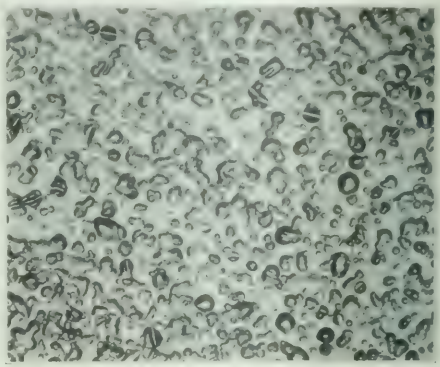


FIG. 11 × 2

Colonies of *Bacterium invertens*

50 cc. of a solution of 21° Brix was conducted for three weeks at 28° C.

	Solution Diluted to 100 Cc.		Original 50 Cc. Solution Contains	
	Polarization	Clerget Value	Sucrose Grams	Invert Sugar Grams
Blank.....	+41.30	41.81	10.8706	0.6368
Bacterium invertens	+22.30	27.53	7.1578	4.0862

A raw sugar solution of 64° Brix was inoculated with *Bacterium invertens* and kept in an incubator for three weeks at 28° C. The organism appeared unable to thrive in a solution of this concentration. No perceptible change took place in the appearance of the medium and an analysis at the end of the three weeks showed no difference in composition from the blank.

The four microörganisms just described were the most common forms observed by the author in Cuban raw sugars. Other organisms, including moulds (such as *Penicillium* and *Oideum*) and various bacilli and micrococci, were also detected in different sugars but a description of these must be passed over. The conclusions which the author desires to emphasize are (1) that the microörganisms of raw cane sugars, as regards their action upon sucrose, are in part harmless and in part destructive; (2) that the destruction of sucrose in deteriorated sugar is not due to any single organism or class of organisms; moulds and budding fungi, as well as bacteria, must be looked for, when searching for the agents of destruction; and (3) that the fungi and bacteria, which cause the inversion of sucrose in raw sugars, are unable to thrive in saturated solutions. The washing of raw sugars in the centrifugals, by diluting the saturated films of sirup to a point where the inverting organisms can thrive, must therefore be regarded as a leading cause of deterioration.



FIG. 12 × 2000

Magnified cells of *Bacterium invertens*.

ORIGIN OF THE INFECTION OF RAW SUGARS BY MICROORGANISMS—The opinions of various authorities upon the infection of raw sugars from the air, from dirt adhering to the cane, from contaminated wash water at the centrifugals, from unclean tanks and unsanitary factory conditions have already been mentioned. A few other sources of infection remain to be considered.

INFECTION FROM BAGASSE—Another possible source of infection, to which attention has been lately directed, is the contamination by fine bagasse particles (generally called bagacillo from the Spanish diminutive) which find their way, in greater or smaller amounts, from the cane mills into the raw sugar. The contamination may take place through the juice by reason of imperfect filtration,[1] or through the air by means of the wind.

According to Owen[2] the only possible ways by which bagacillo can affect the keeping quality of sugar are

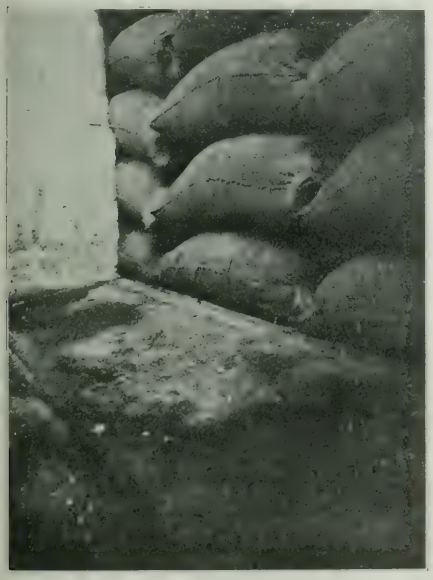


FIG. 13
Bottom of pile of sugar bags in a Cuban warehouse.

(1) by retaining microörganisms which would otherwise be eliminated, (2) by providing nutritive material for microörganisms, (3) by retaining moisture and creating zones favorable for the growth of microorganisms. In Owen's opinion, whatever merit may reside in the bagacillo theory is based solely upon the retention of moisture.

The percentage of water-insoluble organic matter, which consists mostly of bagasse particles, in Cuban raw sugars was found from analyses made in the New York Sugar Trade Laboratory to vary from 0.01 per cent to 0.46 per cent, the average being 0.17 per cent. The average per cent of water-insoluble organic matter in sugars which deteriorated was found to be 0.22 per cent, and in sugars which did not deteriorate 0.10 per cent. In other words, the deteriorated sugars contained twice as much water-insoluble organic matter as the sound samples and this apparently would lend support to the bagacillo theory of contamination. It seems more probable, however, that bagacillo is not so much the cause of deterioration as an indication of general carelessness and sloppiness in manufacture. In other words, if a superintendent is careless in his clarification or filter-press work, he is probably equally careless about protecting his sugars against infection or deterioration. The washing of raw sugar in the centrifugals with water from the cooling tower or other infected sources is probably responsible for more losses than the introduction of bagasse particles. Without denying the possibility of bagacillo acting as a moisture carrier, it is only necessary to point out the case of soft refined sugars, the higher grades of which are exceedingly subject to deterioration and yet are absolutely free from bagacillo.

INFECTION FROM THE COOLING TOWER—One of the most dangerous sources of infection for raw cane sugars is the cooling tower. In this contrivance the warm condensation water from the factory is cooled by falling in a shower over an outdoor framework into an exposed basin, from which it is afterwards returned to the factory. The cooling-tower water, which contains any sugar lost by entrainment, is quickly invaded by microörganisms, the conditions for infection and growth being exceedingly favorable. The spray from the cooling tower is not only carried into the factory, where it can come into contact with bags and sugars, but the cooling-tower water itself is sometimes used for washing the sugars in the centrifugals.[1] All things considered, a more ideal source of infection than the cooling tower can hardly be imagined.

INFECTION FROM BAGS—Kamerling[2] has suggested that deterioration of sugars is produced by organisms introduced from the bags. Although this idea has not found general acceptance, much may be said in its favor. While a mass of solid sugars offers more resistance to the invasion of germs than does a liquid, the sirupy films which surround the sucrose crystals are in contact and form a continuous medium for the spread of microörganisms. The ramifying mycelium of the *Moniliae* also offers an easy means for this class of organisms to penetrate to the interior of a sack of sugar.

Infection of bags may take place not only by wetting with spray from the cooling tower, but it may also occur in the warehouse, or in the hold of a ship. Fig. 13 is a photograph of the bottom of a pile of sugar in a Cuban warehouse. The dark discoloration upon the floor consists of a slimy mass of fermenting molasses and sugar dissolved from the bags by rain from a leaky roof. The sugar in the bottom bags was in direct contact with this filth and was in a bad state of deterioration. Under such conditions infection might spread

[1] The possibility of deterioration of sugars resulting from infection by bagacillo from high pressure mills through imperfect filtration is discussed by Guijarro in the *Louisiana Planter*, **54**, 348, and **55**, 61.

[2] *Louisiana Planter*, **56**, 174.

[1] An instance in Hawaii where deterioration of the manufactured sugar was traced to the use of cooling-tower water for washing at the centrifugals, has been mentioned to the author by Mr. Noel Deerr.

[2] *International Sugar Journal*, **3**, 484. From Report of the West Java Sugar Experiment Station "Kagok" for 1900.

through a large pile of sugar. Fig. 14 shows the pile of fermenting slime which had been raised up after removing the bags of sugar.

PREVENTION OF THE DETERIORATION OF RAW CANE SUGARS—In concluding the mycological part of this paper a few words might be said about the means for counteracting the destruction of sugar by micro-organisms. In the matter of manufacture it is necessary (1) to exercise the utmost possible cleanliness and care in order to diminish infection, (2) to control the moisture content of the sugar so that the ratio of non-sucrose to water is within the limits of safety, (3) to cool the sugar thoroughly before bagging to prevent the migration of water and the formation of zones of high moisture content. In the matter of storage it is necessary (1) to keep the sugar perfectly dry in warehouses which are rain-proof, (2) to keep the warehouse tightly closed in wet weather to prevent the sugar absorbing moisture from the air, (3) to construct the warehouse and store the sugar so as to secure in dry weather the maximum ventilation underneath and between the bags.



FIG. 14
Pile of fermenting slime on floor of a sugar warehouse

These precautions can be carried into effect with comparatively little expense and would result in eliminating much of the needless loss which occurs at present between the manufacture and refining of cane sugar.

ECONOMIC CONSIDERATIONS

Before concluding this paper upon the deterioration of raw cane sugar there are several economic questions which require discussion.

Inasmuch as there is always danger of raw sugars becoming infected, no matter how extreme the conditions of cleanliness in the factory may be, it is important for the manufacturer always to make the moisture content of his sugars conform to the rules of safe-keeping.

If we accept the formula Water = 0.3 (100 — S) as a requirement for safe-keeping, the moisture content of different grades of raw sugars should not exceed the following percentages:

Sucrose Per cent	Moisture Per cent	Sucrose Per cent	Moisture Per cent	Sucrose Per cent	Moisture Per cent
99.9	0.03	96.0	1.20	90.0	3.00
99.5	0.15	95.5	1.35	89.0	3.30
99.0	0.30	95.0	1.50	88.0	3.60
98.5	0.45	94.5	1.65	87.0	3.90
98.0	0.60	94.0	1.80	86.0	4.20
97.5	0.75	93.0	2.10	84.0	4.80
97.0	0.90	92.0	2.40	82.0	5.40
96.5	1.05	91.0	2.70	80.0	6.00

In order to see how near the manufacturing conditions of Cuba conform to these requirements the following figures are given for the year 1916.

Average polarization of sugar as sampled at New York 95.80
Average per cent moisture of sugar as sampled at New York 1.35

The above per cent moisture, however, owing to drying out of sugar during transportation and during the operations of sampling and mixing is about 0.3 lower than when the sugar was made. As a conservative estimate we may accept 1.5 per cent moisture and 95.65 polarization as the average condition of the sugar between manufacture and delivery. For raw cane sugar of this polarization there is an average difference of 0.35 between polarization and sucrose content, which would make the average condition of Cuba sugars between factory and refinery to be 96.00 per cent sucrose and 1.50 per cent moisture. Sugar of this grade has a safety-factor of 0.375 which is considerably above the limit for safe-keeping. Such sugar, if stored for one season, would deteriorate in New York to a factor of at least 0.30 and in Cuba, where the climate is much warmer, to a factor of 0.25. This would mean that the average Cuban sugar of 96.00 per cent sucrose would deteriorate if stored in New York for one year to 95.00, and if stored in Cuba for one year to 94.00 per cent sucrose.

The average amount of Cuban sugar stored in warehouses at any one time in 1916 was 163,000 long tons in the United States and 440,000 long tons in Cuba. The average price of Cuban sugar per pound for 1916 was 5.786 cents in the United States and 4.767 cents in Cuba.

1 per cent loss on 163,000 long tons at 5.786 cents per lb. =	$ 211,258(a)
2 per cent loss on 440,000 long tons at 4.767 cents per lb. =	939,671
	$1,150,929

(a) This calculation can be checked in a different way. Sixty per cent of the samples tested in 1916 deteriorated and the average loss in polarization per deteriorated sample was 1.8, which would correspond to an average loss of 1.08 on the total 163,000 tons, or, at 5.786 cents per lb., of $228,161.

The above calculation does not take into account the loss due to the deterioration of the 3,000,000 tons of Cuban sugars during transportation. Allowing an average loss of only 0.1[1] per cent sucrose during transit, there would be a deficiency of $320,342 at Cuban prices which would make the total calculated loss from deterioration for the 1916 Cuban sugars nearly $1,500,000.

Reducing the moisture content of raw sugars would not only prevent the losses from deterioration but would accomplish a considerable saving in the costs of transportation. In the shipment of Cuban sugars for the year 1917 approximately 100,000,000 lbs. of water were carried, which, at the rate of $0.004 per lb., would make an expenditure of $400,000 for transportation of a useless ingredient. While the manufacture of moisture-free sugar is practicable only with the very highest grades, the moisture content of the ordinary qualities of raw sugar can be reduced nearly one-half without much extra cost of manufacture.

In conclusion the author desires to thank his assistants Mr. G. H. Hardin and Mr. C. A. Gamble for help in the analytical work of this paper, and Mr. J. A. Hall, Jr., of the A. M. Byers Co., for photographs of Cuban warehouses.

NEW YORK SUGAR TRADE LABORATORY, INC.
80 SOUTH STREET, NEW YORK CITY

[1] This is a conservative estimate. Cuban sugars frequently show a loss of nearly 1.0 in polarization between the times of shipment and delivery.

THEORY AND PRACTICE IN THE DESIGN OF MULTIPLE EVAPORATORS FOR SUGAR FACTORIES

By A. L. Webre

Received February 7, 1918

The purpose of this article is to give a brief outline of the data used in the proper design of a multiple effect evaporator for sugar factories, and its application in practice.

We shall assume a general knowledge of multiple evaporation and, therefore, will not touch upon elementary considerations. In order to study in detail we will subdivide our discussion as follows:

A—Heat transmission considered from the steam side of the surface.

B—Heat transmission considered from the juice or liquor side.

C—A typical problem.

D—Distribution of temperature drops in the various bodies.

E—Heat balance showing flow of heat and liquor for the problem under consideration.

F—Distribution of heating surface arrived at from the heat balance.

G—Considerations necessary in the proper design of a juice heater.

H—Proportioning of the bodies and vapor pipes.

I—The entrainment problem, its cause, provisions required against it.

A—HEAT TRANSMISSION CONSIDERED FROM THE STEAM SIDE OF THE SURFACE

The transmission of heat from steam through the surface of an evaporator is very similar to the operation of a surface condenser, with the exception of the fact that the temperatures of the steam being condensed are higher and, therefore, the specific volume per unit

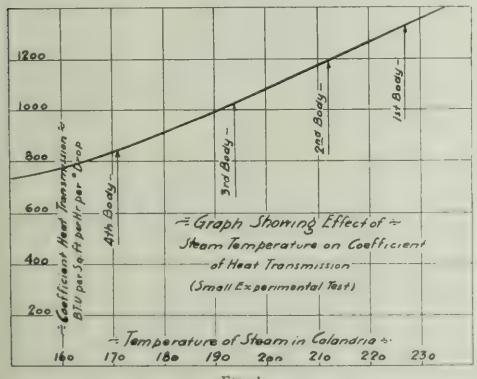


Fig. 1

of weight much smaller. Professor E. W. Kerr in his excellent papers on the subject has shown that the coefficient of heat transmission varies quite considerably with the temperature, being much higher as the temperature increases, and we reproduce a curve herewith showing this variation (Fig. 1).

We also find that the presence of air or non-condensable gas mixed with steam or vapor has a marked retarding effect. This is particularly true if a condition of approximate quiescence obtains within the steam space. It is, therefore, very evident that in order to obtain good results proper provisions should be made to overcome this difficulty. There are designs on the market to-day in which this feature has been carefully

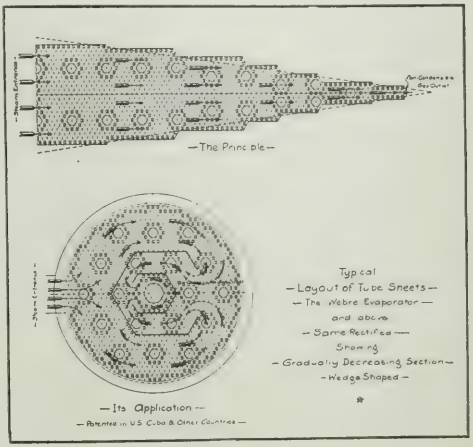


Fig. 2

studied out, giving a rapid, uniform agitation on the steam side. It is to be noted that particularly under vacuum this difficulty will be more noticeable, for not only does a given amount of these non-condensable gases occupy a larger volume by virtue of the reduced pressure, but from the very fact that the equipment is under a pressure lower than the atmosphere, whatever leakage in joints, sight glasses and fittings may take place, this leakage occurs from the outside inward, and becomes mixed with the vapor which eventually reaches the heating surface of the succeeding body, resulting in an accentuated difficulty at this point, so that the provisions relating to this trouble cannot be too thorough.

Fig. 2 shows the writer's arrangement for this purpose.

In this connection it can readily be understood that it is against good logic to vent the steam space of each effect into its vapor space, for in that way the non-condensable gases removed from the steam space of the first effect are in turn put into the steam space of the second, and so on, thus accumulating the undesirable results. This, of course, is doubly true if these gases have a tendency to attack the surfaces. The best plan, and the one in general practice, is to vent each steam belt into a large header connecting to the vapor space of the last body. There are two details in connection with this header that are well worth mentioning. The first is that the header should be in a horizontal position with preferably a slight fall towards the last effect, and that it should enter the vapor belt without rising, for there is always a certain amount of vapor condensing in this pipe, and if the discharge

end is higher than the other, condensed water will accumulate in the lowest point, partially choking the pipe, or at least offering a considerable amount of friction. Under these conditions the steam belt of the first effect which needs least venting will vent most freely, and that of the latter effects which need the most venting will be prevented from doing so, due to the increased pressure at the point of attachment to the header. The other point is that the size of the pipe should be amply large so that the discharge from the vent of the first effect will not prevent the last ones from discharging freely. In fact, the writer has obtained best results on multiple effects having a large number of bodies by having an independent vent for the steam belt of the last body, and having the others connected to the manifold referred to above.

It is useless to state that the steam compartments of the various bodies should be thoroughly drained and water gauge glasses should be installed thereon to make sure that such drainage is complete and thorough, otherwise, of course, water accumulates, blanking off the heating surface and decreasing the work to that extent.

In brief, the above gives a fair idea of the problems to be taken care of on the steam side of the heating surface. We now come to a consideration of the liquor side.

B—HEAT TRANSMISSION CONSIDERED FROM THE JUICE OR LIQUOR SIDE

Liquid in ebullition in an evaporator corresponds to the cooling water in a surface condenser, but the problems involved and the general behavior of the apparatus in operation are quite different. Perhaps the best way to give a good idea of these is to describe an experiment which was made for the purpose.

A small evaporator of the vertical tube type having a central downtake was used. The tubes were of copper 2 in. in diameter by 48 in. in length. This equipment is shown in Fig. 3. The steam side was baffled according to a design originated by the writer and referred to above, and all necessary provisions were made in order to obtain as nearly ideal conditions as possible. For simplicity's sake the evaporator was operated atmospherically, *i. e.*, with the top off, so that a good and uninterrupted observation could be made. The test was run with water, so as to eliminate the density and boiling temperature loss (discussed later). The evaporator was filled until the level of the water was flush with the top tube sheet. The water was cold, about 60° F. The steam valve from a constant high pressure main was opened to a fixed point and allowed to remain thus, so that the amount of steam flowing through was fixed. The air vent was opened to such a point as to make sure that there were practically no dead gases in any part of the heating surface.

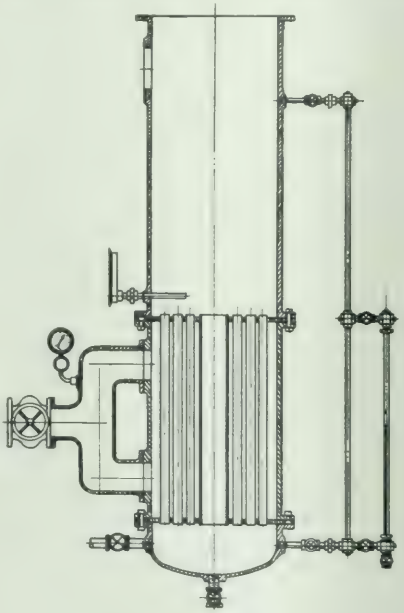
At first with the water still cold, the pressure in the steam space was 5 lbs., and as the temperature increased, this gradually rose until finally just before ebullition started it was 11 lbs. By looking down from the top a large quantity of small bubbles could be seen under the surface of the water clinging to the inside surface of the tubes. Finally the evaporator began to boil and increased very quickly to rapid agitation and circulation.

When this took place three things happened which give a very good insight into the real operation of an equipment of this sort:

I—The pressure dropped very quickly from 11 lbs. to about 5 lbs.

II—The level as indicated by the water gauge glass dropped to a point about two-thirds the height of the tubes.

III—The level of the liquid inside showed intense agitation, and the mixture of steam bubbles and water rose to a point about 12 in. above the top tube sheet.



Sectional Elevation
Experimental Evaporator

FIG. 3

Let us consider carefully each of the above developments in detail with a view to logical interpretation.

I—Inasmuch as the pressure dropped very materially, it follows that the coefficient of heat transmission must have increased in proportion. This increase was due to two causes:

First, the bubbles of steam which clung to the heating surface before ebullition started were liberated and the surface blanked off by these bubbles was now exposed to contact with water. This is merely a duplicate of the oft-mentioned experiment of making a teakettle heat faster by stirring the water with a spoon and liberating the bubbles on the bottom.

Second, before ebullition started there was a quiescent

condition on the inside of the tubes. Now instead we had a rapid circulation. This undoubtedly had a marked beneficial effect on the coefficient of heat transmission. It will be remembered that Mr. Orrok in his experiments on surface condensers found that within certain limits the coefficient of heat transmission varied with the square root of the velocity. Estimating as near as possible, the velocity in this case was about 12 ft. per second.

II—The fact that the water went up on the inside of the evaporator and that the water in the gauge glass went down is explained in this way: The gauge glass shows the static pressure at the bottom; the water on the top is in a dynamic condition, for we must assume that the velocity of the water coming out of each tube must be nearly equal to the velocity of the vapor, and as stated above, this was 12 ft. per second. If this is so, the water left to itself would jump about two and one-quarter feet above the tube sheet. Each tube then is spouting up at this rate and a blanket of water is practically kept in suspension by impingement from below, and this impingement from the tubes near the downtake prevents the free flow of water from the outer diameter of the evaporator towards the center; in other words, interferes with circulation, the result being that a large amount of water is kept constantly above the tube sheet. Now the net area of the diameter of the evaporator being much larger than the net area of the tubes, the original water which was contained in the tubes, now being held in the evaporator above the tubes, does not correspond to as much height in the water gauge glass. In addition, a good part of this water above the tube sheet, is in the form of a spray in mid-air, we might say, and this does not show on the water gauge glass. This lowering of the static pressure as shown by the gauge glass lowers the pressure on the bottom of the heating surface, and consequently tends to cause an increase in the coefficient by giving a larger net temperature drop at this point. To make it plainer, before ebullition begins, the hydrostatic pressure at the lower part of the tube is 4 ft. of water (the tubes being 4 ft. long), which corresponds roughly to two points. The boiling temperature at that pressure is about 218° F. as against 212° at the top of the tube. If we had 5 lbs. pressure on the steam side at this point we would have had 227° steam, with a net drop of 9°, as compared with 15° at the top. Now with the lower static head, the boiling temperature at the lowest part of the heating surface is reduced to about 216°, and, therefore, we can evaporate more inasmuch as the net temperature difference has been increased, which is the same thing as saying that the coefficient of heat transmission as a whole has been increased.

As a supplement to our experiment, the evaporator was again filled to the top tube sheet, brought to ebullition as above, and the steam suddenly shut off, when the level in the water gauge glass went back to exactly the starting point.

Another experiment conducted with the same apparatus was to carry a uniform pressure of 5 lbs. and maintaining the levels at different points to determine what would be the best working level, as shown by the water gauge glass. In this case also there were several surprises. The method of operation was to make time runs in which either the feed or the condensate were measured carefully and the coefficient of heat transmission determined from this. Fig. 4 represents the results obtained. Two things are apparent from this curve. The first is that *under our conditions* of operation the best level was from one-fourth to one-third the height of the tube; the second was that the slowing-up effect of carrying the level too high was much more than expected. It is easy to estimate theoretically what this should be. It is represented by the dotted line above the graph.

The other things that were brought out by this test were that contrary to the common impression, circulation understood as the rapid traveling of the liquor from the bottom of the evaporator to the top and back again has a negligible effect on heat transmission. Test runs were made at the following levels above the bottom tube sheet: 6 in., 12 in., 18 in., 24 in., 30 in., 36 in., 42 in., and 48 in. At 6 in. and 12 in. the tops of the tubes were perfectly dry, and a

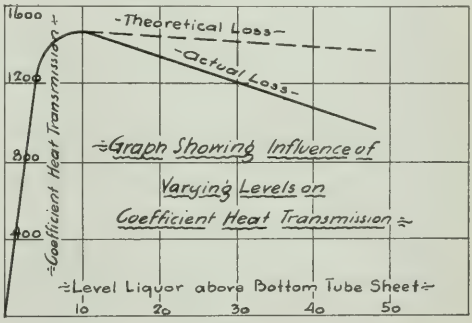


FIG. 4

thermometer placed immediately above the tube sheet, showed a superheat of a few degrees. The highest coefficient was obtained when tops of the tubes were just wet. In this case there was no liquor above the tube sheet, at all, only a little spray out of each tube, and this spray did not reach the down tube. Therefore, we can say that there was no circulation in the proper sense of the word, inasmuch as none of the water returned to the bottom of the evaporator *via* the central pipe. Of course, there was agitation and velocity of travel caused by the rapid vapor currents coming out of the tube, but there was no circulation. As soon as the level was carried beyond this point to such a height that water was going down the center pipe, the coefficient of heat transmission began to decrease, the result being more and more marked, until when water showed level with the tube sheet in the gauge glass, the rate of evaporation was two-thirds of the maximum recorded. We can then safely make the statement that we found the critical point of maximum work to be the level required to keep all parts of the surface wet.

The function of circulation in the proper sense of

the term is evidently a thorough mixing of the solution in order to prevent the material from concentrating locally, resulting in excessive densities in certain parts of the apparatus and low densities in other parts.

Under those conditions there should be selected for the running point a sufficiently high level so that this mixing will take place. This is only slightly above the critical maximum point referred to in the discussion above. Any additional liquor beyond this is a material detriment to the successful and efficient operation of the equipment and should be carefully avoided.

In order to accomplish this result, provision should be made to insure positively against improper operation by using automatic level regulators, the selection of the design depending upon the character of the work. For instance, in non-crystallizing solutions in which the concentration is carried on continuously, an overflow control is advisable, whereas in crystallizing solutions, or solutions concentrated in batches, a properly designed float control is necessary.

It will be understood the above-mentioned working part of one-third the length of the tube only refers to the particular equipment in question under the conditions of the experiment. Changing the proportions of the tubes, the temperature of ebullition, the surface tension of the material being concentrated, the percentage of solids contained, the viscosity, or the rate of evaporation, all affect the behavior of the equipment, and the best point should be determined in each case, and the control set so that the level will be high enough to secure proper circulation under all possible conditions of operation for the particular apparatus in question.

Another factor which greatly affects the performance of any equipment is the accumulation of scale, dirt or incrustations on the liquor side of the tubes. It is, therefore, most essential for uninterrupted operation to remove as far as possible all suspended matter and scale-forming elements before the material enters the evaporator. It is beyond the scope of this paper to discuss in detail the character of each, or the most advisable means for their removal, except to state that in the sugar business the usual method is to clean out at regular intervals, possibly once a week, by boiling out first with a weak caustic soda solution and then with muriatic acid. If the character of the scale is very obdurate it may be necessary to supplement this treatment by mechanically scraping the tubes. It is far better in extreme cases to clean at shorter intervals if the deposit is found to accumulate very rapidly, as it is much easier to remove two thin layers of scale than one thick layer. In this connection it might be well to state that whereas rapid circulation has a tendency to reduce the incrustations and change their character, it is far from being an infallible remedy. Especially is this true in the case of calcium sulfate, and calcium and magnesium carbonates. When the incrustations consist of mechanically suspended matter, on the other hand, rapid circulation greatly minimizes troubles from this source.

C—A TYPICAL PROBLEM

Having briefly discussed general considerations, we shall now proceed more into detail by designing a quadruple effect in accordance with standard practice. We shall assume the following conditions:

Capacity of factory per 24 hours	1,250 short tons
Weight of juice, 120 per cent of wt. of cane	1,500 short tons
Weight of juice per hour	62.5 short tons
Weight of juice per hour	125,000 lbs.
Evaporation per hour required, 75 per cent	93,750 lbs.
Initial temperature at juice heater	75° F.
Hot juice leaving heater	205° F.
Hot juice entering evaporator from heater	189° F.
Initial density of juice entering evaporator	13.7 Brix
Final density of juice leaving evaporator	55 Brix
Exhaust pressure available first body	5 lbs.
Vacuum obtainable	26 in.

D—DISTRIBUTION OF TEMPERATURE DROPS IN THE VARIOUS BODIES

We will select in this case a quadruple effect with juice heating by vapors from first body.

The first item to consider in our design is the drop of temperatures and vacua from one body to the next, and the logical distribution of these drops.

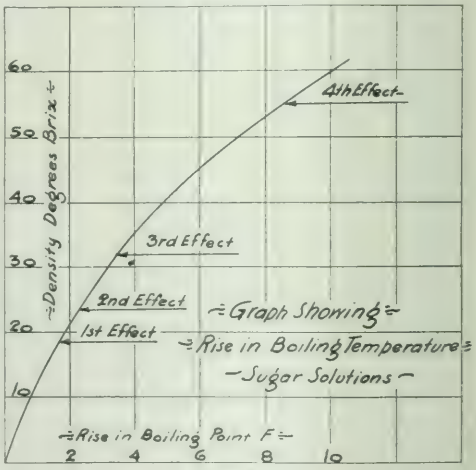


FIG. 5

The temperature of steam at 5 lbs. is 227° F., and that at 26 in. vacuum is 125°. Our total range of temperature, therefore, is 102°, to be divided up among the four bodies of the evaporator. This is not equally divided, being much more on the last body than on the first, for a number of reasons:

1—The coefficient of heat transmission is not the same in all the bodies, but is much more in the first than in the last body. As stated before, therefore, it follows that we should divide up the temperature fall in each according to the coefficient for the particular temperature of steam in the heating compartment. This is true even if we had purely surface condenser conditions, but we have no such conditions, and, besides, there are other factors to consider. (Refer to Fig. 1.)

2—The coefficient referred to in the above paragraph relates to the actual temperature difference between liquor on one side and steam on the other. We find,

however, that as concentration goes on, and the percentage of solids increases, the boiling point rises materially above that of water, which would be the same as that of the vapor leaving the liquid. A curve is shown in Fig. 5 which gives this increase for normal cane sugar juice. We must then deduct from our total temperature fall the summation of these differences for each body.

3—It is true that the pressure at which ebullition takes place is in general represented by the vacuum gauge on each body, which also represents the pressure of the vapor going from there to the succeeding effect, and, therefore, its temperature, but we must recall that this is the pressure at the surface of the liquid. Now, inasmuch as ebullition is going on from the top to the bottom of the tube it is fair and logical

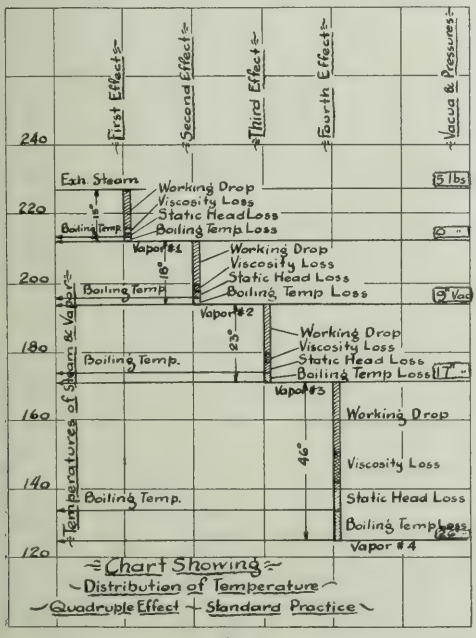


FIG. 6

to say that we should consider the *average pressure* throughout the length of the tube as representing fairly correct conditions, and not the pressure on the surface represented by the vacuum gauge. There will, of course, be a difference between the two which represents a net loss in the temperature fall, and should be taken into account in our calculations. In this instance we will assume, in conformity with accepted practice, that the tubes are 2 in. in diameter and 5 ft. long and that the level is maintained at one-third the length. Our static pressure at the bottom of the tube will then be 20 in. of liquid, and the arithmetical mean will be 10 in. In converting this back to mercury pressure, we must take into account the density of the liquid which is always higher than that of water.

4—The increased viscosity of the juices as the concentration increases also seems to use up temperature drop. The proper determination of this loss is not yet thoroughly defined, but careful experiments by Professor Kerr seem to indicate that for practical purposes we can assume that in cane sugar juices under average conditions it is substantially equal to the boiling temperature loss.

Without going into the detailed calculations, below is a table showing the temperature losses in each body and the distribution of the "working drop" taking into account the available coefficient of heat transmission as affected by steam temperature, and finally the steam and vapor temperatures with their corresponding pressures and vacua (Fig. 6).

BODIES	1	2	3	4
Boiling temperature loss...	1.5	2.0	3.0	9.0
Static head loss.....	1.0	2.0	3.0	8.0
Viscosity loss.....	1.5	2.0	3.0	9.0
Total temperature losses..	4.0	6.0	9.0	26.0
Working drops.....	11.0	12.0	14.0	20.0
Total drops.....	15.0	18.0	23.0	46.0
Steam and vapor temp....	227–212	194.0	171.0	125.0
Pressure and vacua.....	5 lbs. 0 lbs.		9 in.	17 in. 26 in.

E—HEAT BALANCE SHOWING FLOW OF HEAT AND LIQUOR FOR THE PROBLEM UNDER CONSIDERATION

Having studied the proper and logical distribution of temperature differences, we are now in a position to make up a heat balance, showing the flow and distribution of steam, vapor, condensate and juices. In making up this heat balance, in order to avoid complications, we have assumed that the specific heat of sugar solutions will be unity in all cases. Of course, this is not so, but the error introduced is so small that it can be neglected. Also we have assumed that the condensate coming out of each steam compartment will leave at steam temperature. As a matter of fact this condensate is always slightly cooler but the error introduced is very small.

The cycle used is as follows:

1—Juice at 180° F. is fed to the first effect, then to the second, to the third, and to the fourth, whence it is removed in a concentrated condition by the syrup pump.

2—Steam is admitted into the first effect at 5 lbs. pressure. The vapor from here goes partly to the heater, where it warms the juice from 75° to 205°, and the remainder goes to the second effect; the vapors from the second to the third, and from the third to the fourth, and from the fourth to the condenser.

3—The condensate from the first effect goes back to the boilers, that from the heater is wasted, that from the second steam chest is passed to the third, and from the third to the fourth, whence it is removed by a pump.

The heat balance and diagram (Fig. 7) represent theoretically what happens in the evaporator. The steam consumption, however, will be slightly greater, due to radiation losses. These are comparatively small amounting to about $2^1/_2$ per cent in a well-insulated equipment. It is advisable in basing calculations to allow 5 per cent, so that our consumption under these conditions should be 40,500 lbs. per hour.

Heat Flow	Heat Balance[1]	Liquor Flow
First Body		
Steam 38,250 lbs. at 5 lbs. = 38250 × 961 =	36,760,000	125,000
Deduct for heating 125,000 × (213.5 — 180 = 33.5) =	4,190,000	
Available for evaporation	32,510,000	
L at 212° = 970, E = $\frac{32,510,000}{970}$ =		33,500
Transferred to No. 2		91,500
Second Body		
Vapor from No. 1	32,510,000	
Liquor flash 91,500 × (213.5 — 196 = 17.5) =	1,600,000	
Heat available	34,110,000	
Deduct for juice heater 125,000 × (205 — 75 = 130) =	16,250,000	
Available for evaporation	17,860,000	
L at 194° = 981, E = $\frac{17,860,000}{981}$ =		18,200
Transferred to No. 3		73,300
Third Body		
Vapor from No. 2	17,860,000	
Liquor flash 73,300 × (196 — 174 = 22) =	1,610,000	
Condensate flash 16,750 × (212 — 194 = 18) =	302,000	
Available for evaporation	19,772,000	
L at 171° = 995, E = $\frac{19,772,000}{995}$ =		19,850
Transferred to No. 4		53,450
Fourth Body		
Vapor from No. 3	19,772,000	
Liquor flash 53,450 × (174 — 134 = 40) =	2,135,000	
Condensate flash 34,950 × (194 — 171 = 23) =	805,000	
Available for evaporation	22,712,000	
L at 125° = 1021, E = $\frac{22,712,000}{1021}$ =		22,200
Concentrated liquor out		31,250

Note—The above figures are correct to slide rule accuracy.

[1] Representing hourly work. All quantities in pounds.

I—Distribution of Heating Surface Arrived at from the Heat Balance

The next step is to determine the heating surface required and its proper distribution. The total amount of surface will depend upon the design of the evaporator and a unit basis must be taken which has been proved out in practice. In our case, we shall assume that we are contemplating a standard effect and we shall take an evaporation of $5\frac{1}{2}$ lbs. per sq. ft. per hour as a fair basis for a quadruple under the assumed conditions. Our total evaporation being 93,750 lbs. per hour, the surface required will, therefore, be 17,000 sq. ft.

The actual heat flowing through the surface of each body per hour is as follows:

First effect	36,700,000 B. T. U.
Second effect	16,260,000 B. T. U.
Third effect	18,162,000 B. T. U.
Fourth effect	20,577,000 B. T. U.

It is to be noted that all the heat given up by the steam in the first body must be transmitted through the surface. It is likewise to be noted that the heat represented by the liquor flash in the other bodies does not have to be transmitted. These facts have been given due consideration in the above. If we proportioned the surface in each effect in accordance to the above, we should have four different-sized units. We, therefore, make a comparison by making the first effect of one size, and the other three of another size which will be an approximate mean of their individual requirements. By referring to the figures, it is evident that practically we can do this, giving the first body twice as much surface as the others. Our distribution then will be as follows:

First effect	[illegible] sq. ft.
Second effect	[illegible] sq. ft.
Third effect	[illegible] sq. ft.
Fourth effect	3400 sq. ft.

In this connection it might be well to correct a common mistake which consists of giving to the first effect only as much more surface as is contained in the juice heater. This is entirely in error, for the evaporator is working with a temperature drop of only 15°, whereas the heater has a mean temperature difference of practically 72°. Furthermore, the two units being of entirely different design and performing an entirely different class of work, we can say that their coefficients of heat transmission have no relation one to the other except that both transmit heat into juice through copper tubes.

G—Considerations Necessary in the Proper Design of a Juice Heater

And while we are on the subject of the heater let us say that it is a very material advantage to bring the juice while passing through to as near steam temperature as possible, for if supplemental heating is to be done it must be accomplished by the use of expensive single-stage heat. This being true, the surface should be ample for the work. The steam side should be designed so as to give good circulation with thorough removal of condensed vapor and non-condensable gas. The liquor side must be so proportioned as to give rapid flow of juice through the tubes, thereby minimizing fouling. This, of course, is done by means of cells or divisions in the heads giving many passes from the front to the back. The writer has found that with a high juice velocity excellent results are obtainable; indeed the juice can be heated to steam temperature if the unit is properly cleaned at regular intervals. With a good design, as outlined above, a coefficient of 250 can be obtained; therefore, the surface required would be 1000 sq. ft. There should be two such heaters, as they have to be cleaned frequently, the juice going through them not having been defecated.

H—Proportioning of the Bodies and Vapor Pipes

Now going back to the design of the evaporator, it is merely a question of laying out the tube sheet to get the proper diameter. Downtakes or circulating tubes should be provided, so as to get a complete mixing of the liquor being concentrated. The height above the tube sheet should be ample, not less than 8 to 10 ft. The steam pipes must be large enough to take care of the vapors without undue friction. We find that a velocity of 100 ft. per sec. is good practice for exhaust pipes and vapor pipes except in the case of the last effect, when, due to the low density of the steam, it is permissible to increase this to 200 ft. per sec. On this basis the following sizes are advisable:

Exhaust pipe	[illegible] in.
Vapor ex. No. 1	[illegible] in.
Vapor to heater	[illegible] in.
Vapor ex. No. 2	15 in.
Vapor ex. No. [illegible]	[illegible] in.
Vapor ex. No. [illegible]	[illegible] in.
Vapor ex. No. [illegible]	[illegible] in.

By maintaining the velocities and sizes as above, the friction losses will be practically negligible. There are, of course, other small details of design which it is not in the scope of this paper to discuss as we are

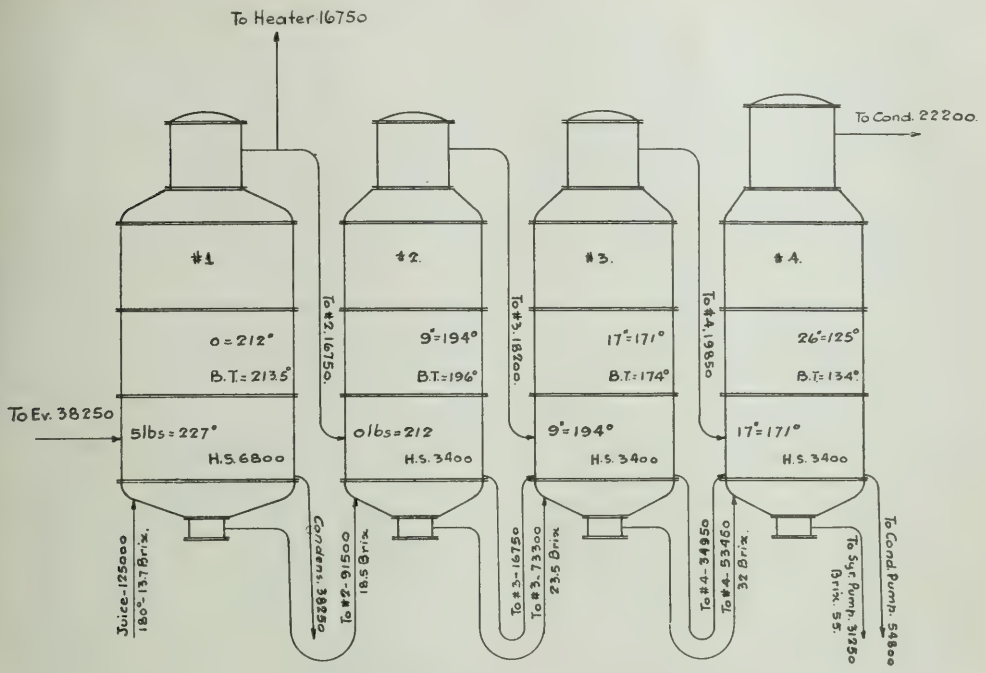


Fig. 7 — Diagrammatic of Quadruple Effect Showing flow of Steam, Condensate & Liquor

confining ourselves to the important items. Such, for instance, are the size and arrangement of liquor pipes, drain pipes, air pipes, etc.

I—THE ENTRAINMENT PROBLEM, ITS CAUSE, PROVISIONS REQUIRED AGAINST IT

We now pass to another phase of our consideration. This is entrainment. The loss of liquor from this source can be divided up generally into two classes. The first is foaming or frothing and occurs in the sugar industry only very rarely, in cases where the juices have been frozen or derived from burnt cane and fermentation has taken place. It is very difficult to overcome, perhaps the best method being to boil at a high vacuum. There are a number of other expedients, such as floating a small quantity of grease or tallow on the surface of the liquid, carrying the level very low, etc. This occurs so rarely, however, that a brief mention of it is sufficient.

The other phase of the problem is loss by spraying or spouting of the tubes, the liquor entering the vapor pipes. The explanation of this is that while evaporation is going on, theoretically at least, some of the liquor leaving the top of the tubes must travel as fast as the vapor driving it out. It is easy to estimate what this is, for obviously all of the vapor generated in each tube must pass through its upper end. Knowing the surface of the tubes, the rate of evaporation per tube and the pressure or vacuum in each, we can readily determine, not only the velocity, but the maximum height to which drops will be projected in this way. Below is a table giving this information for each effect.

Bodies	Evaporation per Tube(a) Lbs. per Hr.	Sp. Vol. Steam Cu. Ft. per Lb.	Vol. per Tube per Hr. Cu. Ft.	Speed per Sec. Ft.	Mean Height of Projection Ft.
First effect....	12.9	26.8	346	5.01	0.390
Second effect...	14.0	37.4	524	7.60	0.896
Third effect....	15.3	58.6	896	13.00	2.625
Fourth effect..	17.1	176.7	3020	43.80	29.800

(a) Tubes are 2 in. o.D., No. 16, 5 ft. 0 in. long as stated previously.

It is therefore apparent that under normal conditions, spray in the first and second effects is negligible. This is not true of the third effect and very far from being so in the last. It must be remembered that not only is this spray projected very high in the last body, but in the very act is broken up into a fine mist, which is floated along by the upward vapor currents. Therefore, one cannot be too careful in providing against loss of liquor from this source. In addition to the regular separators or catchalls commonly used, the writer places baffles in the vapor space where by shifting the direction of vapor currents at a low velocity, it is possible to secure an excellent preliminary separation before reaching the catchall, for it must be remembered that once this spray enters the separator the velocities obtained are so high that the particles of liquor break into fine ones by impingement against the baffles, resulting in a very fine mist which floats along with the vapor to the condenser, with resultant loss.

Along this same topic, it is a very wise precaution to use great care in admitting the liquor from each body to the succeeding one. If it is simply allowed to enter into the bottom below the tube sheet, the "flash" will be local, causing the tubes in the immediate vicinity to spout violently, projecting liquor to the dome. The proper remedy is to distribute this feed in the bottom by means of a perforated coil or manifold, or if this is not used, to provide a flush pot or recipient on the outside of the evaporator, with the upper part connecting with the vapor belt and the lower part with the bottom. Still another way is to use a spray pipe above the tube sheet, and still another is to feed from above with the pipe extending to the center, the opening facing downward.

Many have the tendency to make small of this problem, but when it is recalled that enormous quantities are treated in a given time, it will be found that the game is well worth the candle. For instance, a loss of 1/4 per cent in the evaporator contemplated above would amount to about 800 lbs. of sugar per day, worth, on a six cent basis, $48, and in a campaign of one hundred and twenty working days, this would be $5760, which justifies almost any kind of provision to recover it. And yet there are many evaporators which lose more than 1/4 per cent, but the man who owns it does not know, for evidently the loss is greatest in the last body when the vapor goes into the condenser, and in so doing is diluted about 30 to 1.

E. B. Badger & Sons Company
Boston, Mass.

NOTES ON THE ANALYSIS OF MOLASSES

By Herbert S. Walker

Received January 11, 1918

In comparing the results of a large number of determinations of sucrose in final molasses analyzed by students at the College of Hawaii and by myself, I have noticed that the same sample of molasses appears to contain from 0.5 per cent to 1.0 per cent less sucrose if clarified with dry lead subacetate than if the lead subacetate solution is used. These discrepancies were at first attributed to personal errors, but as the differences invariably persisted in the same direction, an attempt was made to trace out their causes and ascertain which, if either, of the two methods of clarification could be relied upon.

The method of clarification by lead subacetate solution used in this laboratory is that prescribed by the Hawaiian Chemists' Association. 35.75 g. molasses are dissolved in water, clarified with 40 cc. of a solution of basic lead acetate of 54° Brix, made up to 250 cc. with water and filtered. 50 cc. of the filtrate are treated with 1 cc. of a saturated solution of aluminum sulfate, made up to 55 cc. with water and filtered. Reading (in a 200 mm. tube) multiplied by 2 gives the direct polarization. 75 cc. of the original filtrate are inverted by the Herzfeld method and made up to 110 cc. Reading multiplied by 8/3 is the invert polarization. The factor used is 142 — 0.5*t*.

For clarification with dry lead subacetate a method derived from that proposed by Cross and Taggart[1] has been tried. 35.75 g. molasses were dissolved in water and made up to 250 cc., then clarified with 12 to 15 g. dry basic lead acetate and filtered. About 50 cc. of the filtrate were de-leaded and made slightly acid by the addition of 0.3 g. dry powdered sodium bisulfite and filtered for direct polarization. 75 cc. of the original filtrate were inverted and made up as in the previous method for invert polarization.

Since the same concentrations of molasses and of lead subacetate were used in both methods, the direct polarizations were both made in a slightly acid solution and the inversion procedure was identical, it follows that the difference in results must have been due either to the volume occupied by the lead precipitate causing too high results in the "wet" method, or to the dilution in the "dry" method produced by an excess of lead going into solution over that required to precipitate impurities, which would tend to yield too low figures.

VOLUME OCCUPIED BY THE LEAD PRECIPITATE

35.75 g. of a waste molasses were dissolved in water, clarified with 40 cc. lead subacetate solution and the precipitate washed by decantation during a period of several days until the clear decantate from four consecutive washings showed no polarization in a 400 mm. tube. This sugar-free lead precipitate was transferred to a 250 cc. flask together with 22 g. granulated sugar, made up to the mark with water and polarized in a 400 mm. tube, giving R = 68.36. 22 g. of the same sugar made up with water alone in the same flask read 67.46. The difference of 0.90 or 1.33 per cent of the total polarization could have been caused only by the volume occupied by the lead precipitate. The volume left in the flask for the solution in this case must have been not 250 cc., but $250 \times \frac{67.46}{68.36} = 246.72$ cc. The precipitate itself then occupied 3.28 cc. The sugar-free lead precipitate from another 35.75 g. sample of this same molasses was placed in a 250 cc. flask with 32.50 g. granulated sugar, made up to the mark with water, filtered and polarized in a 400 mm. tube, giving R = 101.20. The same weight of sugar dissolved in 250 cc. water alone read 99.80. The presence of the lead precipitate caused an increase of 1.40 per cent of the total polarization. If the molasses from which this precipitate was made contained say 35 per cent sucrose, its apparent value would be increased by 35 × 0.014 = 0.49 per cent sucrose.

The washed lead precipitate from 35.75 g. of molasses from another plantation was still more voluminous. Duplicate tests on it were as follows:

	Reading	
32.50 g. sugar made up to 250 cc. with water alone	99.74	99.83
32.50 g. sugar made up to 250 cc. with lead precipitate and water	101.63	101.87
Increase due to lead precipitate	1.89	2.04
Average	1.96	

If this molasses contained 35 per cent sucrose it would appear to contain 35.69 per cent if analyzed by the H. C. A. method, providing there were no other errors in the method.

[1] *Louisiana Bulletin* **136**.

DILUTION BY DRY LEAD SUBACETATE

A solution of refined sugar containing 13 g. per 100 cc. polarized in a 400 mm. tube 99.51. To a portion of this solution was added dry basic lead acetate in the proportion of 3 g. per 100 cc. The filtered solution then polarized 98.99, a drop of 0.52 per cent. To obtain the maximum clarification of a half-normal molasses solution, up to 6 g. lead per 100 cc. may be required. Assuming that half the lead goes into solution without being precipitated, a molasses containing 35 per cent sucrose might suffer an apparent loss of $35 \times 0.0052 = 0.18$ per cent sucrose on account of this dilution.

EXPERIMENTS WITH ARTIFICIAL MOLASSES

The great difficulty in testing a method for the determination of sucrose in molasses is of course due to the fact that we cannot know exactly how much sucrose there really is in the molasses. If it were possible to remove all the sucrose from a molasses without disturbing its other constituents, it would be a simple matter to make up standard samples for testing out new methods. An attempt in part to accomplish this was made by dissolving 1 kg. of molasses in 10 liters water, clarifying with 1 liter basic lead acetate solution and washing the precipitate by decantation until free from polarization. The lead precipitate was then decomposed by hydrogen sulfide, the lead sulfide filtered off and the clear solution evaporated to about 1 liter, yielding a concentrated solution containing most of the lead-precipitable impurities of the original molasses. 50 cc. of this "impurities" solution were found to require about 40 cc. basic lead acetate for complete precipitation and therefore represent roughly the precipitable impurities in a 35.75 g. sample of molasses.

50 cc. of "impurities" alone analyzed by the H. C. A. method gave a direct polarization of —0.55, an invert polarization of —0.57 and "sucrose" —0.02, or practically nothing.

12 g. pure sucrose alone, analyzed by the H. C. A. method for sucrose in final molasses but omitting clarification and de-leading, indicated 33.59 per cent sucrose (based on a 35.75 g. sample) as against $\frac{12.0}{35.75}$ or 33.56 per cent actually present.

12 g. pure sucrose mixed with 50 cc. "impurities" and analyzed by the H. C. A. method indicated 34.15 per cent sucrose, or 0.59 per cent too much.

12 g. pure sucrose mixed with 50 cc. "impurities" and analyzed by the dry lead method, using 15 g. dry lead subacetate instead of 40 cc. of the solution, indicated 33.28 per cent sucrose, or 0.28 per cent too little.

THE EFFECT OF INVERT SUGAR

Much has been written concerning the influence of the invert sugar in cane molasses on the Clerget determination and the necessity for making direct and invert polarizations in solutions of the same acidity. I have made numerous experiments with many different acids and acid salts in a vain endeavor to find some concentration or combination of a weak acid which would cause invert sugar to polarize as strongly to the left as does 5 cc. of concentrated HCl per 100 cc. solution, and still not cause any inversion of sucrose during the 15 min. or more required to filter and polarize a molasses solution. Fortunately the error introduced in cane molasses analysis is not as large as might be supposed from the amount of time and labor spent in attempting its correction. The invert sugar resulting from the inversion of a normal weight of sucrose in 100 cc. has a minus polarization of about 31.7 at 20° C., in neutral solution, while the same weight of invert sugar in a solution containing 5 cc. concentrated HCl per 100 cc. reads 32.7 to the left, the increased reading due to acid being 1.0 in 31.7, or 3.2 per cent of the total minus polarization. The amount of invert sugar present in cane molasses, calculated from average differences between direct polarizations and sucrose values, has a total minus polarization of from about 3 to 5, so that we should expect an increase in acid over neutral reading of from —0.1 to —0.16, indicating a fictitious increase in sucrose in the final calculation of about 0.1 per cent when direct polarizations are made in neutral or weakly acid solution and invert readings are taken in a solution containing 5 g. HCl per 100 cc. Of course, if direct readings are made in alkaline solution this error may be largely increased.

To test the above theory, a neutral solution of invert sugar was prepared, containing about 24 g. per 100 cc. 25 cc. of this, containing somewhere near the amount of invert sugar ordinarily present in 35.75 g. waste molasses, were analyzed in duplicate by the H. C. A. method for sucrose (omitting clarification and subsequent de-leading) with the following results:

Direct polarization in neutral solution	—4.44	—4.47
Polarization after inversion (25.6° C.)	—4.62	—4.61
"Sucrose"	0.14%	0.12%

On two more samples the direct as well as the invert reading was made in a solution containing 5 cc. concentrated HCl per 100 cc. and gave the following results:

Direct polarization	—4.63	—4.65
Polarization after inversion	—4.62	—4.61
"Sucrose"	—0.01	—0.04

This proves the absence of sucrose in the invert sugar solution and gives an idea of the magnitude of the error introduced by making direct readings in neutral instead of acid solution.

12 g. pure sucrose together with approximately 6 g. invert sugar were next analyzed by the H.C. A. method. The readings (based on a 35.75 g. sample) were: Direct 28.94, Invert (at 24.6°) —14.76, "Sucrose" 33.68 per cent against 33.56 per cent actually present. The error involved appears to be in the neighborhood of 0.1 per cent sucrose, which is well within the limit of personal error of most analysts.

ANALYSES OF RECONSTRUCTED MOLASSES

A mixture of 12 g. sucrose, 6 g. invert sugar and 50 cc. "impurities" was analyzed by the H. C. A. method. The readings on two separate samples were

Direct	29.79	29.70
Invert	14.83	14.73
Temperature	24.7°	24.7°
"Sucrose"	34.41%	34.26%
Average	34.34 per cent sucrose	

A mixture of 12 g. sucrose, 6 g. invert sugar and 50 cc. "impurities" analyzed by the dry lead method (15 g. dry lead subacetate) read

Direct	29.17	29.24
Invert	14.15	14.15
Temperature	25.0°	25.0°
"Sucrose"	33.44%	33.50%
AVERAGE	33.47 per cent sucrose	

The method of clarification with basic lead acetate solution, when worked on a reconstructed molasses of a known sucrose content, is thus found to yield results in this particular case 0.68 per cent too high, while clarification with the dry subacetate gave a figure 0.09 per cent too low.

While the dry lead method previously described has been shown to give fairly accurate results on known mixtures, due in part to compensating errors, it still suffers from the disadvantage that a large excess of lead which is sometimes necessary for clarifying dark colored products causes low results on account of the dilution which it produces. Extreme care must also be taken to add just the proper amount of de-leading agent. Too little of this may cause too high a direct polarization, while any excess over that required for precipitation of the lead introduces a still further dilution of the solution. Especial care is needed when sodium bisulfite is used for de-leading; subsequent experiments have caused me to abandon this reagent altogether in sugar analysis, owing to the marked specific effect it has on the rotation of glucose.

To obviate some of these difficulties the following modification of the dry lead method for final molasses has been evolved, and is submitted for trial and criticism.

NEW PROCEDURE FOR DRY LEAD CLARIFICATION

Dissolve a double normal weight of molasses (52 g.) in water and make up to 300 cc. Clarify in a larger flask with 15 to 20 g. dry lead subacetate and a few grams of dry sand and filter. To 75 cc. of the filtrate in a 100 cc. flask add 20 cc. of a solution containing 100 g. phosphoric acid per liter, make up to 100 cc. with water and filter. (The addition of half a gram or so of zinc dust just before filtration, while not usually necessary, lightens up the color of the solution perceptibly and has no effect on the polarization.) Reading in 400 mm. tube = direct polarization (D). Take another 75 cc. portion of the original filtrate in a 100 cc. flask, add 2 cc. dilute HCl (1 volume concentrated acid to 1 volume water) to neutralize the alkalinity due to excess of lead subacetate, heat to 65°–70° C., add 10 cc. HCl (1 to 1), let stand in air 15 min. or more, cool to room temperature, make up to 100 cc., add zinc dust in slight excess and filter. Reading in 400 mm. tube = invert polarization (I). Then

$$\text{Sucrose} = \frac{D - I}{142.1 - 0.5t}.$$

This method has several apparent advantages over ordinary dry lead clarification of molasses. The addition of a moderate excess of phosphoric acid to a portion of the first filtrate before making up again to a definite volume throws down all the lead as a voluminous, easily filtered precipitate whose volume compensates for the dilution caused by any excess lead originally dissolved. A pale yellow filtrate results which can be read with ease in a 400 mm. tube, so there need be no multiplication of the reading error. The concentration of phosphoric acid selected (2 g. per 100 cc. solution) is based on a number of tests made to determine the maximum acidity possible without danger of inversion. While this amount of phosphoric acid does not, in pure solution, produce quite as high a left rotation of invert sugar as does 5 cc. of concentrated HCl, yet, under working conditions of analysis, the difference is so slight as to introduce practically no error. A number of different acids were tried out in this connection, but none was found to be as generally satisfactory as phosphoric. Sulfurous acid in a concentration of 50 cc. of the saturated solution per 100 cc. total solution causes approximately as high a rotation of invert sugar as does 5 cc. of concentrated HCl; in fact, if sodium salts are also present, the left rotation of invert sugar may become appreciably greater in sulfurous than in hydrochloric acid solution, due not to an increase in the polarization of fructose but to a depressing effect on the rotation of glucose. Moreover, a molasses solution containing sulfurous acid of this concentration is not absolutely free from danger of inversion at tropical laboratory temperatures. I have found a loss in direct polarization of approximately 0.5 per cent sucrose in one hour at 26° C. Owing to the finely divided condition of the lead sulfite precipitate a very considerable time often elapses between the addition of sulfurous acid and the direct reading, so this chance of error, while not very great, is worthy of note.

TESTS OF THE NEW DRY LEAD METHOD

CORRECTION OF DILUTION ERROR

To 500 cc. of a half-normal solution of refined sugar 15 g. dry lead subacetate were added. 75 cc. of the resulting solution were made up to 100 cc. with water, filtered and polarized in a 400 mm. tube, giving R = 74.24. To another 75 cc. portion 1 cc. of a 50 per cent solution of phosphoric acid was added to completely precipitate the lead, the solution then made up to 100 cc. with water, filtered and polarized in a 400 mm. tube, giving R = 74.53. The original solution, before adding lead, polarized 99.51, corresponding to 74.63 if diluted from 75 to 100 cc. The loss in polarization caused by a very considerable dilution by dissolved lead is thus very nearly if not quite restored by precipitating the lead from a definite volume of solution and then making up with water to another definite volume, the theory being that the volume occupied by the lead phosphate precipitate is practically the same as the increased volume caused by solution of lead acetate.

TESTS WITH ARTIFICIAL MOLASSES

A solution of lead-precipitable impurities was made by dissolving 1 kg. of waste molasses in 40 liters water, precipitating with 2 liters lead subacetate solution, washing free from polarization, decomposing the lead precipitate with H_2S, filtering and evaporating the filtrate to about 2 kg. 100 cc. of this solution required about

40 cc. basic lead acetate solution for complete precipitation. A Clerget determination on this solution of impurities showed: Direct polarization = —0.02, Invert polarization = 0.00.

12 g. "Domino" sugar and 100 cc. "impurities" were analyzed by the H. C. A. method and gave D = 34.05, I (27.2° C.) = —9.64, "Sucrose" = 34.05 (based on a 35.75 g. sample).

17.455 g. "Domino" sugar and 150 cc. "impurities" were made up with water to 300 cc. and analyzed by the new dry lead method, using 15 g. dry lead. The results were D = 33.58, I (27.3° C.) = —9.51, "Sucrose" = 33.54 (based on a 52 g. sample). The sucrose actually present in each case was 33.55 per cent.

INVERT SUGAR AND "IMPURITIES" WITHOUT SUCROSE

Samples were prepared containing approximately the amounts of "impurities" and invert sugar found in cane molasses (about 17 per cent invert sugar) and analyzed for sucrose by three different methods with the following results:

Method	D	I	"Sucrose"
H. C. A.	—3.67	—3.74	0.05
Sulfurous Acid	—3.66	—3.52	—0.11
Dry Lead	—3.42	—3.42	0.00

SUCROSE, INVERT SUGAR AND "IMPURITIES"

12 g. "Domino" sugar, 100 cc. "impurities" and about 6 g. invert sugar were analyzed by the H. C. A. method and gave D = 30.20, I (27.0° C.) = —13.58, "Sucrose" = 34.07 per cent.

17.455 g. "Domino" sugar, 150 cc. impurities and about 9 g. invert sugar were analyzed by the new dry lead method, using 18 g. lead subacetate and gave D = 30.01, I (26.8° C.) = —13.27, "Sucrose" = 33.63 per cent.

Sucrose actually present in each case = 33.55 per cent.

The H. C. A. result was therefore 0.52 per cent too high, while that of the dry lead method was 0.08 too high, or practically correct within the limit of experimental error, though a rather large excess of dry lead was used for clarification.

For comparison, 20.142 g. "Domino" sugar (representing 33.55 per cent sucrose on a 60 g. sample), 170 cc. "impurities," but no invert sugar, were clarified with 60 cc. lead acetate solution in a 300 cc. flask and analyzed by Pellet's sulfurous acid method.[1] The results were: D = 34.11, I (26.9°C.) = —9.58, "Sucrose" = 33.99 per cent.

EFFECT OF VARYING AMOUNTS OF DRY LEAD

52 × 10/3 = 173.33 g. of a waste molasses were dissolved in water and made up to 1 liter. Three portions of this were clarified separately with dry lead subacetate corresponding to 10, 20 and 30 g., respectively, per 300 cc. and analyzed as usual, except that in deleading, the amount of phosphoric acid used was varied according to the amount of lead, 3, 4 and 5 cc., respectively, of a 50 per cent solution being used.

Lead subacetate to 300 cc. solution	D	I	t	"Sucrose" Per cent
10 g.	34.45	—15.18	27.3°	38.64
20 g.	35.02	14 47	27.3°	38.53
30 g.	35.71	—13.90	27.1°	38.59

[1] Pellet, *Intern. Sugar J.*, **1913**, 424.

Increasing the amount of lead up to double that required for efficient clarification has no effect on the sucrose value.

For comparison, this same molasses was analyzed by the H. C. A. method, using varying amounts of lead subacetate solution and correspondingly varying amounts of aluminum sulfate for de-leading.

Lead subacetate for 35.75 g. molasses in 250 cc. solution	D	I	t	"Sucrose" Per cent
20 cc.	35.05	—15.48	26.4°	39.23
30 cc.	35.27	—15.25	26.2°	39.19
40 cc.	35.56	—14.88	26.5°	39.18
50 cc.	36.08	—14.57	26.2°	39.30
50 cc.(a)	36.01	—14.64	25.9°	39.25
70 cc.	37.10	—14 02	26.1°	39.64

(a) Sulfurous acid method.

Within reasonable limits the sucrose indicated by this method is independent of the amount of lead used for clarification, but taking the new dry lead method to be correct, the H. C. A. method yields results averaging about 0.7 per cent too high. It will be noted that practically no improvement in this respect results from making the direct polarization in a solution strongly acid with sulfurous acid. This is to be expected, since the principal error, that due to the volume of the lead precipitate, remains the same.

DETERMINATION OF BRIX, SUCROSE AND PURITY IN THE SAME SOLUTION

The dry lead method lends itself readily to the determination of gravity solids and sucrose in the same weighed sample of molasses. As these determinations are both required, some time may be saved by not having to weigh out separate samples for each. The only extra operation involved is to weigh the molasses solution after making it up to 300 cc. preparatory to clarifying. Knowing the water capacity of the flask at standard temperature, the specific gravity and thence the Brix of the molasses can readily be calculated. For this method it is sometimes more convenient to take 86.67 g. molasses in 500 cc. instead of 52 g. in 300 cc.

An alternate method for making the two determinations on the same sample is to prepare a large sample of molasses diluted with 5 times its weight of water, determine Brix on a portion of it and clarify another portion with dry lead subacetate for the sucrose determination. The sucrose is gotten from special tables[1] or from the formula

$$\text{Sucrose} = R \times \frac{26.121}{100 \times \text{sp. gr. at } 27.5^\circ \text{ C.}}$$

An example of each of the above determinations follows:

I—86.67 g. molasses were dissolved in water and made up to 500 cc.
Weight of solution at 26.3° = 528.75 g.
Water capacity of the flask at 27.5° = 497.88 g.

$$\text{Sp. gr. of solution} = \frac{528.75}{497.88} = 1.0620 = 15.28 \text{ Brix} = 15.19 \text{ Brix corrected for temperature}$$

$$15.19 \times \frac{528.75}{86.67} = 92.68 \text{ Brix of original molasses.}$$

The 500 cc. molasses solution after weighing were clarified with 30 g. dry lead subacetate and on analysis gave the following results:
D = 34.96, I 26.3° = 14.91, Sucrose = 38.70, Gravity purity = 41.65.

[1] Hawaiian Chemists' Association, "Methods of Chemical Control," Table 4.

II—A second sample was diluted with 5 times its weight of water
Brix of diluted molasses by pycnometer at 26.3° C. = 15.51
Brix corrected = 15.42.
Brix original = 6 × 15.42 = 92.52
500 cc. of this diluted molasses were clarified with 30 g. dry lead and gave, when analyzed, the following results:
Direct reading (400 mm. tube) = 35.53.
Invert reading (26.3° C.) = —15.17.
Clerget reading = 39.32.
Sucrose (from tables) = 9.66.
Sucrose in original molasses = 9.66 × 6 × 5/4 × 200/400 = 38.64 per cent.
Gravity purity = 41.73.

SUMMARY

In an attempt to explain the discrepancies in results obtained in Clerget sucrose determinations in waste molasses, a large amount of experimental evidence indicates that the method of clarification with lead subacetate solution as recommended by the Hawaiian Chemists' Association yields results from 0.5 to 0.7 per cent too high, this being mostly due to the large volume occupied by the lead precipitate. Clarification with dry lead subacetate gives figures more nearly approaching the true sucrose content of the molasses, but is apt to run a little low, especially if an excess of lead is used in clarifying. A modification of the dry lead method to overcome the dilution error is suggested, and experimental proof of its correctness is offered.

College of Hawaii
Department of Sugar Technology
Honolulu, Hawaii

RELATION BETWEEN EFFICIENCY OF REFRIGERATING PLANTS AND THE PURITY OF THEIR AMMONIA CHARGE[1]

By F. W. Frerichs

Received January 5, 1918

Since writing this paper several months ago a singular case of unpreparedness has developed in the ammonia trade.

As you all know, most ammonia is obtained as a by-product from gas works and from coke oven plants. In gas works and in the older coke oven plants the ammonia is obtained by scrubbing the gas with water and recovering the ammonia from the diluted gas liquor by distillation, whereby free ammonia is obtained, which may be used in the manufacture of aqua and anhydrous ammonia and ammonium salts.

In the more modern coke oven plants the so-called direct process is employed in which only so much ammonia is obtained in the form of ammoniacal liquor as condenses with the water distilling from the carbonized coal. This amounts to only about 20 per cent of the total ammonia. The remaining 80 per cent is obtained by washing the gas with a slightly acid solution of sulfate of ammonium in small apparatus. These plants produce therefore a large amount of sulfate of ammonium, and they are not provided with scrubbers by the use of which all ammonia might be obtained as ammoniacal liquor. This was desirable in peace times because the larger part of ammonium salts was used in the fertilizer trade in the form of sulfate of ammonium.

But when the war demanded ever-increasing quantities of nitrate of ammonium for explosives, the ammoniacal liquors were insufficient in quantity; and although much sulfate of ammonium was available, there was only one plant in the United States in which aqua ammonia could be made from sulfate, and this plant was entirely engaged in the manufacture of ammonia for the refrigerating industry. And it had become necessary to reconstruct this one plant to adapt it to the use of crude ammoniacal liquor on account of the high price demanded by sulfate of ammonium during the war. Upon request of the Food Administration of the United States, remodeling of the plant was temporarily abandoned and even a 50 per cent increase in capacity of the sulfate plant was agreed to for the purpose of securing ample supply for cold storage warehouses and ice plants, the Government aiding in obtaining a supply of sulfate of ammonium at reasonable cost.

After this was arranged there arose a sudden and large demand for ammonia for the manufacture of nitrate of ammonium, and sulfate of ammonium being the only available material, it had to be manufactured from this ammonium salt.

There exists the singular condition that we have coking plants which are prepared to make much sulfate, but which can make only a limited amount of ammoniacal liquor; and we have nitrate of ammonium plants which can work ammoniacal liquor, but which cannot make nitrate of ammonium from sulfate. We have ample ammonia material, but we are utterly unprepared to make nitrate of ammonium from it.

It is known that in England nitrate of ammonium is made by double decomposition of sulfate of ammonium and nitrate of sodium, but it is understood that in this process about 20 per cent of the ammonia is wasted. To investigate this process a Commission went to England several weeks ago, and their report by cable is expected now. But even in the case of a favorable report, it is estimated that it will require six months before works of sufficient size can be put into operation.

Being familiar with the manufacture of ammonia from sulfate, I was called to Washington to consult with officials of the War Department. Complete plans, patterns, assistance, and patent rights were promptly offered and accepted for the purpose of erecting new plants, each the size of our St. Louis plant, a number of which are contemplated for the various explosive works. We have the singular opportunity of witnessing unprecedented growth of an industry which (economically speaking) has outlived its usefulness, and which after the war must die out, being unprofitable under peace conditions.

Reconstruction of our St. Louis plant is being carried on under great difficulties and I must ask your indulgence if I show you this afternoon a sadly disarranged plant, which must be operated while it is being reconstructed. I had hoped to have the plant finished for this convention, but Government demands changed the plans, and if I wish to keep my promise to you I must show the works as they are now.

The scarcity of ammonia is unprecedented and the importance of saving ammonia has become para-

[1] Paper read at the 10th Annual Meeting of the American Institute of Chemical Engineers, St. Louis, Mo., December 5–8, 1917.

mount. Waste of ammonia must be prevented at almost any cost, so much so that officials of the Government contemplate closing ice plants where waste is permitted to continue.

For these reasons a report of the relation between the efficiency of refrigerating plants and the purity of their ammonia charge is of greatest interest at this time, since it tends to prove that pure ammonia and smallest waste of it are inseparable factors in the operation of refrigerating plants.

When I visited the Loan collection of scientific apparatus exhibited in Kensington Museum, London, England, in 1876, I saw for the first time ice machines on exhibit. They were small affairs, operated with ether, carbon dioxide, sulfur dioxide, or with ammonia by the absorption process.

In the years immediately following, Linde published his classical investigations on the Ammonia Compression Ice Machine, laying thereby the foundation for that type of refrigerating plants, which at present is predominant here and abroad.

In 1880, when I arrived in the United States, artificial refrigeration was still in its infancy. But even at that time the superiority of ammonia as a refrigerating agent for larger plants, in preference to other agents, was well established.

Liquefied ammonia gas, however, had not yet become an article of commerce, and the compression ice machines at that time had an attachment by which liquefied ammonia gas could be made from aqua ammonia. Aqua ammonia of great purity was not available and the quality of liquefied ammonia gas made by non-chemists with simple apparatus in the ice plant left much to be desired.

In a paper read before this Institute on the occasion of its first annual meeting, I gave a full account of the methods of analysis and the standards of purity of liquefied ammonia gas up to 1908; and from this account it would seem that in early times 2 per cent impurity, or even more, was quite the rule. But in those times the efficiency of refrigerating plants was low. They were largely confined to wort cooling and to cooling of storage rooms in breweries where considerations other than economy were paramount. Only when refrigerating machinery was utilized for making ice in competition with natural ice, was greater efficiency demanded, and this called for purer ammonia.

Refrigeration is not a chemical industry, and for that reason chemists, as a rule, are not familiar with the details of ice plants. But the importance of chemical purity of the refrigerating agent cannot be fully understood without reference to some details of the plant in which it is used, and for this reason a few words would seem justified to explain the function of those parts of the apparatus which have a bearing on the action of ammonia in ice machines. If these are well understood, the importance of the purity of the ammonia charge will become apparent and will be easily appreciated.

In utilizing ammonia, the latent heat required for evaporation of liquid ammonia is employed for the production of "cold."

Liquid ammonia has a boiling point of — 28° F. at atmospheric pressure. Its latent heat of evaporation at 0° F. is about 555 B. T. U., and this heat is readily extracted from surrounding bodies having a higher temperature than —28° F., thus producing "cold," which by suitable apparatus may be utilized for the production of ice or for refrigeration.

The general arrangement of a refrigerating plant is such that liquid anhydrous ammonia is evaporated at a low pressure and a corresponding low temperature in a closed vessel which is submerged in a medium like brine or air. In evaporating at low temperature, the ammonia extracts heat from this medium, thereby lowering its temperature. The resulting ammonia vapors are again reduced to the liquid state by applying pressure and subsequent cooling in a condenser, and the liquid anhydrous ammonia is returned to the cycle of operations.

Refrigeration by ammonia is therefore a physical process and in theory the chemical composition of ammonia in the cycle of operation remains unchanged. The transformation of ammonia from the liquid to the gaseous state and vice versa can go on indefinitely and, theoretically, a given amount of ammonia can produce an infinite amount of "cold."

Any set of apparatus constituting a refrigerating plant using ammonia for an agent includes, therefore, a device in which liquid ammonia is evaporated and a device to reduce ammonia from the gaseous to the liquid state. The first operation, as a rule, takes place in a pipe-coil which is submerged in the medium which is to be cooled. The second operation can be carried out in different ways, and from the method employed, refrigeration plants are classified as absorption or compression plants.

In absorption machines the ammonia gas is absorbed in cold, weak aqua ammonia to make strong aqua ammonia of about 30 to 35 per cent. This operation is carried out in the absorber. The resulting strong aqua ammonia is forced by a pump into the retort or boiler to be heated to about 150° C., whereby it splits into weak aqua ammonia, 15 to 18 per cent, and hot ammonia gas standing under a pressure of 150 to 250 lbs.

The hot gas under this high pressure is led into the condenser to be cooled and thereby liquefied, producing in good plants liquid ammonia of 95 to 98 per cent purity, the balance being water, which had evaporated with the ammonia. The weak aqua ammonia is returned to the absorber.

In compression machines, the ammonia gas coming from the evaporating or freezing coil is taken by suction into the ammonia pump, whereupon it is compressed to 150 to 250 lbs. pressure per sq. in.; the gas, hot from compression, is delivered to the cooler or condenser to be liquefied to ammonia of approximately 100 per cent purity, which is to be delivered again to the freezing coil, thus completing the cycle of operation.

Comparing the principles involved in absorption and compression machines, it is apparent that apparatus in which evaporation of liquid ammonia takes

place at low temperature and low pressure, and the condenser or cooler in which hot ammonia gas of high pressure is reduced to the liquid state, are alike for both types of refrigerating machines. The expansion valve between the two apparatus and the valves in the pump separate the high-pressure side from the low-pressure side of the machine.

In compression machines the ammonia pump handles ammonia in the gaseous state. The pump is large on account of the great volume of ammonia gas

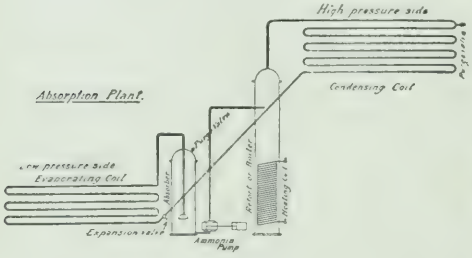


FIG. I

and its suction side has the same function as the absorber in absorption machines. The compression side has the same function as the aqua ammonia pump and the retort or boiler in absorption machines combined, and it delivers ammonia gas under high pressure to the condenser or cooler. In absorption machines the ammonia pump is comparatively small, since it handles ammonia in the liquid state, *viz.*, in the form of aqua ammonia which has a smaller volume than the equivalent amount of ammonia gas. The pump operates on cold aqua ammonia and does not require lubrication of the pistons.

In compression plants, the ammonia pump is large, operates on hot ammonia gas, and requires generous lubrication of cylinder pistons. Therefore, in compression machines, the lubricants require serious attention.

The arrangement of the fundamental apparatus in both types of machine is illustrated by the diagrams Figs. I and II.

The object of both types of plant is to abstract heat from the low pressure or evaporating side and to deposit the same heat at the high pressure or con-

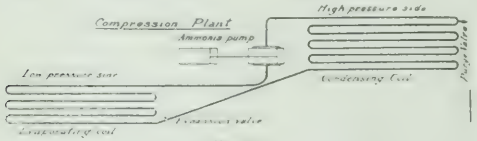


FIG. II

denser side. This transfer is accomplished by evaporating liquid ammonia at low temperatures, subsequently compressing the resulting ammonia vapors either by application of heat in the retort of absorption machines, or by application of power in compression plants, and to deposit the heat which was extracted at the low-pressure side in the condenser on the high-pressure side, whence it is carried off by cooling water which runs through the condenser.

The amount of heat used in the retort of an absorption machine or the amount of power consumed in a compression plant multiplied by a constant is a measure of the amount of refrigeration actually produced. The value of this constant is the product of many factors, one of which is the free and ready evaporation and condensation of ammonia in the machine. All other conditions being equal, the evaporation and condensation of liquid ammonia goes on most freely if the ammonia is pure. If it contains substances either in suspension or in solution, which retard evaporation or which cause ammonia to boil only in a superheated condition, or which retard the transmission of heat to the ammonia, then the efficiency of the machine is impaired. For this reason ammonia of high purity will produce better results than impure ammonia.

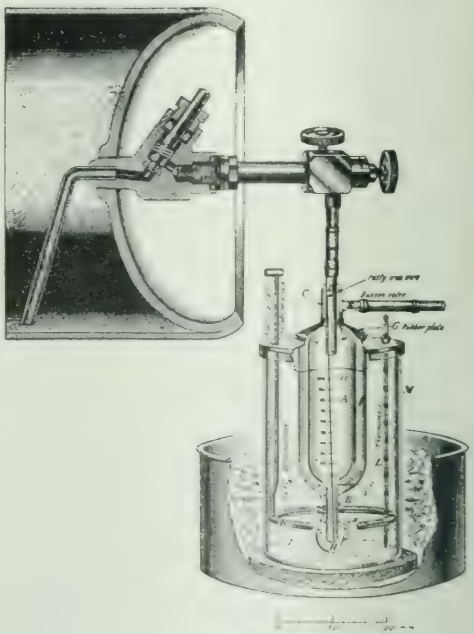


FIG. III

Many impurities which retard evaporation are soluble in ammonia and are less volatile than liquefied ammonia gas. For this reason they may be detected by the evaporation test. An account of this test was given in an earlier paper (*Transactions* I, page 133). But there are many substances less volatile than ammonia, which are harmless and do not impair the speed of evaporation, and yet show up in the evaporation test. To distinguish between harmful and harmless impurities in this regard, the apparatus shown in Fig. III was used to measure the time of evaporation of a definite quantity of liquid ammonia under constant conditions. The apparatus is made of glass and consists of a cylindrical evaporating vessel, A, graduated on its side and having at its lower end a

narrow tube, *B*, in which liquid residues from evaporation may accumulate. The upper part of *A* is drawn out to a small cylindrical part, *C*, with tube *D* inserted which serves to connect the apparatus with the nozzle of the test valve on the ammonia shipping cylinder. *E* is an outlet tube for discharging ammonia vapors coming from the apparatus. *A* is surrounded by jacket *F*, which is joined to tube *B*, and a piece of sheet rubber having a round opening in the center is slipped over tube *C* and is tied over the upper rim of jacket *F* to make an air-tight connection. The air between *A* and *F* must be dry. The lower part of the tube *B* is surrounded by an evacuated bulb, *H*, and the entire apparatus is set in a bath of a 20 per cent solution of calcium chloride, *I*, provided with agitator, *K*, and thermometer, *L*, which serve to maintain a uniform temperature in the apparatus. The calcium chloride solution is contained in a glass jar, *M*, which stands in a bath of ice water and crushed ice.

In evaporating, the ammonia takes heat from the solution of calcium chloride, which in turn takes heat from the melting ice. The object of the apparatus is to make the transfer of heat to the ammonia uniform, in order to make time the measure of evaporation. Dry air in jacket *F* and the vacuum in bulb *H* being bad conductors, all heat must travel through the glass walls of tube *B* between *a* and *b*, which represents the heating surface of the apparatus. Tube *B* extends into bulb *H* to serve as the receptacle for residues of evaporation, which may accumulate in this place, without reducing the area of the heating surface of the apparatus.

The operation of the apparatus is self-evident. By operating the valves on the ammonia cylinder, the apparatus is filled to the 100 cc. mark, whereupon evaporation of the ammonia takes place regulated by the amount of heat which travels from the calcium chloride solution through the walls of tube *B* to the ammonia.

When the ammonia in *A* is evaporated to point *c*, the time of evaporation is noted, together with the temperature of the calcium chloride bath, whereupon a new charge of ammonia is admitted by filling the apparatus up to the 100 cc. mark, and any number of additional charges of liquid ammonia may be evaporated. In repeating the operation, the impurities in the ammonia are concentrated and the time necessary for the evaporation of successive portions is a measure of the increasing amounts of impurities in the ammonia.

Tables I and II give the results of two series of experiments, one of which is made with pure ammonia, similar to quality *B* in Table III, on page 209; the other with less pure ammonia, resembling in composition quality *H* in the same table.

Comparing the values in the two tables, it would seem that the velocity of evaporation of liquid ammonia is not affected by the presence of such small amounts of impurities as are contained in sample *H*. However, the velocity of evaporation decreases rapidly as soon as the oily material, which separates in increasing quantities from the ammonia in successive tests, increases in volume, covering part of the heating surface of the apparatus, and the table shows also that by the time the entire heating surface is covered with oily material the velocity of evaporation is reduced by 50 per cent.

Among the substances not soluble in liquid ammonia but always present in compression plants, is lubricating oil from the compressor. Its retarding action rests in its low coefficient of conductivity for heat. If it enters the condenser it coats the inside of the ammonia pipe, but owing to the high temperature the oil is very liquid and the coating is thin. Nevertheless, the thin coating of oil in the condenser retards the transfer of heat, but the amount of retardation is small and can be overcome by increasing the pressure on the discharge side of the ammonia pump. If the plant is operated at 200 lbs. pressure, 5 lbs. of which is used for overcoming the retardation caused by the coating of oil, then the loss of efficiency for the sake of argument may be assumed to be $2^1/_2$ per cent.

Conditions in the evaporating coil are widely different. The evaporating coil is cold, the oil is thick, the coating of the walls inside the pipes is heavy, and consequently the retardation is large. If in this place the pressure is 15 lbs. per sq. in., and if it must be reduced by 5 lbs. to overcome the retardation in the travel of heat, then the loss of efficiency must be counted as $33^1/_3$ per cent instead of $2^1/_2$ per cent, as was the case in the condenser. For this reason the evaporating coil must be kept free of lubricating oil.

TABLE I—EVAPORATING TEST OF LIQUID ANHYDROUS AMMONIA
PURITY SIMILAR TO SAMPLE *B* IN TABLE III

1914	Temperature, Deg. F. at Start Air(*a*)	Water	Brine	100 cc. Evaporated Duration of Test Minutes	Temperature Deg. F. at End Brine	Water	Air(*a*)	Calculated Time of Evaporation at 15 Lbs. Pressure, 15° F. Minutes
July 21	90	38	42	130	28	38	90	...
	90	38	28	140	28	40	90	570
	90	40	28	135	26	38	90	540
	90	38	26	140	26	38	90	549
Average								553
July 22	95	42	46	125	30	42	95	...
	95	42	30	135	28	38	95	559
	95	38	28	140	28	38	95	570
	95	38	28	135	28	38	95	549
Average								559
July 23	95	40	46	125	30	40	95	...
	95	40	30	130	28	40	95	538
	95	40	28	140	28	36	95	570
	95	36	28	140	28	36	95	570
Average								559
July 24	97	42	48	125	28	36	97	...
	97	36	28	135	26	34	97	540
	97	34	26	140	26	34	97	549
	97	34	26	140	26	34	97	549
Average								546
Grand Average								554
Probable Error			±2.5					±10

(*a*) Average temperature of air.

NOTE—No residue accumulated in the lower part of tube *B*, therefore any number of evaporations of new quantities of ammonia could be carried out with the same results. Evaporation of the first sample on every day was not considered, because the high temperature of brine made results irregular.

The evaporated ammonia is withdrawn from the freezing coil by the absorber in absorption machines, or by the ammonia pump in compression plants. Here again the efficiency is greatest if the ammonia is pure. If the ammonia is contaminated with gases, which cannot be absorbed by water, then these gases will accumulate in the absorber in the case of absorp-

TABLE II—EVAPORATING TEST OF LIQUID ANHYDROUS AMMONIA
PURITY SIMILAR TO SAMPLE *H* IN TABLE III

1914	Temperature, Deg. F. at Start Air(*a*)	Water	Brine	100 cc. Evaporated Duration of Test Minutes	Temperature, Deg. F. at End Brine	Water	Air(*a*)	Calculated Time of Evaporation at 15 Lb. Pressure 15° F. Minutes
Aug. 15	88	42	52	130	28	38	88	...
	88	38	28	150	26	36	88	540
	88	36	26	150	26	36	88	520
Aug. 17	94	42	50	135	28	38	94	...
	94	38	28	150	28	38	94	560
	94	38	28	150	26	34	94	540
	94	34	26	150	26	34	94	520
Aug. 18	95	40	50	140	28	36	95	...
	95	36	28	150	28	36	95	560
	95	36	28	150	28	34	95	560
	95	34	28	150	28	34	95	560
Aug. 19	93	40	50	140	28	36	93	...
	93	36	28	150	28	36	93	560
	93	36	28	150	28	36	93	560
	93	36	28	155	28	36	93	579
AVERAGE.								550
					Oily liquid at *a*, Fig. III			
Aug. 20	88	48	54	140	28	38	88	...
	88	38	28	155	28	36	88	579
	88	36	28	155	28	36	88	579
	88	36	28	155	28	34	88	579
Aug. 21	90	50	58	140	28	36	90	...
	90	36	28	155	28	36	90	579
	90	36	28	160	28	36	90	597
	90	36	28	160	28	36	90	597
Aug. 24[a]	75	48	58	155	28	38	75	..
	75	38	28	195	28	36	75	...
	75	36	28	200	28	36	75	747
Aug. 25	70	50	58	205	28	36	70	..
	70	36	28	205	28	36	70	765
Aug. 26	81	40	52	205	28	36	81	...
	81	36	28	220	28	36	81	821
Aug. 27	75	50	58	225	28	36	75	...
	75	36	28	235	28	36	75	877
Aug. 28	70	40	48	250	28	36	70	...
	70	36	28	260	28	36	70	971
Aug. 29	..	44	50	265	38	36	..	...
	..	36	28	270	28	36	..	1008
Aug. 31	..	44	50	260	30	36	..	...
	..	36	30	275	30	36	..	1063
Sept. 1	..	42	52	270	30	34	..	...
	..	34	30	285	30	36	..	1102
					Oily liquid at *b*, Fig. III			
Sept. 2	..	46	54	280	30	34	..	...
	..	34	30	295	30	34	..	1141
Sept. 3	..	36	38	285	30	36	..	...
	..	36	30	295	30	36	..	1141
Sept. 5	..	50	54	290	30	36	..	...
	..	36	30	295	30	36	..	1141
PROBABLE ERROR.....				±2.5	..	..	..	±10

(*a*) Average temperature of air.

tion machines and cause pressure, which prevents the ready flow of ammonia gas towards the absorber, whereby the efficiency of the plant is reduced.

In the case of compression machines, any gases not ammonia will fill space in the cylinder of the ammonia pump, and will reduce the efficiency of the pump in direct proportion to the volume of such gases present. If the ammonia gas contains 10 per cent of such gases, then the efficiency of the pump will be reduced by 10 per cent.

More serious is the presence of non-condensing gases in ammonia at the compression side of the machine. In both absorption and compression plants, the gas under high pressure enters the condenser to be liquefied. Liquefaction depends upon the pressure and temperature in the condenser. The temperature being largely invariable since it is dependent upon the temperature of the cooling water, the efficiency of a given plant depends largely upon the pressure of the ammonia gas alone.

Pure ammonia gas condenses to liquid ammonia at lowest pressure at a given temperature. If the ammonia gas is contaminated with gases of a non-condensing nature then the pressure necessary for condensation of the ammonia in the gas mixture is increased, according to well-known physical laws. The increase of pressure is in direct proportion to the amount of non-condensing gases present. If the ratio of ammonia to other gases is 1 to 1, then twice as much pressure is required for its condensation as for the condensation of pure ammonia.

This applies both to absorption and compression machines. It becomes serious if the space which is occupied by the gases in the condenser is small. Double pipe condensers, which are mostly used, have a very small condensing space, measuring at an average 12 cu. in. per ft. of pipe. The ammonia in a gas mixture forced into a condenser is liquefied and withdrawn while the contaminating non-condensing gases remain, gradually filling the condenser in cumulative action and paralyzing its efficiency. For this reason ammonia of high purity will produce superior results.

The non-condensing gases mixed with ammonia may be air and in this case they are easy to detect. An apparatus for measuring them is published in Vol. VI, p. 214, of our *Transactions*. But there may be other impurities in ammonia, which, liquid in themselves, may produce non-condensing gases in ice machines, and many of these substances are difficult to detect by analysis. Therefore, the consumer must largely rely upon the reputation of the ammonia manufacturer who stands for the quality of his goods.

There is another source from which non-condensing gases may develop in compression machines, and it must be well understood that not in all cases is the quality of ammonia responsible for the presence of non-condensing gases in the machine. The oil used for lubricating the compressor mixes intimately with the ammonia and if it contains substances, which at temperatures prevailing in the machine develop permanent gases, then these constituents of the oil act in the same manner as if they were brought in with the ammonia charge. Fortunately most oil is good in this respect; and particularly the cheaper grades of compressor oil give good satisfaction. However, there is oil on the market which is undesirable, and operators of ice machines do well to make sure of the good quality of the oil they use in their machines.

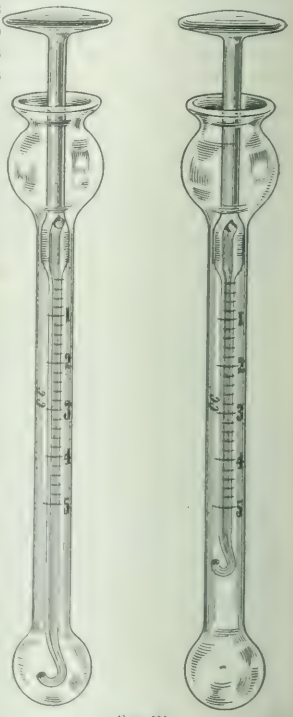


FIG. IV

A simple apparatus for testing oil in this respect is represented by Fig. IV. It is operated as follows:

With the stopper removed, the bulb tube is filled entirely with the oil which is to undergo the test, whereupon the stopper is firmly inserted and the excess oil removed from the funnel over the stopper. Upon heating in a metal bath, undesirable oils will develop gases which will accumulate under the stopper, while an equivalent volume of oil is forced through the capillary tube into the funnel over the stopper and the volume of gas may be measured by the graduation on the tube.

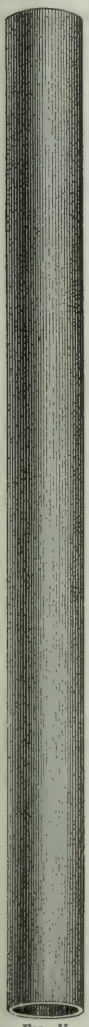


FIG. V



FIG. Va

If non-condensing gases accumulate in the machine, it becomes necessary to remove them and the operation of doing this is called purging.

Purging is generally done by opening a small valve on the top of the condenser, or absorber, or both. The gases which always contain a large proportion of ammonia may be led by a tube under water, whereby ammonia is absorbed, the permanent gases rising in bubbles to the surface of the water. If no bubbles form, all the non-condensing gases are removed, and purging is completed. Another way of purging is to let the gases escape into the air and ignite them by a torch, in which case they burn with a luminous flame which dies out as soon as pure ammonia flows from the orifice. With pure ammonia in the machine, purging may be done at long intervals of time, while with impure ammonia daily purging becomes a necessity.

There is finally a class of impurities found in ammonia which causes corrosion of iron, from which ice machines are made. This occurs more frequently in absorption plants, where corrosion often destroys parts of machinery, causing leaks, and subsequent loss of ammonia during operation.

Acetic acid, acetonitrile, and similar compounds belong to this class of impurities, and they are frequently found in aqua ammonia. A small amount of acetic acid can corrode large quantities of iron by hydrolysis, since the acid always is regenerated. The chemical action on parts of apparatus is illustrated by two tubes represented in Fig. V and Va. Both tubes were used for four years in two absorbers, the one in pure, the other in impure, aqua ammonia. The one has lost hardly any of its weight, while the other is corroded to a thin shell.

In absorption machines the heating coils in the retort are most seriously affected by impure ammonia.

Fig. VI represents the lower part of a retort containing a double heating coil. The coil is made from $1^1/_4$-in. extra strong iron pipe, and weighs about 1200 lbs. If used with pure aqua ammonia, it will last many years, while with impure ammonia frequent renewal becomes imperative. I hold records about coils of this particular size, which in a single year lost as much as 100 lbs. of their weight by corrosion if used with impure ammonia, and I have records of other coils of the same size which were used for as much as 10 years with pure ammonia under the same conditions as the first-mentioned coils and which lost less than 5 lbs. of their original weight.

How seriously the efficiency of an ice plant can be affected by impure ammonia is strikingly demonstrated by the results which were obtained in the operation of two new and identical absorption ice machines, operated in parallel and independently of one another by the same steam plant, by condensing water of the same temperature, and by the same set of engineers, but charged with an equal quantity of ammonia of different purity. Both qualities of ammonia were goods offered in the regular market and were purchased by the manufacturer of the two ice machines for the purpose of making a comparative test of the ammonia. The operations were conducted under the direction of the manufacturer of the ice machines and by the proprietors of the plant, who were disinterested parties. Each of the two ice machines had a capacity of 50 tons and there was an independent ice-tank for each machine. The test was run over a period of almost 17 months, beginning June 6, 1914, and terminating October 31, 1915.

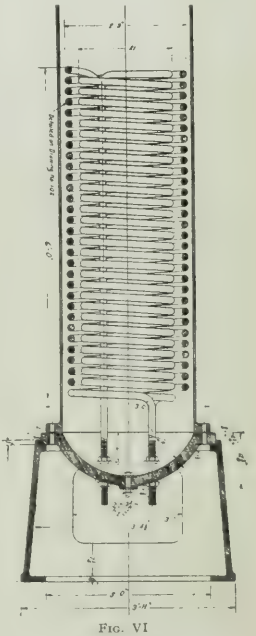


FIG. VI

The first charge of each machine consisted of 16,500 lbs. aqua ammonia, 26° Bé., and 3855 lbs. liquid anhydrous ammonia. During the 17 months of operation 375 lbs. aqua ammonia 26° Bé. and 775 lbs. liquid anhydrous ammonia were added to replenish the charge in Plant No. 1, and on Oct. 31, 1915, after 17 months' operation, the charge was approximately of the same strength as at the beginning of the test run. The machine was operated 24 hrs. per day except between seasons, when it was run in day time only, and in winter, when it was shut down. Ice was drawn

at the rate of 55 tons per day during about 8 months and refrigeration was supplied to the ice-storage room estimated to be equivalent to 3 tons of ice per 24 hrs. in the warm season of the year. The plant ran regularly about 15 per cent over rated capacity. A total of 15,862 tons of ice was pulled, and counting the refrigerating done as equivalent to 1000 tons, 16,862 tons of ice were produced in 17 months at an expense for ammonia amounting to 1.27 cents per ton of ice. Nineteen tons of ice were made for every pound of ammonia lost in operating the plant.

No serious leaks were observed in the plant. Small quantities of permanent gases were burned off during the first weeks of operation, giving a flame about 3 in. long from a $^3/_8$-in. pipe. No gas was purged off during the following four months and in the second summer a flame of only about $^1/_2$ in. length could be burned from the purge tube at intervals of time and then only for a few minutes.

A sample of aqua ammonia drawn from the machine after a 17 months' run was clear as water and it is believed that no corrosion whatever has taken place inside the plant. This, however, can be confirmed only by opening the apparatus, which will probably not be necessary for several years to come.

The result of this run is remarkable if it is compared with the result in Plant No. 2. This plant was started June 22, 1914, 18 days later than Plant No. 1. With the same quantity of ammonia, bought from a different manufacturer and used for the initial charge, Plant No. 2 could produce only 42 to 44 tons of ice while Plant No. 1 had made 57 tons. Upon the addition of 1000 lbs. anhydrous ammonia, 50 tons of ice could be made per day in No. 2.

From June 22, 1914, to November 1, 1915, that is, in about $16^1/_4$ mo., 13,183 lbs. aqua ammonia, 26° Bé., and 3484 lbs. anhydrous ammonia were used in addition to the initial charge, and at the end of the period the ammonia charge in the machine was about 1000 lbs. short on ammonia. 11,308 tons of ice had been made during the period and the cost of ammonia per ton of ice was 15.16 cents, as against 1.27 cents in Plant No. 1. One and one-third tons of ice were made for every pound of ammonia lost in operating the plant.

Serious leaks were observed after a few weeks' operation in the screw connections of the pipes and condensers, caused by corrosive action of the ammonia. Large quantities of permanent gases were burned off daily during the entire period of operation, giving a flame of as much as 3 in. diameter, and over 24 in. long, and this flame would burn from 20 to 30 min. at a time. The excessive consumption of ammonia was caused by leaks and purging.

A sample of aqua ammonia drawn from the machine after 16 months' operation was dark and dirty, and no doubt considerable corrosion had taken place inside the apparatus.

Plant No. 1 had made during the test period an equivalent to 16,862 tons of ice, while Plant No. 2 made 11,308 tons, a deficiency of 33 per cent, and this deficiency must be attributed alone to the difference in quality of the ammonia charge.

The consumption of coal in Plant No. 1 was ascertained to be one ton of Illinois coal to eight tons of ice, while in Plant No. 2 only $5^1/_2$ tons of ice were made per ton of coal, consumed under the boiler.

Similar differences in efficiency were experienced in many plants, which led to the belief that the quality of the ammonia charge had an important bearing upon the operation of ice plants. There were no methods of analysis known to be delicate enough for the purpose of differentiating between the quality of different brands of ammonia, and it seemed to be of sufficient importance to have methods of analysis developed even at great cost for the best of the refrigerating industry. Upon the request of the American Association of Refrigeration, Congress appropriated $30,000 to be put to the credit of the Bureau of Standards, which sum was to be used for the development of methods of analysis of commercial ammonia and for the determination of physical constants of refrigeration.

The composition and testing of commercial liquid ammonia was admirably investigated by E. C. McKelvy and C. S. Taylor, both of the U. S. Bureau of Standards, Washington, D. C., by experiments equal in accuracy to determinations of atomic weights.

A progress report on the result of 2 years' work was presented at the twelfth annual meeting of the American Society of Refrigerating Engineers in December, 1916, and published in their journal for March, 1917.

The report describes in detail methods of sampling and methods of analysis for the quantitative determination of, first, non-condensing gases; second, residue on evaporation; third, volatile impurities containing carbon; fourth, water; fifth, pyridine; sixth, acetonitrile and ammonium acetate; and seventh, direct determination of ammonia.

McKelvy and Taylor made by these methods a series of comparative tests on eleven samples of liquid anhydrous ammonia made by ten different manufacturers and tabulated the results. The eleven samples were marked by letters of the alphabet from *A* to *S*. Samples *A* to *H* represented eight standard American brands provided in 50- to 100-lb. cylinders. They were obtained either by purchase in the open market, or by purchase or donation from manufacturers, and are believed to represent fairly well the material now used in the refrigerating industry. Samples *K*, *L* and *LL* were of German origin, *L* having been purchased in 1906. Sample *M* was an American product purchased in 1907. Sample *S* was prepared from Sample *B* by several fractional distillations, the first of which was made from metallic sodium.

The results of the comparative tests are given in Table III, opposite the letter indicating the origin of the sample. The column headings show the nature of the test and the manner of expressing the results.

As to the limit of accuracy of the figures given in

the table, it was found that in the case of volatile carbon compounds the results were too low. Fifty-eight grams of pure ammonia, mixed with 3 mg. acetonitrile, yielded 95 per cent of the carbon in the combustion test, while 58 g. of ammonia mixed with 15 mg. acetonitrile yielded only 67 per cent of the calculated amount of carbon dioxide, owing to incomplete combustion in the experiment. For this reason, the values given in the table for Samples *B* and *K* are fairly correct, while the amounts of carbon dioxide obtained from other samples were much too low, probably by 40 to 100 per cent. In the case of pyridine, the limit of accuracy was found to be 1 in 100,000,

TABLE III—COMPOSITION OF LIQUID ANHYDROUS AMMONIAS

	Non-Condensing Gas					Residue on Evaporation	Volatile C Compounds	Water	
	In Liquid	In Gas	Composition					Method	Method
Sample	Cc. Per 100 g.	Cc. Per 100 g.	N_2 Per cent	O_2 Per cent	H_2 Per cent	By Weight Per cent	G. CO_2 Per 100 g. NH_3	KOH Per cent	CaC_1 Per cent
A	7	..	69.1	30.9	0.0	0.012 *h*	0.019	0.006	0.013
	..	26	86.7	13.3	0.0	0.007 *l*	...	0.001	...
B	4	..	70.8	29.2	0.0	0.009 *h*	0.002	0.007	0.042
	..	9	70.0	30.0	0.0	0.011 *l*	...	0.008	...
C	6	..	70.3	29.7	0.0	0.008 *h*	0.051	0.007	0.030
	..	8	69.4	30.6	0.0	0.008 *l*	...	0.005	...
D	6	...	68.4	31.6	0.0	0.014 *h*	0.029	0.006	0.030
	..	12	72.6	27.4	0.0	0.017 *l*	...	0.004	...
E	6	...	65.0	35.0	0.0	0.011 *h*	0.019	0.006	0.030
	..	11	74.0	26.0	0.0	0.010 *l*	...	0.006	...
F	15	...	67.0	28.7	4.0	0.015 *h*	0.061	...	0.026
	..	8032	80.1	19.9	0.0	0.022 *l*	...	...	...
G	6	..	70.0	27.0	3.0	0.025 *h*	0.032	0.007	0.026
	..	9	68.0	26.0	6.0	0.100 *l*	...	0.009	...
H	6	..	66.7	33.3	0.0	0.062 *h*	0.902	0.010	0.027
	..	11	66.7	33.3	0.0	0.134 *l*	...	0.010	...
K	7	..	69.0	31.0	Trace	0.276 *h*	0.004	0.011	0.80
	..	19	80.0	20.0	Trace	0.300 *l*	...	0.032	...
L	9	..	77.5	22.5	0.0	0.533 *h*	0.497	0.041	0.50
	..	5680	99.4	0.6	Trace	0.540 *l*	...	0.069	...
LL	15	...	79.0	21.0	0.0	0.318 *h*	0.103	0.053	0.33
	..	1870	99.3	0.7	0.0	0.230 *l*	...	0.040	...
M	..	..	..	..	...	0.040 *h*	0.014	...	...
	..	..	..	..	...	0.051 *l*	0.011	...	...
S	..	..	..	..	...	0.000	0.000	...	0.008

(*h*) Evaporation at room temperature. (*l*) Evaporation at low temperature.

and for acetonitrile and ammonium acetate quantities less than 5 in 100,000 could not be detected.

In addition to the results in the table, McKelvy and Taylor point out the following data of interest:

Sample *F* contained a trace of pyridine and sample *H* 0.02 per cent. The German Samples *L* and *LL* contained 0.015 per cent and 0.005 per cent, respectively. All others contained less than 0.001 per cent.

In the samples showing a low residue on evaporation (*A* to *E*), the residue consisted of a reddish film hardly visible. For the other samples at most a brownish drop of oily liquid was left, and only for Samples *K*, *L* and *LL* could the volume of the results have been measured. The percentage of iron oxide in the residue was greater, the smaller the amount of residue in the sample.

Sample *F* contained 0.005 per cent ammonium acetate or acetate-forming substance, and Sample *L* a trace. All others contained less than 0.005 per cent.

The results of the combustion tests showed a marked difference in the various samples, but in practically all of the tests McKelvy and Taylor observed that no carbon dioxide appeared in the absorber until at least 95 per cent of the liquid had evaporated.

In making this observation, the Bureau of Standards in 1916 disclosed the fact that small quantities of volatile carbon compound can be concentrated into a small volume of liquid anhydrous ammonia by fractional distillation. The Badische Company observed the same fact and patented its invention in 1913. The same process was discovered and put into operation in 1892 in these works and has been in successful operation ever since. While inspecting our works this afternoon you will have an opportunity of seeing the first apparatus used in 1892 and the present plant comprising 5 compressors and 3 stills capable of redistilling 25,000 lbs. of liquid anhydrous ammonia per day of 24 hours. The product corresponds in quality to Sample *B* in the table, the volatile carbon compounds of which are so small that by burning 100 g. ammonia only 0.002 g. carbon dioxide could be obtained, which indicates that less than 0.001 per cent volatile carbon compounds could have been in the ammonia.

Sample *K* in the table, which comes nearest to *B*, was ammonia made in Germany by the Haber process and was evidently redistilled since the Badische Company holds a patent for purifying ammonia from the Haber process by fractional distillation.

The importance of this investigation is emphasized if I state that in the test run, with the two 50-ton machines described in this paper, Plant No. 1 was charged with ammonia which in quality was equal to Sample *B* in the table. The aqua ammonia for the prime charge of this machine was also made by saturating pure distilled water with ammonia of purity *B*.

Plant No. 2 was charged with aqua ammonia of unknown purity. The same brand, however, has given good satisfaction in other instances. But I have reason to believe that the liquid anhydrous ammonia in this charge was similar in quality to Sample *H*, and from this the conclusion might be drawn that the difference in efficiency of the two plants was caused by the difference in purity of the ammonia charges and more particularly by the presence of volatile carbon compounds in the ammonia.

It is to be hoped that this progress report of the Bureau of Standards may soon be followed up with a complete account. The remaining part of the report will include an investigation and analysis of aqua ammonia, a most difficult problem, and at the same time, a problem of the greatest importance for the operation of absorption ice machines. At the present we possess no method of analysis sensitive enough to ascertain small quantities of impurities in aqua ammonia, and enormous sums of money are constantly being lost in the operation of absorption ice machines on account of impure ammonia.

The only way to minimize these losses at the present time would seem to be in using liquid anhydrous ammonia of known purity and pure distilled water for charging absorption plants. But attention should be paid to the quality of distilled water, which rarely is made of sufficient purity to answer this purpose. Here in St. Louis, we are fortunate to have a supply of city water which upon a single distillation yields an excellent product for use in making aqua ammonia. In the city water plant, Missouri River

water is first purified by sedimentation, after the suspended matter has been coagulated by sulfate iron and lime. A subsequent filtration by sand filters removes the last suspended matter and oxidation with chlorine removes bacteria.

From water obtained by distillation of St. Louis city water, and liquid anhydrous ammonia of purity *B*, my company is manufacturing pure aqua ammonia for use in absorption ice machines, and aqua ammonia used in the test run in Plant No. 1, which was described before, was aqua ammonia of this purity.

Reverting to the question of analysis of aqua ammonia, it is believed that the quick detection of minute quantities of volatile substances which render aqua ammonia unfit for use in refrigerating machines will hardly be accomplished by chemical analysis. It is most likely that methods have to be resorted to which are based upon physical principles and which reveal actions of such impurities, although they do not disclose their identity. In looking over the literature on the subject, I found a statement by G. Tammann in his investigation on vapor tensions[1] that apparently the increase of vapor tension of volatile substances following a decrease in space, which is occupied by the same vapors, is caused by minute impurities, and it would seem possible to use this observation for a method of testing volatile substances for purity.[2]

This remark is prompted by the observation of A. Wullner and O. Grotrian[3] that the vapor tension of volatile substances increases if the vapor volume is decreased.

Wullner and Grotrian found the increase of vapor tension for water smaller than for other volatile substances, yet it would be 5–10 mm. if the vapor volume was reduced from $^1/_5$ to $^1/_{10}$ of the original volume.

G. Tammann has repeated these experiments, and has found that there is no increase of vapor tension caused by decrease of vapor volume for water, *if it is pure*, and he succeeded in making water of sufficient purity to prove this fact.

For ether and carbon bisulfide he could materially reduce this irregularity by purifying the substances, but he could not make them sufficiently pure to show the same tension at varying volumes.

From this Ostwald[4] draws the conclusion that no substance except water has ever been made of absolute purity.

G. Tammann then suggests that this observation might be used for a method of testing volatile substances for purity and Ostwald states[4] that one part benzene in 10,000 parts of water can be detected in this manner.

It has occurred to me that these observations may be used for determining volatile impurities in aqua ammonia in the following manner:

Two barometers are combined in one apparatus, one of which is charged over mercury with a solution of pure sulfate of ammonium and pure water, the other with aqua ammonia, which is to be tested, and which previously was neutralized with pure sulfuric acid to make a solution of ammonium sulfate in water of the same concentration as the solution charged into the first barometer; and then the relative vapor tension in the two barometers at various temperatures is determined.

To prove the possibility of this method, apparatus shown in Fig. VII was constructed, having two barometers in a narrow space allowing of uniform heating of both barometers.

Two barometers were made from one length of glass tubing which was equally wide at both ends. The tube was drawn out to a point in the center and both points were closed. Therefore both barometers were equally wide near the closed end of the tube and 1 cc. of mercury filled 22 mm. of the barometer tubes. For making the test both tubes were filled with mercury and the air was removed by repeated evacuation, and filling up with mercury. A 25 per cent solution of pure sulfate of ammonium in water was prepared from which air was expelled by boiling, and methyl orange was added to prove acidity. 2.5 cc. = 2.825 g. of this solution were introduced into each barometer, and in Barometer *B* 0.015 g. benzene enclosed in a small flask was also inserted, whereupon the following readings were taken at various temperatures and various pressures.

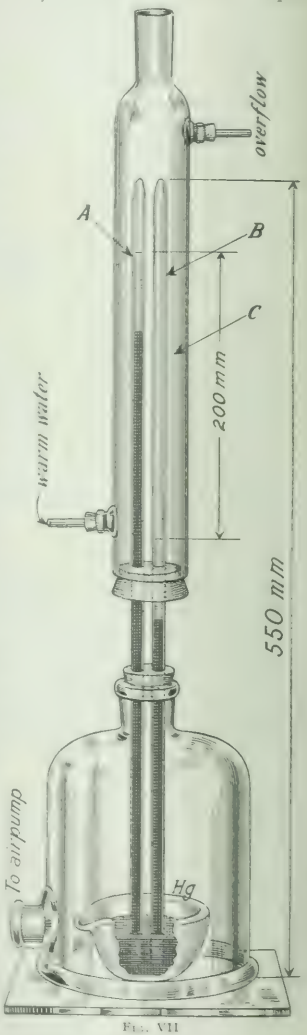


FIG. VII

Table IV shows that 0.003 per cent benzene can

[1] *Mémoires de l'Academie des sciences de St. Petersburg* VII, serie tome 35, No. 9 (1887), 18.
[2] Compare Ostwald, *Allgem. Chemie*, I, 306–309.
[3] Wiedemann, *Annalen*, 11 (1880), 600.
[4] *Allgem. Chemie*, I, 309.

easily be detected in 25 per cent solution of ammonium sulfate by use of this apparatus:

TABLE IV

Temp. Deg. C.	Difference in Barometer $B - A$ = mm.	1 mm. Indicates Benzene Per cent
20	52	0.0106
27	77	0.0071
35	105	0.0051
45	148	0.0038
60	184	0.0030
70	200	0.0027
86	215	0.0026

I am well aware that the apparatus and experiments which I have presented to you are in no way exact and complete in the way physicists will look at them, and I would hesitate indeed to present them for publication in a physical journal. In no way can they compare with the investigations of H. C. Dickinson and N. S. Osborne of the U. S. Bureau of Standards on the constants of refrigeration. But incomplete as they are, they have served me as guides in the manufacture of pure ammonia for use in ice machines, and I find satisfaction in the assurance that the most painstaking investigations of McKelvy and Taylor have confirmed the fact that commercial liquid anhydrous ammonia of such purity is made that it is more worthy of the designation "chemically pure" than many other chemicals which are sold at a high price as chemicals of highest purity.

4320 WASHINGTON BOULEVARD
ST. LOUIS, MISSOURI

TESTING NATURAL GAS FOR GASOLINE

By G. G. OBERFELL

Received July 5, 1917

CASING-HEAD GAS

A very complete description of the methods for testing natural gas for gasoline is contained in the publication by G. A. Burrell and G. W. Jones.[1]

The objections to the various methods have been well stated in this publication. Owing to the fact that tests with the portable absorber seem to be more practical, that method has been preferred in most of the test cases carried out for the Ohio Fuel Supply Company. The main objection to the use of the portable absorber in field testing is the effect of pressure on the yield.[2]

In order to meet the requirements for a method that would give the content and gravity of gasoline in natural gas, it was deemed advisable to modify the absorption method so as to meet all conditions of pressure encountered in field testing. The pressure therefore chosen was atmospheric.

Tests have shown that the allowable saturations of oil with gasoline for complete extraction of gasoline depend upon the gas pressure, the temperature of the oil, the gasoline content of the gas, and the type of absorber. The four-coil type of absorber designed by P. M. Biddison[3] gives a greater yield in most cases in tests with casing-head gases than the absorber with one coil. Experience has shown that the four-coil type of absorber when used in testing casing-head gas gives practically the same yield as the apparatus used in these experiments, providing a low percentage saturation of oil with gasoline is maintained.

The absorber (Fig. 1) used in these experiments was designed so as to give sufficient contact of oil and gas in order to completely remove the gasoline. The absorber is cylindrical in form and made of 22 gauge galvanized iron. It is 10 in. in diameter and 24 in. in length. The ends of the absorber should be conical. The ends are fitted with quarter-inch nipples attached by a boss. Quarter-inch globe valves or quarter-inch cocks are attached to the nipples. The dimensions chosen give the absorber a capacity of about 1 cu. ft.[1]

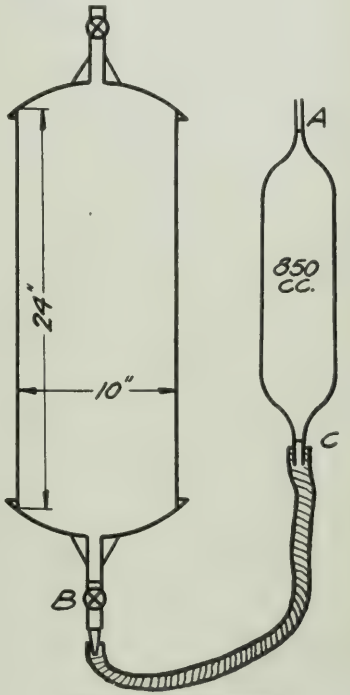


FIG. 1—CUBIC-FOOT ABSORBER

The absorber was calibrated by weighing with water and checked against the meter made by the American Meter Company and used for determination of heating values of gases.

METHOD OF OPERATING

One end of the absorber is attached to the gas supply by means of rubber tubing. The absorber placed in a vertical position is then purged for 30 min. Connection with the gas supply is made at the top in case the gas is lighter than air, or at the bottom in case the gas is the heavier. In either case the last 15 min. for purging should be made at the top so as to expel small amount of oil left from the previous test. The valves

[1] "Methods of Testing Natural Gas for Gasoline Content," Bureau of Mines, *Technical Paper* **87**.

[2] *Proceedings of The Natural Gas Association*, **8**, 1916.

[3] *Natural Gas Journal*, **1916**.

[1] "Industrial Gas Calorimetry," Bureau of Standards, *Technologic Paper* **36**, 35.

are closed with the absorber filled with gas at atmospheric pressure. The temperature of the gas and barometric pressure are recorded. With the absorber in a vertical position oil is forced into it by pressure applied at *A*. After a small amount of oil is added, reduced pressure caused by absorption of gas will generally draw the liquid into the absorber. The re-

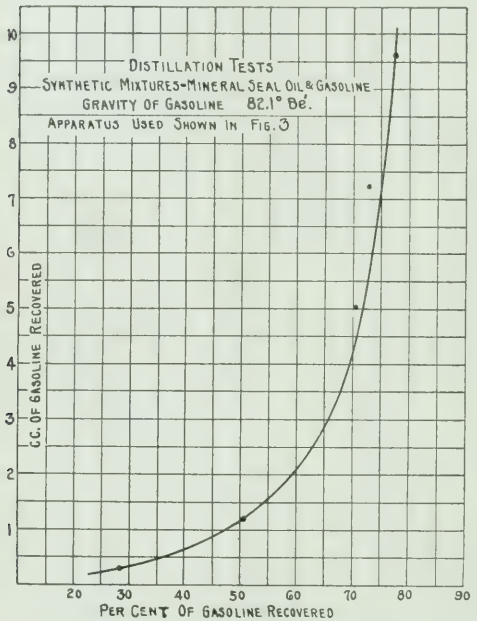


FIG. 2

ceptacles used in these experiments were made of glass and had a capacity of 850 and 880 cc., respectively, having been calibrated at room temperature. The tube between *B* and *C* is filled with oil before the receptacle is attached or the filling of tube and receptacle is accomplished by a three-way cock at *B*. Attempts to add oil by placing the receptacle at the top of the absorber are liable to result in loss of gas. After adding oil the absorber is agitated for 20 min. In case the gas is very rich in gasoline vapor considerable reduced pressure results. If such is the case, air is allowed to enter. The manometer used in flow tests will show if there is a reduced pressure. This point should not be overlooked in order to prevent distortion of the apparatus. After a few minutes of agitation the trouble due to reduced pressure will be overcome. The oil is withdrawn and sent to the laboratory for a distillation test. In order to ascertain time required for purging, the following test was carried out:

Rate of gas flow	27 cu. ft. per hr.
Connection for purging	At top
Specific gravity of gas used	0.65
Gas flow began at	9.01 A.M.
Oxygen in exit gas at 9.05 A.M.	19.9 per cent
Oxygen in exit gas at 9.06 A.M.	1.7 per cent
Oxygen in exit gas at 9.11 A.M.	0.3 per cent
Oxygen in exit gas at 9.16 A.M.	0.0 per cent

METHOD OF DISTILLATION

Anticipating losses in evaporation during distillation of oil samples containing such small quantities of gasoline as would be obtained from 1 cu. ft. of natural gas, distillation tests were made on synthetic mixtures of gasoline and mineral seal oil. The results of these tests are shown graphically in Fig. 2. Practical tests with the absorber checked against plant yield on natural gases having a gasoline content of 1.8 pints, 1.6 gallons and 2.6 gallons, respectively, show that these losses need not be taken into consideration if the gas and oil are thoroughly agitated. This is probably due to a more complete extraction of "wild gasoline," chiefly pentanes. (See Tests 1, 2 and 3.)

The apparatus used in distillation consists of a 1000 cc. copper flask to which is attached a metal exit tube (Fig. 3). The condenser is made from glass tubing and contains 3 bulbs of about 80 cc. total capacity. The condenser jacket is made from a gallon can, the bottom of which has been removed. The temperature of the bath is maintained at 32° F. by an ice-water mixture. The distillate is received in a graduated cylinder (Fig. 4) surrounded by an ice-water mixture. The receiving cylinder is graduated in tenths and capable of being read to $^2/_{100}$ cc. The thermometer bulb is placed $2^1/_2$ in. below the outlet of the exit tube and 800 cc. of oil are used in distillation. (If desired, an aliquot portion by weight could be used.) Distillation is carried on until the exit vapors show a temperature of 350° F.

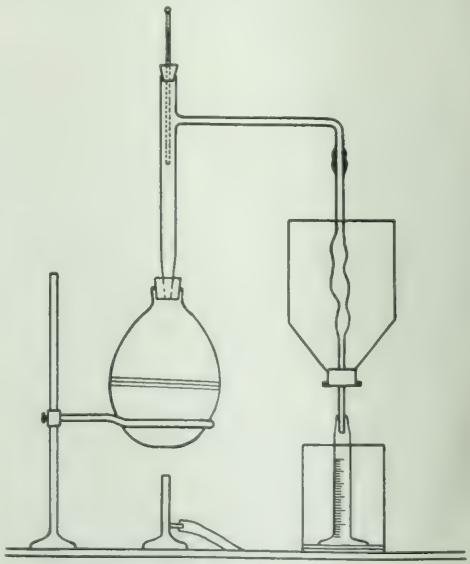


FIG. 3—DISTILLATION APPARATUS

The thermometer is then removed. It is advisable to run a blank on the mineral seal oil before using for testing purposes since some of the grades of oil will give an appreciable amount of distillate if heated to 350° F. After allowing time for drainage the cylinder is removed

and placed in a water bath at 60° F. The volume at 60° F. is recorded. The condenser is washed by running a small amount of alcohol and ether through the tube and dried with air before a second distillation is begun.

GRAVITY OF GASOLINE

The apparatus selected for taking the gravity of a small volume of gasoline was checked against the following instruments: the Tycos Standard Hydrometer made by Taylor Instrument Company, U. S. Bureau of Standard Specifications; the Boots Specific Gravity Bottle, 25 cc. capacity; and the Westphal Balance.

The following methods were used to obtain the gravity of small volumes of gasoline:

I—Graduated cylinder (Fig. 4) for samples of 4 to 10 cc. volume. A cylinder of dimensions of left arm of Pycnometer No. 2 (Fig. 5) for samples of 1 to 4 cc. volume. Such a cylinder can be readily made in the laboratory. Liquid may be transferred to the pycnometer from the receiving cylinder of the distillation ap-

FIG. 4—GRADUATED CYLINDER FIG. 5—PYCNOMETER NO. 2

paratus by means of close-fitting rubber connections. The open ends of the pycnometer are closed with connection tubing and glass plugs, the cylinder, tubing and glass plugs being weighed before gasoline is added. Care must be taken to use fresh pieces of rubber tubing, since rubber tubing increases in weight due to absorption of gasoline vapor. Upon standing the rubber will gradually lose in weight due to escape of the vapor.

II—Graduated cylinder (Fig. 4) and tube for samples of 1 to 4 cc. volume. A small tube with elongated tip and 2 mm. bore was calibrated by weighing with air-free distilled water at 60° F. The tube, after being carefully cleaned and dried, is placed in an air bath at 60° F. The cylinder containing the gasoline is carefully weighed on an analytical balance and then placed in a water bath at 60° F.

A measured amount of gasoline is forced into the calibrated tube and then rapidly removed. The cylinder is stoppered, dried and weighed. From the loss in weight the gravity of the gasoline is determined. Results are generally low. The operation should be repeated with the exception that no gasoline is removed. Loss in weight during this trial is used in correcting gravity.

III—Pycnometer No. 2 (Fig. 5) for samples of 1 to 4 cc. volume. This method is similar to that used by

SUMMARY OF RESULTS OBTAINED WITH THE CUBIC-FOOT ABSORBER

Laboratory Number	1	2 Low Fields Homer, O.(a)	3	4 Blue Creek, W. Va. Compression plant(b)	5	6	7 Walgrove, W. Va. Compression plant(c)	8	9	10	11	Lincoln County, Wells, W. Va.(d) 16	17	18(1)	18(2)	21	22	39	40	41	42
Source of Gas																					
Date of Test		5–12–17		5–19–17			5–19–17			5–26–17		5–28–17				6–1–17		6–13–17		6–15–17	
Time of Test	12.30 P.M.	1.30 P.M.	2.30 P.M.	7.50 A.M.	9.00 A.M.	10.00 A.M.	12.55 P.M.	1.50 P.M.	2.45 P.M.	8.30 A.M.	..	7.15 A.M.	..	1.20 P.M.	..	9.00 A.M.	..	9.00 A.M.	..	9.00 A.M.	..
Number of Absorber	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Capacity of Absorber, Cu. Ft.	1.089	1.089	1.089	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114	1.114
Minutes Purged	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Minutes Agitated	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Temp. of Gas Deg. F.	69	66	64	74	88	88	88	94	95	64	64	61	61	62	62	62	62	61	63	65	65
Barometer, Inches	29.1	29.1	29.1	29.2	29.2	29.2	29.1	29.1	29.1	Remainder estimated at 29.2 in.											
Temp. F. of Atmosphere.	83	83	83	80	80	80	85	85	85	70	70	65	65	61	61	71	71	71	71	80	80
Oil Added, Cc.	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850	850
Oil Recovered, Cc.	835	840	840	805	805	825	805	805	805	825	830	835	835	815	815	830	830	830	830	855	855
Sample for Distillation, Cc.	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Distillate, Cc.	0.86	0.85	0.85	7.89	9.97	9.54	4.88	5.50	4.90	4.12	4.42	3.54	3.76	4.86	4.70	1.12	1.24	4.12	4.38	3.50	4.11
Distillate, Be.	83.5	..	..	87.7	86.7	87.7	81.3	83.6	81.4	81.1	84.0	85.3	85.6	85.6	80.2	80.2	..	..	..	..	..
Conversion Factor for Gas	0.947	0.954	0.959	0.937	0.897	0.897	0.894	0.876	0.872	0.963	0.963	0.970	0.970	0.968	0.968	0.968	0.968	0.970	0.965	0.960	0.960
Cu. Ft. Gas Consumed 60° F. and 30 in.	1.031	1.039	1.044	1.044	1.000	1.000	0.996	0.976	0.971	1.073	1.073	1.081	1.081	1.078	1.078	1.078	1.078	1.041	1.075	1.069	1.069
Gasoline Extracted, Cc.	0.91	0.90	0.90	8.47	10.73	10.26	5.22	5.88	5.24	4.40	4.72	3.78	4.02	5.20	5.04	1.26	1.38	4.83	5.17	4.98	4.80
Gasoline Yield, Gal. per 1000 Cu. Ft. Gas	0.23	0.23	0.23	2.14	2.83	2.71	1.33	1.59	1.43	1.08	1.11	0.92	0.98	1.27	1.24	0.31	0.34	1.18	1.38	0.98	1.14
Sp. Gr. of Gas	..	0.67	..	1.29	1.33	1.32	..	1.09	1.05	0.85	1.07	..	..	1.03	..	0.77	..	0.96	1.00	0.74	0.86
Gas Flow, Cu. Ft. in 24 hrs	..	..	..	..	..	..	..	..	..	390	7122	..	..	15432	..	.30368	..	11240	11825	8830	..
Well Last Pumped, Date	..	..	..	..	..	..	..	..	..	5–25–17 8.30 A.M.	5–28–17 7.00 A.M.	..	..	5–26–17 ..	..	5–29–17 ..	..	Before Pumping	After Pumping	Before Pumping	After Pumping

(a) Yield of gasoline in test with portable one-coil absorber at pressure of 225 lbs. per sq. in. (4–18–16) 0.22 gal. per 1000 cu. ft. gas, gravity 92° Bé.
(b) Yield estimated from production and piston displacement, 2.64 gals. per 1000 cu. ft. gas, gravity 67° Bé.
(c) Yield calculated from production and piston displacement, 1.55 gals. per 1000 cu. ft. gas, gravity 67° Bé.
(d) Tests made in duplicate.

the Bureau of Mines and the pycnometer is essentially the same type of instrument as that devised by Dr. J. A. Culler, Miami University, 1908. The pycnometer is calibrated by weighing it filled to the etch mark with air-free distilled water at 60° F. The dry pycnometer is filled above the etch mark with gasoline. It is placed in a water bath at 60° F. The excess gasoline is removed by a roll of filter paper. The instrument is dried and weighed.[1] From the weight of gasoline and water the gravity of the gasoline is computed.

Results of tests with 80° Bé. gasoline show that the above methods have an accuracy of 0.5° Bé. The objection to the use of the method is evaporation of the volatile liquid during the process of weighing. The objection to the use of the cylinder (Fig. 4) is the error in reading. The presence of heavy gasoline vapors in such a cylinder would also introduce error.

COMMENTS ON TESTS

Attention is called to the apparent inconsistency of the gravity of the gas and the yield of gasoline.[2] Preliminary tests on the absorption method with 100 cc. of gas and 35 cc. of mineral seal oil[3] seem to show a more definite relation to yield of gasoline obtained with the cu. ft. absorber, the tests having been conducted on gases in one field. However, there is not enough information on hand to state this definitely.

DISTILLATION OF 100 CC. OF GASOLINE RECOVERED FROM CU. FT. ABSORPTION TESTS, USING THE ENGLER FLASK

Per cent of Distillate	Temperature Range—Deg. F.
0–10	82–105
10–20	105–120
20–30	120–134
30–40	134–140
40–50	140–173
50–60	173–196
60–70	196–228
70–76	228–300

Residue in Flask = 3 Per cent. Loss in Distillation = 21 Per cent.

There are some objectionable features to the use of the method just described. The absorber is rather bulky. This objection could be overcome by changing the size of absorber and working under pressure, providing the absorber is made rigid to prevent change in volume. Pressure could be obtained with a small pump, which could be used also to force oil into the absorber.

If the absorber were fitted with a removable close-fitting end, it could be used as a case for other instruments. Another objection which would apply to all laboratory methods is that yields reported on a well would be lower than those which would be obtained after the well was put under reduced pressure. However, it happens that an increase in quantity of gasoline from a given well due to reduced pressure causing an increase in yield of gasoline per thousand cubic feet of gas is compensated to some extent by a decrease in volume of gas.

Preliminary tests indicate that alcohol may be used as the absorbing medium instead of mineral seal oil and the separation of the gasoline and alcohol made by dilution with an equal volume of water.

[1] "The Analytical Distillation of Petroleum," by W. F. Rittman and E. W. Dean, Bureau of Mines, *Bulletin* **125**, 27.

[2] "The Condensation of Gasoline from Natural Gas," Bureau of Mines, *Bulletin* **88**, 45.

[3] "Methods of Testing Natural Gas for Gasoline Content," Bureau of Mines, *Technical Paper* **87**.

The cubic foot absorber is intended especially for casing-head gas testing and has been found to give trustworthy results. When the method is used for testing natural gas of lower gasoline content the results are less accurate.

The above tests and tests by others indicate that the practical absorber for testing natural gases for gasoline content would consist of small unit absorbers grouped in series. A testing outfit in which absorbers and meter were made of aluminum could be carried by one man. Preliminary tests at atmospheric pressure with an outfit built on this principle and consisting of a four-unit series absorber resulted in 85–90 per cent recovery of gasoline from a natural gas having a yield of 1.4 pints per thousand cubic feet of gas.

THE OHIO FUEL SUPPLY COMPANY
HOMER, OHIO

THE VALUATION OF LIME FOR VARIOUS PURPOSES

By RICHARD K. MEADE

Received June 8, 1917

The subject of the valuation of lime for various purposes is one which has received very little attention in the scientific press. The methods of analysis have been very carefully worked out but these all follow the standard procedure for the analysis of silicate and carbonate rocks, and required nothing more than the application of well-known gravimetric separations and volumetric titrations. The methods differ in no essential from those employed in the analysis of any calcium mineral or artificial product decomposable by acid and containing the same elements as lime. Outside of the analytical methods, very little has been published on the testing of lime. The standard textbooks contain nothing other than analytical methods and in even the special works on calcareous materials little attention is paid to the subject. In some treatises on the manufacture of certain products in whose elaboration lime is used, there are given special methods for the analysis of lime to be used in this art. The American Society for Testing Materials has drawn up specifications, but these latter are little more than a classification of various kinds of lime and could hardly be used to control the general purchase of lime as, for example, are the cement specifications of the same organization.

The difficulty with lime is that it is not only a building material but it is also an important raw material in many industries, notably the chemical and metallurgical ones. The requirements are quite different in these various industries and the qualities which the builders ask of the lime are quite different from those needed by the chemical manufacturer.

Even here again the qualities necessary in one class of building lime are not required in another, while in one chemical process one kind of lime is required and in another an entirely different sort of product is necessary. Generally speaking, the building trade is most interested in color, plasticity and possibly strength; while the chemical manufacturer wishes purity from carbon dioxide, silica and the oxides of iron and alumina, and to have either a high or low content of magnesia as the process may require.

Unfortunately there are no standards of physical properties and the builder grades his lime largely by means of experience. No color scheme or standard grade of color has yet been devised nor are there even any methods which are generally accepted as reliable for testing plasticity. On the chemical side of the question, however, much more has been done, as I have said, and at the larger chemical works quite reliable methods are employed for the valuation of the lime which they employ. At many of the smaller works, however, very crude methods of analysis are employed. It is the purpose of this paper to outline the methods most generally employed for the chemical analysis of lime. No originality is claimed for these methods on the part of the writer and whenever their source could be traced credit has been given. The object of the paper is rather to collect these methods in one place where they will be generally accessible to the chemist interested in lime.

By way of introduction it may not be amiss to give the various more important uses of lime in the arts, the classification of limes according to chemical composition, etc., and to designate the properties which lime should possess to be acceptable in each industry.

CLASSIFICATION OF LIME

The standard specifications of the American Society for Testing Materials (Report of Committee C-7 for 1915) divide lime into two grades:

(*a*) *Selected*—Shall be well burned, picked free from ashes, core, clinker or other foreign material.

(*b*) *Run-of-Kiln*—Shall be well burned, without selection.

Quicklime is shipped in two forms:

(*a*) *Lump Lime*—Shall be kiln size.

(*b*) *Pulverized Lime*—Shall be reduced in size to pass a $^1/_4$-in. screen.

Quicklimes are divided according to their chemical composition into four types:

(*a*) High Calcium (*c*) Magnesium
(*b*) Calcium (*d*) High Magnesium

The following chemical limits are prescribed by the specifications above referred to:

TABLE I—CHEMICAL COMPOSITION

	Calcium		High-Calcium		Magnesian		High-Magnesian	
	Selected Per cent	Run-of-Kiln Per cent	Selected Per cent	Run-of-Kiln Per cent	Selected Per cent	Run-of-Kiln Per cent	Selected Per cent	Run-of-Kiln Per cent
Calcium Oxide	85–90	85–90	90 (min.)	90 (min.)	...	...	..	..
Magnesium Oxide	..	..	..	..	10–25	10–25	25 (min.)	25 (min.)
Calcium Oxide + Magnesium Oxide	90	85	90	85	90	85	90	85
Carbon Dioxide (max.)	3	5	3	5	3	5	3	5
Silica + Alumina + Oxide of Iron (max.)	5	7.5	5	7.5	5	7.5	5	7.5

Hydrated lime takes the same chemical classification as the lime from which it was made.

USES OF LIME

In the building trade, lime is used for three important purposes: (1) Mixed with sand as a bonding material in laying brick and stone; (2) for plastering; and (3) hydrated and mixed with Portland cement to confer certain properties to mortars of the latter, such as plasticity and imperviousness to water.

As I have said, the suitableness of a lime for building purposes depends entirely on physical properties, although these in turn are, of course, affected by chemical composition. For all of the above purposes a lime may belong to any of the grades referred to above. For bonding brick and stone, the important qualities of lime are the sand-carrying capacity, the crushing strength and tensile strength. For plastering, selected lump lime or hydrated lime is employed. Good color and plasticity are, of course, important in lime for this use. The lime must not "pit" or "pop" and must not give too great change of volume during setting—the quicker the latter the better, also hydrate must be thoroughly hydrated in addition to the foregoing properties. Magnesian or dolomitic limes are generally considered preferable to calcium limes for plastering.

For use with Portland cement, very impure and off-color hydrate may be successfully employed. Here the fineness and completeness of hydration are most important.

The tests ordinarily employed for building limes, therefore, are those for chemical composition, sand-carrying capacity, crushing strength, tensile strength and setting time. Hydrated limes in addition are subjected to tests for fineness and constancy of volume.

Large quantities of lime are used in agriculture both in the form of quicklime and hydrated lime. Some authorities claim that only calcium lime should be used for this purpose, while others contend that magnesium and dolomitic limes are just as efficient. The question may, therefore, be considered an open one, depending usually on the attitude of the agricultural department of the state in which the lime is sold. Generally speaking, the cheapest grades of lime are used for fertilizer, as color and physical properties need not be considered and chemical impurities are only undesirable as they detract from the amount of calcium oxide present. The value of lime for fertilizer depends entirely on the cost per unit of calcium oxide (or calcium and magnesium oxide if the latter is considered equivalent to the former). For convenience in applying, ground lime is to be preferred to lump lime, while hydrated lime owing to its extreme fineness is to be preferred to either lump or ground lime.

Many sprays used for trees and plants are prepared from lime. For this latter purpose the value of the lime depends entirely on the percentage of free calcium oxide which it contains. Magnesia is of no value here.

In the manufacturing arts, what is wanted in all cases is a very pure lime, and the value of the latter depends entirely on the percentage of active or quicklime in the latter, that is, the uncombined calcium oxide (sometimes calcium and magnesium oxides combined). In the manufacture of caustic soda and of sugar, magnesia is considered harmful. Following is a list of the more important chemical industries in which lime is employed and the class of lime employed by each.

SODA ASH produced by the "Solvay" or ammonia process. A high-calcium lime must be employed and impurities are undesirable aside from their lowering the unit contents of lime. The valuable content of the lime is the *free* calcium oxide.

CAUSTIC SODA produced by "causticizing" soda ash with lime. The requirements for lime are the same as in the manufacture of soda ash.

AMMONIA—Requirements for lime are the same as in the manufacture of soda ash.

POTASSIUM DICHROMATE—Requirements are the same as for soda ash.

PAPER AND PULP BY THE SODA PROCESS—Requirements are the same as for lime used for caustic soda.

CALCIUM CARBIDE—Magnesia and impurities are decidedly objectionable and the lime should be very well burned and as pure as possible. The valuable content is the *free* calcium oxide.

BLEACHING POWDER—Magnesia should be as low as possible. Impurities are objectionable as they lower the quality of the powder. The valuable constituent of the lime is the *free* calcium oxide.

CALCIUM CYANIDE—Pure high-calcium lime is desired, the value depending on the quantity of free calcium oxide present.

CALCIUM ACETATE (ACETATE OF LIME)—Value of lime for this purpose depends solely on the percentage of free calcium oxide. Magnesia and impurities of themselves do no harm.

GLYCERINE, LUBRICATING GREASES AND FAT INDUSTRIES—Requirements are same as for calcium acetate.

PURIFICATION OF ILLUMINATING GAS—Requirements are the same as for calcium acetate.

PURIFICATION AND SOFTENING OF WATER—Requirements are the same as for calcium acetate.

SUGAR—Pure high-calcium lime is required. Magnesia and silica cause trouble in the process and should, therefore, be present only in small quantities. The valuable constituent is *free* calcium oxide.

LEATHER—For tanning, *free* calcium oxide is the valuable constituent. Iron oxide is objectionable as it causes stains.

SAND LIME BRICK—A pure high-calcium lime is desired. Impurities are not objectionable of themselves. Magnesia should not be very high. If hydrate is employed it must be completely hydrated.

PAPER AND PULP BY THE SULFITE PROCESS—Requirements are for a high-magnesium or dolomitic lime. Impurities are only objectionable as they detract from the quantity of the *free* oxides of calcium and magnesium present, the two latter being the valuable constituents.

MAGNESIA—Dolomitic limes alone are required for the purpose and the value depends solely on the percentage of *free* magnesium oxide present.

GLASS—Both high-calcium and high-magnesium limes are used. The oxide of iron should be low but other impurities are immaterial.

COLD WATER PAINTS—Hydrated lime is employed and fineness and color are the main requirements. Chemical composition is unimportant.

METALLURGY—Both high-calcium and high-magnesium limes are employed. Impurities are objectionable only when present in large quantity. Generally speaking, the lime should be burned much harder than usual for this use.

PHYSICAL TESTS

The only physical tests of lime for which standard methods are available are those for determining (1) the proper or normal consistency of lime paste, for which purpose the Chapman apparatus is now pretty generally employed, (2) the percentage of waste in quicklime and (3) the fineness and constancy of volume of hydrated lime. For conducting these latter tests, the standard specifications of the American Society for Testing Materials prescribe the procedure. These same rules also instruct as to sampling. Their directions are as follows:

SAMPLING QUICKLIME—When quicklime is shipped in bulk, the sample shall be so taken that it will represent an average of all parts of the shipment from top to bottom, and shall not contain a disproportionate share of the top and bottom layers, which are most subject to changes. The samples shall comprise at least 10 shovelfuls taken from different parts of the shipment. The total sample taken shall weigh at least 100 lbs. and shall be crushed to pass a 1-in. ring, and quartered to provide a 15-lb. sample for the laboratory.

When quicklime is shipped in barrels at least 3 per cent of the number of barrels shall be sampled. They shall be taken from various parts of the shipment, dumped, mixed and sampled as specified above.

All samples to be sent to the laboratory shall be immediately transferred to an air-tight container in which the unused portion shall be stored until the quicklime shall finally be accepted or rejected by the purchaser.

SAMPLING HYDRATED LIME—The sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. A 2-lb. sample to be sent to the laboratory shall immediately be transferred to an air-tight container, in which the unused portion shall be stored until the hydrated lime has been finally accepted or rejected by the purchaser.

PERCENTAGE OF WASTE IN QUICKLIME—An average 5-lb. sample shall be put into a box and slaked, by an experienced operator, with sufficient water to produce the maximum quantity of lime putty, care being taken to avoid "burning" or "drowning" the lime. It shall be allowed to stand for 24 hours and then washed through a 20-mesh sieve by a stream of water having a moderate pressure. No material shall be rubbed through the screens. Not over 5 per cent of the weight of the selected quicklime nor 5 per cent of run-in-kiln quicklime shall be retained on the sieve. The sample of lump lime taken for this test shall be broken to all pass a 1-in. screen and be retained on a $\frac{1}{4}$-in. screen. Pulverized lime shall be tested as received.

FINENESS OF HYDRATED LIME—A 100-g. sample shall leave by weight a residue of not over 5 per cent on a standard 100-mesh sieve and not over 0.5 per cent on a standard 30-mesh sieve.

CONSTANCY OF VOLUME—Equal parts of hydrated lime under test and volume-constant Portland cement shall be thoroughly mixed together and gauged with water to a paste. Only sufficient water shall be used to make the mixture workable. From this paste a pat about 3 in. in diameter and $\frac{1}{2}$ in. thick at the center, tapering to a thin edge, shall be made on a clean glass plate about 4 in. square. This pat shall be allowed to harden 24 hrs. in moist air and shall be without popping, checking, cracking, warping or disintegration after 5 hrs. exposure to steam above boiling water in a loosely closed vessel.

For the other physical tests for lime the methods employed for the most part are similar to those used in testing cement. As a matter of fact, however, such complete testing of lime is hardly ever done by the architect or engineer and about the only time that a complete set of tests is made is in the case of a scientific investigation. One or two of the larger producers have made some extended tests of their product along scientific lines, and here and there an engineering organization has undertaken this work with a view to obtaining information on the properties of various limes. The various government bureaus have also made and are constantly making elaborate tests. So far as we know, however, lime is not regularly inspected and tested by any large user.

The methods which are employed in such investigations are in general quite similar, as I have said, to those employed in testing cement although the details for the most part differ with each operator. The first step is always to determine the proportions of lime and water which are necessary to make a paste of standard consistency. This is now usually done by means of the Chapman apparatus. This apparatus is fully described in the *Proceedings of the American Society for Testing Materials*, Vol. 13, p. 1045. This consists of a split cylinder of thin, hard rubber about 2 in. in diameter by 3 in. high, tapering slightly towards the bottom. When this is filled with paste and dropped a short distance (3 in.) the cylinder will spread and may be measured from the widening of the slit in the cylinder. Chapman considers 0.40 in. to be about the correct amount for a lime putty of normal consistency either with or without sand. All tests which are to be made of the lime should be made with a paste of the standard consistency as determined with this apparatus.

For determining the crushing and tensile strength, a mortar consisting of standard lime paste and standard Ottawa sand should be used, the proportions being lime paste of standard consistency equivalent to one part by weight of dry lime to three parts of sand. The crushing test should be made on 2-in. cubes and the tensile-strength test on the standard cement briquette. The specimens are, of course, stored in air and may be broken at any period, generally after 3 months.

For testing the sand-carrying capacity of lime, test pieces are made up employing varying proportions of standard lime paste equivalent to a definite quantity of dry lime and standard Ottawa sand. The test is made just as is the crushing test.

The Vicat needle is used to determine the time of set and is employed as in cement testing.

There is no very well-accepted method for testing hardness. Sometimes a sand blast is used. Very recently, however, the Bureau of Standards has been employing the following method: 1000 g. of BB lead shot are allowed to drop from a reservoir through a 1-in. iron pipe 6 ft. $\times$ $10^3/_4$ in. long on a mortar placed at an angle of 45° with the vertical axis of the pipe. The loss in weight of the mortar due to the impact and wearing action of the shot determines the hardness.

Color can, of course, be obtained by comparison with known standards. These may be made by mixing any pure white powder such as ground calcite with definite amounts of brown coloring matter. There is no recognized standard, however.

No satisfactory tests have been proposed for plasticity and about the only method of judging this is the purely empirical one of spreading over a surface by an experienced operator.

DETERMINATION OF FREE CALCIUM OXIDE OR HYDROXIDE

For determining the free calcium oxide in quicklime or free calcium hydroxide in hydrated lime, the following methods are used in the laboratories of chemical manufacturers and in many instances the lime is bought on a unit basis as the result of this determination.

BY TITRATION WITH STANDARD HYDROCHLORIC ACID—This is the oldest and simplest method. Weigh 28 g. of the coarsely ground sample into a liter graduated flask containing about 250 cc. of recently boiled distilled water. Boil for 10 min., close with a cork containing a 6-in. capillary tube and allow to cool somewhat. Make up to the mark and mix well. *Immediately* after mixing draw off 50 cc. of the milk of lime and titrate at once with normal hydrochloric acid, using phenolphthalein as an indicator. Allow the flask to remain some time to see if the pink color returns. For the percentage of free calcium oxide, multiply the number of cc. required by 2.

In the case of hydrated lime use a 1.4-g. sample, place in an Erlenmeyer flask with 250 cc. of water and titrate the entire volume after boiling and cooling as above. In the case of quicklime the larger weight is necessary in order to get a proper average. The sample should be quickly ground and placed in a tightly corked bottle —never in a sample envelope.

SCAIFE METHOD—The chemists for the Scaife Company modify this method as follows: Weigh 1.4 g. of the carefully prepared and finely ground lime into an 8-oz. assay flask, add about 80 cc. hot water, cover with a beaker, carefully heat and then boil for three minutes.

Cool, remove cover, add 2 drops phenolphthalein and titrate with N HCl adding the acid rapidly in a thin stream while shaking constantly to avoid local excess of acid. Near the end drop in the acid rapidly while shaking until the pink color disappears. Note the reading but ignore any return of color.

Repeat the experiment adding about 5 cc. less acid than before, call the number of cc. used "A." Grind up any small lumps with the round end of a thick glass rod, transfer the pink mixture to a 250-cc. volumetric flask, dilute to the mark with distilled water, mix, let settle half an hour.

Titrate 100 cc. slowly with phenolphthalein and N HCl until colorless. Call this additional number of cc. used "B." Then, percentage of available calcium oxide $= 2A + 5B$.

BY TITRATION WITH OXALIC ACID—Lunge in his "Technical Chemists' Handbook" gives the following method for determining calcium oxide in quicklime:

"Weigh 100 g. of an average sample carefully taken, slake it completely, put the milk into a half-liter flask, fill up to the mark, shake well, take 100 cc. out, run it into a half-liter flask, fill up, mix well, and employ 25 cc. of the contents, equal to 1 g. quicklime, for the test. Titrate with normal oxalic acid and phenolphthalein as indicator, adding the acid very slowly and shaking well after each addition. The color is changed when all free lime has been saturated and before the $CaCO_3$ is attacked. One cc. normal oxalic acid = 0.02805 CaO."

Lunge also give the following method for carbon dioxide: "Titrate CaO and $CaCO_3$ together by dissolving in an excess of standard hydrochloric acid and titrating back with standard alkali. By deducting the CaO estimated as above the quantity of $CaCO_3$ is obtained."

BY SUCROSE SOLUTION—Guilford L. Spencer gives the following method for determining the calcium oxide in quicklime in his "Handbook for Cane Sugar Manufacturers." As this method is related to the industrial process in which lime is used in sugar manufacture it is presumably especially applicable to testing lime at the sugar works.

"Add sufficient water (30 cc.) to 10 g. of lime, in a mortar, to form a thick milk. Add an excess of pure sucrose in the form of a solution of 35–45° Brix and mix it intimately with the lime, which forms a soluble saccharate. Transfer the solution and residue to a 100-cc. flask, using a sugar solution of the above composition to wash the last portions from the mortar and to complete the volume to 100 cc., mix and filter. Titrate 10 cc. of the filtrate with a normal solution of hydrochloric acid using phenolphthalein or lacmoid as an indicator. The burette reading × 0.028 = the weight of calcium oxide (CaO) in 1 g. of the lime, and × 100 = percentage of calcium oxide."

SOLVAY METHOD—The following method was devised by the chemists of the Solvay Process Co. and is very reliable. For carrying it out a special flask shown in Fig. I will be needed. Boil 4 g. of the lime ground to pass a 100-mesh sieve in a 250-cc. Erlenmeyer flask for a few minutes with a little (60 cc.) water to thoroughly disintegrate it.

After cooling, transfer to the lime bottle (Fig. I) filling up to the lower mark (129 cc.) with water, then to the upper mark (178.6 cc.) with ammonium chloride solution made by dissolving 250 g. of crystallized ammonium chloride in a liter of water.

Mix thoroughly by inverting about 30 times. Do not mix afterwards or results will be too high.

Let settle from 15 to 20 minutes, draw out 50 cc. of the clear liquid with a pipette and deliver with stirring into a slight deficiency of normal hydrochloric acid and about 150 cc. of water.

For 90 per cent lime, deficiency is 30 cc. normal hydrochloric acid.

For 65 per cent lime, deficiency is 20 cc. normal hydrochloric acid.

Titrate to the end-point using methyl orange as indicator.

The number of cc. of normal hydrochloric acid times 2.5 gives the percentage of active (available) CaO.

BY CONVERTING SODIUM CARBONATE TO SODIUM HYDROXIDE—The chemists of some plants in which lime is used to causticize soda employ a method making use of this reaction. The method is as follows:

Weigh 5 g. of the sample into a 500-cc. graduated flask and add 200 cc. of approximately normal sodium carbonate, or 10 g. of sodium carbonate and 200 cc. of water. Close with a stopper having a Bunsen valve in it or a 6-in. tube drawn out to a thin point and boil for one-half hour. Add 10 g. of barium chloride dissolved in a little water and make up to the mark with

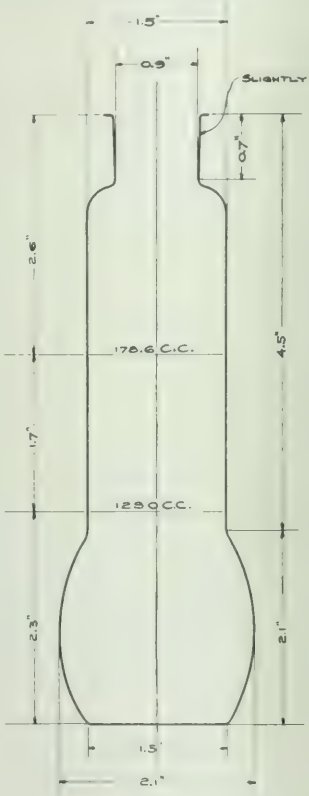


FIG. 1

cold water. Stopper tightly and mix well. Allow precipitate of calcium carbonate and barium carbonate to settle. Draw off 100 cc. of the clear solution and titrate with normal hydrochloric acid. The number of cc. of acid used multiplied by 2.8 is equivalent to the percentage of free calcium oxide in the sample.

ESTIMATION OF THE PERCENTAGE OF CAUSTIC LIME IN MILK OF LIME BY MEANS OF THE SPECIFIC GRAVITY (BLATTNER)

The method devised by Blattner making use of the specific gravity of milk of lime which is only suitable

for very rough work is also given in Lunge's Handbook and is as follows: Thin milk of lime is poured into the cylinder and the reading of the hydrometer is taken quickly before the lime subsides. For thick milk of lime employ a somewhat wide cylinder, put the hydrometer in without using any force and turn the cylinder slowly around, so that it receives a slight shaking until the hydrometer ceases to sink. The following table is valid for 15° C.:

TABLE II—AMOUNT OF LIME IN MILK OF LIME
(Calculated from Blattner)

Degrees Twaddell	G. CaO per liter	Lbs CaO per cu. ft.	Degrees Twaddell	G. CaO per liter	Lbs. CaO per cu. ft.
2	11.7	0.7	28	177	11.1
4	24.4	1.5	30	190	11.9
6	37.1	2.3	32	203	12.7
8	49.8	3.1	34	216	13.5
10	62.5	3.9	36	229	14.3
12	75.2	4.7	38	242	15.1
14	87.9	5.5	40	255	15.9
16	100	6.3	42	268	16.7
18	113	7.1	44	281	17.6
20	126	7.9	46	294	18.4
22	138	8.7	48	307	19.2
24	153	9.5	50	321	20.0
26	164	10.3	..	..	..

608–12 Law Building
Baltimore, Maryland

A STUDY OF THE DeROODE METHOD FOR THE DETERMINATION OF POTASH IN FERTILIZER MATERIALS

By T. E. Keitt and H. E. Shiver

Received July 25, 1917

Determinations of potash have been made in America for the past thirty years by a method first proposed by Lindo[1] in 1881 and modified by Gladding[2] in 1885. The Lindo-Gladding method is familiar to every chemist and does not need repetition here; it has been adopted by the Association of Official Agricultural Chemists.[3] "The process depends upon the fact that potassium platino-chloride is insoluble in strong alcohol, and the easy solubility of the associated salts, for instance sodium, in the same reagent."[4] In this method the earthy bases have to be removed before precipitating the potash, necessitating the addition of reagents and their subsequent removal by precipitation and filtration, which does not contribute to the ease or the accuracy of the determination.

The fertilizer manipulators have contended that the Lindo-Gladding method does not account for all of the water-soluble potash. Likewise, it has been recognized by certain chemists that this method does not obtain all of the potash.[5,6] One of us[7] has shown that there are grounds for the manipulators' contentions that our present method of analysis does not account for all of the potash present in water-soluble form, and that there is another source of error which compensates for the occlusion. The second source of error is the diminished volume of the solute due to the volume occupied by the precipitates formed on addition of ammonia and ammonium oxalate. Breckenbridge,[1] Porter and Kenny,[2] Bell,[3] and Shiver[4] have studied certain errors occurring in the official method, laying particular stress on occlusion and the solubility of the precipitate. Wiley[5] calls attention to "The remarkable facility with which potash becomes incorporated with the precipitates of other bodies." Hibbard[6] states that occlusion "may amount to from 1 to 10 per cent of the original amount of the potash." Garrigues[7] in reporting a new modification gives some good results on the discrepancies of the official method, showing among other things that the loss from occlusion varied from 0.11 to 0.20 per cent on six samples run by him. One of us[5] has found that more than 0.5 per cent of potash was occluded by the ammonia precipitate in certain samples.

Robinson[8] and Winton[9] have studied the character and magnitude of certain errors in this method, and the influence of concentration on the accuracy of the determination, with startling results. Smith[10] in a general discussion on occlusion remarks, "As is well known, many insoluble compounds which are precipitated in the course of analytical processes possess the property of carrying down and retaining certain soluble salts in such a manner that the latter oftentimes cannot be removed, even by prolonged washing."

Chemists, realizing the need of an improved method, have suggested many processes[11] none of which have shown sufficient merit to replace the Lindo-Gladding method. The perchlorate method received special attention, and for a time threatened to replace the Lindo-Gladding method, but the latest results may be summarized as follows: "The perchlorate method for the determination of potash was found less suitable than the platinum method. It is longer, more difficult and more expensive as to reagents."[5]

A method based on the principle of moist combustion was proposed by DeRoode[12] in 1895 and modified by Vietch[13] in 1905, who says, "It is unfortunate that more attention has not been called to the method of Moore[14] (DeRoode) for in it many of the preliminary operations are omitted and it is at once the simplest

[1] "Original Method for Potash Determination," *Chem. News*, **44** (1881), 77, 86, 97, 129.

[2] "Improvement on Lindo Method," U. S. Dept. of Agr., Div. of Chem., *Bull.* **1885**, 7, 38.

[3] A. O. A. C., U. S. Dept of Agr., Bureau of Chemistry, *Bull.* **107**.

[4] Wiley, "Principle and Practice of Agriculture Analysis," **11** (1895), 540, 554, 555, 570.

[5] Lunge's "Technical Methods of Chemical Analysis," Part II, **1** (1908), 526.

[6] Hintz and Weber, *Chem. Anal. Anorg.*, **1896**; Körper, *Z. anal. Chem.*, **35**, 685.

[7] Keitt, "Potash in Mixed Fertilizers," South Carolina Agricultural Experiment Station, *Bull* **173** (1913), 11.

[1] "Potash Tests in Mixed Fertilizers," This Journal, **1** (1909), 409; "Potash Tests in Commercial Fertilizers," *Ibid* **1** (1909), 804.

[2] "Loss of Potash in Commercial Fertilizers," *Ibid.*, **1** (1909), 304.

[3] "The Estimation of Potash," *Chem. News*, **79** (1899), 135.

[4] "The Determination of Potash as Perchlorate," *Ibid* **79** (1899), 265.

[5] *Loc. cit.*

[6] "A Study of Determination of Potash," This Journal, **9** (1916), 505.

[7] "The Determination of Potash in Manures," *J. Am. Chem. Soc.*, **17** (1895), 47.

[8] "Some Sources of Error," *Ibid* **16** (1894), 634.

[9] "On Some Conditions Affecting, etc," *Ibid* **17** (1895), 483.

[10] "Contamination of Precipitates in Gravimetric Analysis," **1917**.

[11] Hicks, "A Rapid Modified Chlorplatinate Method, etc," This Journal, **5** (1913), 650.

[12] "The Determination of Potash in Kanite," *J. Am. Chem. Soc.*, **17** (1895), 85, 86.

[13] "The Estimation of Potash in Soils, etc," *Ibid.*, **27** (1905), 56.

[14] "On the Determination of Potash, etc," *Ibid.*, **20** (1898), 340.

and shortest, and possesses a high degree of accuracy." However, the method has been allowed to stand unperfected in details and unnoticed. This method eliminates all of the preliminary precipitation, filtration, and incineration, with its accompanying sources of error due to occlusion, diminished volume and sputtering, besides loss of time and some of the personal equation due to lessened number of operations. A method very similar to DeRoode's was suggested by Lösche.[1]

Much work has been done in the laboratory of the South Carolina Experiment Station using the DeRoode method as a skeleton, and the final results show a very high degree of accuracy, also the modified process obviates the objections of the chemist and the manufacturer.

The method is applicable to all commercial fertilizers, including concentrated salts. The details of the method follow: 10 g. of the sample are placed in a 500-cc. flask and 300 cc. of water added. The contents of the flask are maintained at boiling temperature for approximately 30 min., cooled and diluted to volume. After allowing to stand until the material has settled, filter and draw out 50 cc., an aliquot representing one gram. Place the aliquot in a porcelain dish and add 3 to 5 cc. of nitric acid to destroy any organic matter that may be present.[2] Evaporate to dryness over a water bath, take up with hot water and an excess of hydrochloric acid. Evaporate again to dryness, take up with hot water, adding several drops of hydrochloric acid, and enough platinic chloride to precipitate all of the potash present. Thus all of the details through the precipitation are carried out on one bath, in almost one operation, and in a very short time. Cover the precipitate with the acidulated alcohol, the method of preparation of which is described later. Allow to stand for 15 to 20 min., in which time all iron, aluminum, and magnesium will dissolve; filter, and wash with the acidulated alcohol solution until the runnings are colorless, washing free of the excess of platinic chloride. Next wash well with ammonium chloride (saturated with K_2PtCl_6). This washing should be thorough, for the accuracy of the method is largely dependent upon this operation; 6 or 7 washings usually suffice. The function of the ammonium chloride wash is the same as in the Lindo-Gladding method. Wash thoroughly with 95 per cent alcohol to remove the ammonium chloride; then dry and weigh the precipitate and calculate results as in the older method.

The preparation of the acidulated alcohol is as follows: To each 1000 cc. of 95 per cent alcohol add 75 cc. of conc. hydrochloric acid, then pass dry hydrochloric acid gas into the mixture until 1 cc. of the alcohol neutralizes 2.25 cc. normal potassium hydroxide,[3,4] using phenolphthalein as an indicator. The hydrochloric acid gas may be prepared by using C. P. sodium chloride and concentrated sulfuric acid, or by heating concentrated hydrochloric acid and first passing the gas through sulfuric acid and then into the alcohol. The solvent action of this acidulated alcohol on potassium chloroplatinate is about equal to that of the Lindo ammonium chloride solution, which is about one-third that of ordinary 80 per cent alcohol. Or, if expressed numerically, one gram of pulverized potassium chloroplatinate was digested for two hours in 500 cc. of acidulated alcohol, at room temperature. The solvent action under these conditions was found to be one part in 60,000.[1] The ammonium chloride is made up by adding to each 1000 cc. of water 200 g. of ammonium chloride and saturating in the cold with potassium chloroplatinate. The acids used are C. P. concentrated. Whatman's filter papers No. 42 (9 cm.) were used on 130 mm. funnels. Drying was effected in a Freas electric oven at a temperature of 110° C. for 1½ hours. *Porcelain dishes are used, entirely replacing platinum dishes which may be liberated for use in the arts and in the manufacture of munitions.*

The following work was done in this laboratory to test the new method with commercial salts. A solution containing 10 g. of potassium chloride and another containing 10 g. of potassium sulfate were made and analyzed by this method. The potassium chloride by theory should give 63.20 per cent K_2O; the results obtained by analysis were 63.12 per cent and 63.04 per cent, showing an average of 63.08 per cent or 99.81 per cent of theory. The potassium sulfate theoretically contained 54.20 per cent K_2O; the results obtained by analysis were 54.08 per cent K_2O and 54.08 per cent K_2O, being identical and 99.78 per cent of theory.

Some samples collected by the State Board of Fertilizer Control were analyzed. These samples are representative of commercial fertilizers as found on the open market. The following results were obtained by (1) the Lindo-Gladding method, (2) the Lindo-Gladding method plus occluded potash, obtained by repeated solution and precipitation of the ammonia and ammonium oxalate precipitates, and (3) the modified method:

TABLE I—COMPARISON OF LINDO-GLADDING METHOD, LINDO-GLADDING PLUS OCCLUDED POTASH AND MODIFIED METHOD

SAMPLE No.	(1) Potash by Lindo-Gladding Method, Per cent	(2) Potash by L.-G. Method Plus Occluded Potash, Per cent	(3) Potash by Modified DeRoode Method, Per cent	(2)-(1) Gain of New Method (2) over Old Method (1), Per cent	(3)-(1) Gain of New Method (3) over Old Method (1), Per cent	Average Increase of (3) over (2), Per cent	Average Increase of (3) over (1), Per cent
58A	3.15	3.28	3.33	0.18	0.05	...	...
58B	....	....	3.35	0.20	0.07	...	...
160A	2.71	2.89	2.97	0.26	0.08	...	...
160B	....	....	2.97	0.28	0.08	...	...
547A	5.98	6.22	6.24	0.26	0.02	0.062	0.232
547B	....	....	6.22	0.24	0.00	...	...
850A	2.68	2.86	2.94	0.26	0.08	...	..
850B	....	....	2.95	0.27	0.09	...	...
1229A	3.10	3.22	3.33	0.23	0.11	...	...
1229B	....	....	3.26	0.16	0.04	...	...

The above table shows that the modified method gives an average of 0.062 per cent more water-soluble potash than the Lindo-Gladding method plus occluded potash obtained by repeated solution and precipitation of the precipitates formed in the flask preparatory to

[1] "The Estimation of Potassium," *Chem.-Ztg.*, **20** (1896), 38.

[2] Crookes, "Select Methods in Chemistry Analysis," Second Edition, **1886**, p. 33.

[3] *Loc. cit.*

[4] Bear and Salter, "Methods in Soil Analysis," West Virginia Agr. Expt. Sta., *Bull.* **159** (1916), 10.

[1] *Loc. cit.*

making the determination as officially directed. Furthermore, the modified method shows an average increase of 0.232 per cent over the Lindo-Gladding method. There is no doubt that this increased amount of potash is present in water-soluble form and is not accounted for by the official method, because one of us[1] has shown that every time the precipitate formed by ammonia and ammonium oxalate in the flask is dissolved and precipitated, the filtrate contains potash. The amount of potash obtained by repeated precipitation and filtration was never as much as the theoretical when pure salts were used.

In order to ascertain whether all potash is determined by the new method, the following synthetic solutions were analyzed by the methods compared in Table I:

Solution 1 contained potassium chloride and ferric sulfate equivalent to 5.99 per cent K_2O and 10.31 per cent Fe_2O_3.

Solution 2 contained potassium chloride and tricalcium phosphate equivalent to 5.99 per cent K_2O and 10 per cent $Ca_3(PO_4)_2$.

Solution 3 contained potassium chloride, iron, and tricalcium phosphate equivalent to 5.99 per cent K_2O, 10.31 per cent Fe_2O_3, and 10 per cent $Ca_3(PO_4)_2$.

Solution 4 contained potassium chloride, iron, tricalcium phosphate, and aluminium sulfate equivalent to 5.99 per cent K_2O, 10.31 per cent Fe_2O_3, 10 per cent $Ca_3(PO_4)_2$ and 10 per cent Al_2O_3.

These solutions were intentionally exaggerated as to content of impurities and the determinations shown are the first and only results obtained, emphasizing the ease and accuracy of the method of determination.

TABLE II—POTASH (K_2O) OBTAINED BY EACH METHOD WITH STANDARD SOLUTIONS OF PURE SALTS

SOLUTION No.	Theoretical Potash (K_2O) in Solution, Per cent	By Lindo-Gladding Method, Per cent	By L.-G. Plus K_2O Recovered by 3 Reprecipitations, Per cent	By De Roode Method, Per cent	Difference between Theoretical and De Roode, Per cent	Difference between De Roode and L.-G., Per cent	Difference between L.-G. Plus Occluded and De Roode, Per cent
1	5.99	5.61	5.643	5.94	—0.05	0.33	0.297
2	5.99	5.61	5.633	5.80	—0.19	0.19	0.167
3	5.99	5.10	5.129	5.75	—0.24	0.65	0.621
4	5.99	5.09	...	5.78	—0.21	0.69	...

Table II shows that soluble iron and aluminium compounds and tricalcium phosphate retain large amounts of potash in the Lindo-Gladding method where these compounds are precipitated and the potash determined in the filtrate. The indications are that the relation is a chemical phenomenon, because of the fact that very little potash is recovered by repeatedly dissolving and reprecipitating the residue. Iron (10.31 per cent) retained 0.38 per cent K_2O, only 0.033 per cent of which was recovered in the filtrate by dissolving and reprecipitating three times in 400 cc. of solution. Tricalcium phosphate (10 per cent) retained 0.38 per cent K_2O, 0.023 per cent of which was recovered in three combined filtrates. Aluminium salts were not used alone with potassium chloride on account of the similarity of their properties to those of iron salts, but aluminium sulfate was included in the fourth solution. A combination of 10.31 per cent Fe_2O_3 and 10 per cent $Ca_3(PO_4)_2$ shows a retention slightly greater than the sum of the retention of the salts added to separate solutions. This appears to indicate a slight additional occlusion by the combined precipitates, which occlusion is doubtless greater than it appears on account of the diminished volume due to the larger precipitate. The retention incident to the use of ferric sulfate and tricalcium phosphate amounts to 0.89 per cent, only 0.029 per cent of which was recovered by three solutions of the precipitates and their subsequent precipitation. The addition of 10 per cent Al_2O_3 in the form of aluminium sulfate to the other two impurities increases the apparent retention only 0.01 per cent, but the diminution in volume by the additional precipitate no doubt compensated for a greater loss which is not apparent. The fact that large retention occurs in these precipitates serves to bring out strikingly the results obtained by the new method which are shown in the fifth column of Table II. These results are consistently slightly lower than theory, but are about within the limits usually allowed for experimental error. The fact that they are within an extreme range of 0.19 per cent and the further fact that a result slightly below theory is to be expected make them quite satisfactory, showing the marked superiority of this method over the Lindo-Gladding from the standpoint of accuracy.

To further test the new method more samples were secured from the Fertilizer Control Laboratory and analyzed by both methods with the following results:

TABLE III—COMPARISON OF LINDO-GLADDING METHOD WITH MODIFIED METHOD

SAMPLE No.	Potash Reported by L.-G. Method Per cent	Potash Determined by De Roode Method Per cent	Difference between Columns 2 and 3 Per cent
18	0.90	0.88	—0.02
59	4.34	4.46	0.12
74	4.45	4.57	0.12
90	2.71	2.79	0.08
93	4.60	4.66	0.06
160	0.90	0.93	0.03
247	1.84	1.84	0.00
302	4.75	4.89	0.14
311	4.61	4.85	0.24
313	3.52	3.59	0.07
335	2.88	2.89	0.01
356	1.64	1.74	0.10
357	2.54	2.71	0.17
386	0.25	0.26	0.01
421	0.95	1.10	0.15
641	1.74	1.97	0.23
694	1.73	1.87	0.09
770	1.38	1.40	0.02
961	0.86	0.93	0.07
54	2.18	2.19	0.01

Table III shows an average gain of 0.085 per cent for the modified method over the Lindo-Gladding method on 20 samples. In every case except one the new method gave higher results as was to be expected. In the case of the exception the results were very close.

It is to be expected that the differences between the methods on different samples will be variable on account of the varying amounts of impurities present in different mixed fertilizers. The results by the modified method are accurate. In the Lindo-Gladding method a case might arise where diminished volume due to large precipitation would more than counterbalance the effect of occlusion. This may be the case in Sample 18, Table III. As a general rule, however, the occlusion takes out more potash than the content

[1] *Loc. cit.*

of the volume that the precipitates occupy, this being evidenced by every result obtained except that on Sample 18.

The new method was used by Mr. T. D. Padgett of this laboratory on 6 samples with concordant results.

SUMMARY

It has been shown that the DeRoode method surmounts the difficulties encountered in the Lindo-Gladding method. These same sources of error are incident to the Anhalt and the Alternate methods to a greater or less extent.

A few of the outstanding advantages of the modified method may be summarized as follows: ease of manipulation; small amount of time consumed, being much less than in the Lindo-Gladding method; a much greater degree of accuracy; all incineration, with possible losses from sputtering; precipitation, with its great loss from occlusion; filtration, not adding to the accuracy of the determination due to the volume occupied by the precipitates; and a great part of the evaporation being dispensed with. Finally, any process that eliminates the use of platinum apparatus without sacrificing accuracy should be welcomed. By avoiding ignition, only porcelain dishes have been used in this method, thus placing at the disposal of the Government large numbers of platinum dishes now kept by all official and commercial laboratories for the determination of potash.

LABORATORY SOUTH CAROLINA EXPERIMENT STATION
CLEMSON COLLEGE, S. C.

LABORATORY AND PLANT

BLUE AND BROWN PRINT PAPER: CHARACTERISTICS, TESTS AND SPECIFICATIONS

By F. P. Veitch, C. Frank Sammet and E. O. Reed

Received October 8, 1917

The manufacture of paper for use in blue and brown printing is an important special branch of paper making. The frequent handling and folding to which this class of paper is subjected in all branches of engineering work and the value attached to many prints as permanent records necessitate that the paper in addition to the essential properties, to withstand coating, printing and washing satisfactorily, shall be of exceptionally high quality and great durability.

The first photograph produced dates back to about 1802, when Thomas Wedgewood published an article in the *Journal of the Royal Institute* entitled "An Account of a Method of Copying Paintings upon Glass and of Making Profiles by the Agency of Light upon Nitrate of Silver, with Observations by H. Davy." In this article it is stated that white paper or white leather when moistened with silver nitrate undergoes no change when kept in the dark, but upon exposure to the light speedily changes to nearly black. Blue print paper was invented in 1840 by Sir John Herschel, and in 1901 brown print paper was patented by Van Dyke.

Formerly the best paper obtainable in this country for blue and brown printing came from Germany and France, and though a number of paper makers have made such papers for years it has been exceedingly difficult to obtain a domestic paper of sufficiently high quality to be satisfactory in service. It is only recently that American-made papers that will meet the accompanying specifications for "Best Quality" and for "High Quality" papers have come to the attention of the Bureau.

In 1910 the Navy Department requested the Department of Agriculture to investigate the quality of blue and brown print papers and submit specifications under which it could purchase high-grade and durable papers. In this investigation more than 2000 samples, including, it is believed, all of the commercial brands of blue and brown print paper, both foreign and domestic, were examined, and from the data thus obtained specifications were issued in 1912 which now serve, with some modifications, as a basis for the purchase of these papers by the Navy Department. Up to that time, so far as can be learned, no complete specifications for blue and brown print paper had ever been prepared and used in this country. By the aid of these specifications and with suggestions from this Bureau, American manufacturers have since made blue and brown print papers which are equal to, and in some respects superior to the foreign-made papers and which have been found to meet all the accompanying specifications in every particular. An important special branch of paper making has been established in this country, and if the quality of the paper is maintained, engineers may confidently depend on these papers for the most exacting requirements.

In a broad sense high-grade blue and brown print paper is a bond paper of the best quality, preferably all rag stock, so sized as to be resistant in a proper degree to the absorption of the sensitizing solution and yet to coat absolutely uniformly. As this class of paper is subjected to much handling in both the wet and dry condition and in many cases is valuable as permanent records, it should possess high physical properties and be very resistant to chemicals.

Practical and laboratory tests have demonstrated that the most reliable indication of the durability and serviceability of blue and brown print paper is obtained by the determination of its folding endurance.[1] This test does not, however, indicate the resistance of paper to tearing when the print is being washed and handled to remove the soluble salts. This information is best obtained by the determination of the tensile strength[2] of the paper when wet, which gives results

[1] Veitch, Sammet and Reed, "The Standardization and Accuracy of the Tester for Determining the Folding Endurance of Paper," *Paper*, No. 12, **20**, 13.

[2] E. O. Reed, "A Method for Determining the Strength of Paper when Wet," THIS JOURNAL, **8** 1916, [illegible]

conforming with actual service. Paper may comply in all other respects with the specifications and yet not withstand thorough washing and handling while wet. In many instances sheets of paper 10 or more feet in length are so handled. In these cases wet strength is a property of the greatest importance, since an otherwise serviceable paper would be entirely unsatisfactory and its rejection would be necessary.

TABLE I—RESULTS OF PHYSICAL TESTS OF BLUE PRINT PAPERS COATED AND UNCOATED

All Physical Tests Made at 70° F. and 65 Per cent Relative Humidity

L & P No.		Stock: Rag Per cent	Stock: Straw Per cent	Weight 24x36 500 Lbs.	Bursting Strength: Average Pts.	Bursting Strength: Factor	Folding Endurance Transverse Double Folds
19724	Uncoated	100	0	29½	30.5	1.03	403
	Coated, exposed and washed			28	31.0	1.11	426
19710	Uncoated	50	50	36½	21.0	0.58	23
	Coated, exposed and washed			37	22.0	0.59	42
19669	Uncoated	65	35	37	27.0	0.73	71
	Coated, exposed and washed			39	28.0	0.72	107
19582	Uncoated	100	0	53½	50.5	0.92	955
	Coated, exposed and washed			52	51.0	0.98	1131
19756	Uncoated	75	25	66	47.5	0.72	352
	Coated, exposed and washed			67	49.0	0.73	364
19757	Uncoated	85	15	92	63.0	0.69	367
	Coated, exposed and washed			88½	65.0	0.73	403

Blue prints are only positive prints, while brown prints are chiefly used as negatives from which to make blue prints. The translucency of the paper used for brown prints is of some importance and can be determined and specified by use of the translucency photometer[1] devised by this laboratory.

For papers to be used as permanent records only the best quality rag stock is recommended. In instances where permanency is not essential, but serviceability for a limited period is desired, rag stock mixed with sulfite or straw will produce a good paper. A paper should have high folding endurance in both directions and this property can be attained only

TABLE II—RESULTS OF PHYSICAL TESTS OF BROWN PRINT PAPERS COATED AND UNCOATED

All Physical Tests Made at 70° F. and 65 Per cent Relative Humidity

L & P No.		Stock: Rag Per cent	Stock: Straw Per cent	Weight 24x36 500 Lbs.	Bursting Strength: Average Pts.	Bursting Strength: Factor	Folding Endurance Transverse Double Folds
19741	Uncoated	100	0	40	36.0	0.90	188
	Coated, exposed and washed			37	31.0	0.84	67
19765	Uncoated	70	30	38½	38.0	0.99	289
	Coated, exposed and washed			39	34.5	0.88	128
19738	Uncoated	100	0	52½	43.5	0.83	554
	Coated, exposed and washed			52	35.5	0.68	140
19742	Uncoated	100	0	55½	38.0	0.68	169
	Coated, exposed and washed			52	37.0	0.71	70
19739	Uncoated	100	0	75	50.5	0.67	457
	Coated, exposed and washed			71½	46.5	0.65	89

through the use of high-grade rag stock. The determination and specification of the folding endurance in the weak (usually the transverse) direction are sufficient, since for practical purposes the results thus obtained are fully as indicative of serviceability and durability as are the results obtained by testing the folding endurance in both directions of the paper.

[1] C. F. Sammet, "A Photometer for the Measurement of the Translucency of Paper," THIS JOURNAL, **9** (1917), 784.

The stock must be so beaten and sized as to produce a flexible sheet with a "closed" formation. Wet strength not only depends on the character of the stock and the beating, but largely also on the effectiveness of the sizing and the formation of the sheet. For proper coating the paper should not be too heavily surface sized nor highly glazed. It must, however, be well sized since a serious defect would be to have the coating solution penetrate the sheet.[1] The best and

TABLE III—SPECIFICATIONS FOR BEST GRADE UNPREPARED OR PREPARED BLUE PRINT PAPER—ALSO UNPREPARED BROWN PRINT PAPER

	Extra Thin	Thin	Medium	Thick
Weight				
Basis 24x36—500 (Pounds)	28	40	55	70
17x22—500 (Pounds)	12	17	24	30
Stock				
Rag (Per cent)	100	100	100	100
Bursting Strength				
Shall be not less than (Points)	25	40	50	63
Strength Factor (24x36—500)	0.90	1.00	0.90	0.90
Wet Tensile Strength				
Longitudinal—Shall be not less than (Grams)	500	600	800	800
Transverse—Shall be not less than (Grams)	300	400	500	500
Folding Endurance				
Weak direction (usually transverse) shall be not less than (Double folds)	400	500	800	1000
Thickness				
Shall not exceed (Inch)	0.0030	0.0035	0.0050	0.0060
Ash				
Shall not exceed (Per cent)	2	2	2	2

most durable papers are those in which the essential characteristics are obtained by the use of high-quality stock, its proper beating, sizing and careful handling on the machine.

The durability and serviceability of all grades of blue and brown print papers are greatly affected by the method and care with which the paper is coated with sensitizing solutions. Paper was formerly coated with sensitizing solutions using a brush or sponge and subsequently allowing it to air-dry in a dark room. Undoubtedly there is less injury to the paper when coated and dried in this manner, but owing to the great demand for this character of print paper this

TABLE IV SPECIFICATION FOR HIGH-GRADE UNPREPARED OR PREPARED BLUE PRINT PAPER

	Thin	Medium	Thick
Weight			
Basis 24x36—500 (Pounds)	40	55	70
Basis 17x22—500 (Pounds)	17	24	30
Stock			
Rag (Per cent)	100	100	100
Bursting Strength			
Shall be not less than (Points)	36	45	50
Strength Factor (24x36—500)	0.90	0.80	0.70
Wet Tensile Strength			
Longitudinal—Shall be not less than (Grams)	600	800	800
Transverse—Shall be not less than (Grams)	400	500	500
Folding Endurance			
Weak direction (usually transverse) Shall be not less than (Double folds)	300	500	600
Thickness			
Shall not exceed (Inch)	0.0035	0.0050	0.0060
Ash			
Shall not exceed (Per cent)	2	2	2

procedure has been almost universally superseded by machines for rapid coating and drying. The durability of machine coated paper is least affected when it is coated at a slow speed and dried at a low temperature. Rapid drying of sensitized paper at a high temperature is very injurious to the paper, especially when coated with brown print solutions.

[1] C. F. Sammet, "The Detection of Faulty Sizing in High-Grade Papers," Bureau of Chemistry, *Circular* **107**.

Brown print paper continually deteriorates with age, even if properly wrapped and stored, due to the nitrates in the coating liberating nitric acid which attacks the fibers. The maximum strength of this paper is retained only through its immediate use after coating. Paper stored two or three months or even for a shorter time, especially in summer or humid localities, is usually unfit for service. It is almost impossible to remove entirely the injurious chemicals from brown prints even by prolonged washing, but a thoroughly washed print will be serviceable for a considerable time.

Most blue print coating solutions are not injurious to the paper if properly applied and the paper protected from light, moisture and heat. Blue print paper is coated for printing at different speeds and at least three speeds are generally obtainable. These speeds are variously designated as "slow" or "regular," "rapid," and "electric." The speed at which a coated paper may be printed is dependent on the proportion of the ingredients of the coating. High-speed coatings are most unstable and will keep only a short time. Best prints are obtained by using the "slow" speed coated paper, and coating of this kind will keep for a much longer time.

TABLE V—SPECIFICATIONS FOR MEDIUM GRADE UNPREPARED OR PREPARED BLUE PRINT

		Thin	Medium	Thick
Weight				
Basis 24x36—500	(Pounds)	40	55	70
Basis 17x22—500	(Pounds)	17	24	30
Stock				
Rag—Shall not be less than. Remainder may be bleached sulfite of straw	(Per cent)	50	50	50
Bursting Strength				
Shall be not less than	(Points)	32.0	38.0	45.0
Strength Factor (24x36—500)		0.80	0.70	0.65
Wet Tensile Strength				
Longitudinal—Shall be not less than	(Grams)	600	800	800
Transverse—Shall be not less than	(Grams)	400	500	500
Folding Endurance				
Weak direction (usually transverse) Shall be not less than	(Double folds)	150	150	150
Thickness				
Shall not exceed	(Inch)	0.0035	0.0050	0.0060
Ash				
Shall not exceed	(Per cent)	5	5	5

Brown print paper continually deteriorates with age, even if properly wrapped and stored, due to the nitrates in the coating liberating nitric acid which attacks the fibers. The maximum strength of this paper is retained only through its immediate use after coating. Paper stored two or three months or even for a shorter time, especially in summer or humid localities, is usually unfit for service. It is almost impossible to remove entirely the injurious chemicals from brown prints even by prolonged washing, but a thoroughly washed print will be serviceable for a considerable time.

Most blue print coating solutions are not injurious to the paper if properly applied and the paper protected from light, moisture and heat. Blue print paper is coated for printing at different speeds and at least three speeds are generally obtainable. These speeds are variously designated as "slow" or "regular," "rapid," and "electric." The speed at which a coated paper may be printed is dependent on the proportion of the ingredients of the coating. High-speed coatings are most unstable and will keep only a short time. Best prints are obtained by using the "slow" speed coated paper, and coating of this kind will keep for a much longer time.

Care in the process of printing, washing and drying of blue or brown prints is fully as important as in the coating of the paper. The most durable results are obtained by printing by sunlight, immersing the whole print and thoroughly washing in tanks of running water, followed by air-drying suspended from racks.

Sun printing is too slow for most commercial requirements and "slow" printing coatings are not used where a large number of prints are required in a short time To meet the commercial requirement for rapid printing, machines combining printing, washing and drying have been developed. Unfortunately these machines subject the paper during the printing and drying to considerable heat arising from the artificial lights and heating coils employed for drying. The washing is not as thorough as tank washing since it is done within a few minutes and with many machines only the sensitized side is washed.

TABLE VI—SPECIFICATIONS FOR HIGH-GRADE BROWN PRINT PAPER
First Grade Unprepared Brown Print Paper Should Equal First Grade Blue Print Paper

		Thin	Medium
Weight			
Basis 24x36—500	(Pounds)	40	55
Basis 17x22—500	Pounds)	17	24
Stock			
Rag	Per cent)	100	100
Bursting Strength			
Shall be not less than	(Points)	35.0	45.0
Strength Factor (24x36—500)		0.90	0.80
Wet Tensile Strength			
Longitudinal—Shall be not less than.	(Grams)	600	800
Transverse—Shall be not less than.	(Grams)	400	500
Folding Endurance			
Weak direction (usually transverse) Shall be not less than	(Double folds)	300	400
Thickness			
Shall not exceed	(Inch)	0.0035	0.0050
Ash			
Shall not exceed	(Per cent)	2	2

The essential characteristics of blue and brown print papers are identical except that only all rag paper of the highest quality is suitable for brown prints.

The relative effects of the two coatings on papers are shown in Tables I and II.

It will be seen that the bursting strength and folding endurance of coated, printed and washed blue print papers are not lower than of the same papers uncoated. On the other hand the bursting strength, but more especially the folding endurance of coated, printed and washed brown print papers are lower than that of the uncoated papers. The folding endurance is decreased so greatly that it is clear that brown prints cannot be durable and that where durability is important blue prints must be used.

Three grades of blue print paper are sufficient for all types of work. The best grade must be of a quality suitable for permanent records and must withstand frequent handling. High grade must be of good quality suitable for records lasting a considerable period, and must withstand frequent handling. Medium grade may be a paper suitable for drawings of brief existence which must, however, withstand a fair amount of wear and tear. Paper not falling in these classifications is not suitable for prints other than those of a small size and requires no specifications, as the use to which these prints are put is not severe.

TABLE VII—ANALYSES OF REPRESENTATIVE UNCOATED BLUE AND BROWN PRINT PAPER
All Physical Tests Made at 70° F. and 65 Per cent Relative Humidity

	Weight		Stock			Sizing				Thickness	Bursting Strength Average	Bursting Strength Factor	Wet Tensile Strength		Folding Endurance	
L & P No.	24x36 500 Lbs.	17x22 500 Lbs.	Rag Per cent	Sulfite Per cent	Straw Per cent	Ash Per cent	Rosin Per cent	Animal Per cent	Starch Per cent	1/10000 Inch	Pts.	24x36	Long. G.	Trans. G.	Long. Double	Trans. Folds
28547	29½	13	100	..	..	0.7	3.6	4.0	Present	22	29.0	0.98	566	310	1284	489
28541	35	15	100	..	..	0.8	1.9	3.6	Present	26	38.5	1.10	820	526	1815	932
31631	48	19½	100	..	..	0.4	1.6	5.1	Present	35	55.5	1.23	552	308	3020	2137
28531	47	20	50	50	..	0.9	1.5	3.7	Trace	38	51.0	0.66	742	398	322	128
28542	52	22½	100	..	..	0.5	3.7	1.7	Present	35	42.0	0.80	808	629	1439	1308
28513	55½	24	100	..	..	0.8	2.6	2.1	Present	39	35.0	0.63	1000+	570	409	153
28517	60	26	100	..	..	0.6	3.8	2.3	Present	43	42.5	0.71	1000+	661	265	135
31803	62	27	100	..	..	0.5	1.8	4.8	Present	40	76.0	1.23	947	538	3576	2666
28532	66	28½	70	..	30	4.7	2.6	...	Present	50	46.5	0.71	852	548	717	400
28530	92	40	75	..	25	2.9	2.0	...	Present	71	60.5	0.66	1000+	886	544	423

TABLE VIII—TYPICAL RESULTS ON VARIOUS COATED AND UNCOATED PAPERS

All Physical Tests Made at 70° F. and 65 Per cent. Relative Humidity

L & P No.	Weight 24x36 500 Lbs.	Weight 17x22 500 Lbs.	Stock Rag Per cent	Stock Per cent	Stock Ash Per cent	Thickness 1/10000 Inch	Bursting Strength Average Pts.	Strength Factor 24x36	Tensile Strength Long. Kg.	Tensile Strength Trans. Kg.	Stretch Long. Per cent	Stretch Trans. Per cent	Wet Tensile Strength Long. G.	Wet Tensile Strength Trans. G.	Folding Endurance Long. Double	Folding Endurance Trans. Folds
28541	35.0	15.0	100	..	0.8	26	38.5	1.10	7.3	5.0	3.6	6.4	820	526	1815	932
28551	37.5	16.0	100	..	0.9	27	38.0	1.01	8.2	4.3	3.1	4.9	905	438	1099	424
31471	39.0	17.0	100	..	1.0	33	30.5	0.78	7.6	4.4	2.1	5.3	421	223	1226	536
				Straw												
28540	39.0	17.0	63	37	2.4	30	18.0	0.46	5.8	3.4	0.8	1.6	690	386	12	9
31246	41.0	17.5	100	..	0.9	30	30.5	0.74	7.3	3.1	2.4	6.2	633	273	473	119
31645	41.0	17.5	100	..	0.9	31	31.0	0.76	6.9	3.5	2.2	4.7	624	274	433	166
31647	42.0	18.0	100	..	0.7	30	37.5	0.89	8.9	3.0	2.9	6.7	854	320	1684	270
31643	42.0	18.0	100	..	0.6	30	36.5	0.87	9.2	3.5	2.9	5.0	878	333	1645	403
31641	42.0	18.0	100	..	0.9	30	31.0	0.74	7.0	3.9	2.9	4.9	634	344	683	249
31639(a)	43.5	19.0	100	..	1.9	30	36.5	0.84	8.9	3.5	2.9	4.3	869	325	1290	309
31629(a)	43.5	19.0	100	..	1.9	32	37.0	0.85	9.3	3.5	3.3	5.2	836	296	1315	320
31633(a)	43.5	19.0	100	..	1.7	31	38.5	0.89	8.7	3.3	3.1	5.9	840	309	1244	331
31631	45.0	19.5	100	..	0.4	35	55.5	1.23	10.3	6.1	4.4	7.5	552	308	3020	2137
31635(a)	45.0	19.5	100	..	1.8	35	52.5	1.17	10.4	5.1	4.2	6.3	582	275	2648	1775
31776	45.0	19.5	100	..	0.4	34	55.0	1.22	10.8	5.8	4.4	6.2	625	328	3265	2156
31802	45.5	19.5	100	..	0.5	35	57.5	1.26	10.1	5.8	3.6	5.7	614	337	3285	2390
31470	48.0	21.0	100	..	1.0	40	36.5	0.76	8.9	4.9	2.2	5.8	577	280	1160	716
31869(a)	48.5	21.0	100	..	0.8	40	67.0	1.38	11.1	6.4	4.2	7.2	1000+	621	2936	2553
31476	49.5	21.5	100	..	0.6	35	39.0	0.79	9.3	4.4	3.0	5.9	934	433	1379	487
28542	52.0	22.5	100	..	0.5	35	42.0	0.80	6.5	5.4	3.5	7.0	808	629	1439	1308
				Sulfite												
31644	54.0	23.5	92	8	1.2	39	47.5	0.88	11.9	5.0	2.8	8.4	1000+	425	2010	1121
31630(a)	54.5	23.5	100	..	2.0	40	48.5	0.89	11.5	4.9	3.0	7.2	959+	375	1577	1054
31648	54.5	23.5	89	11	1.0	40	46.5	0.85	10.8	4.4	3.0	10.3	1000+	429	1385	1058
28513	55.5	24.0	100	..	0.8	39	35.0	0.63	8.8	4.6	2.6	5.4	1000+	570	409	153
31640(a)	56.0	24.0	95	5	2.1	40	48.0	0.86	11.0	4.9	3.1	9.8	974	418	1542	1313
31634(a)	56.5	24.5	100	..	1.9	40	48.5	0.86	12.1	4.9	3.2	9.0	1001	415	1223	849
31636	56.5	24.5	100	..	2.1	37	37.0	0.66	9.1	4.1	2.8	7.1	824	363	825	429
31479	57.5	25.0	100	..	0.5	37	44.0	0.77	10.2	4.7	3.3	8.5	840	408	1402	448
31472	57.5	25.0	100	..	1.0	50	43.0	0.75	11.3	6.0	2.4	6.2	844	408	2075	1252
31637(a)	58.5	25.5	95	5	1.9	40	45.5	0.78	10.9	4.8	2.7	7.1	868	370	1519	621
28517	60.0	26.0	100	..	0.6	43	42.5	0.71	9.2	5.3	2.5	4.9	1000+	661	265	135
31646	61.5	26.5	100	..	0.9	50	55.5	0.58	8.1	5.3	2.4	4.8	974	676	201	197
31632(a)	61.5	26.5	100	..	1.6	52	66.5	1.08	12.0	7.3	4.0	7.0	805	420	3624	2406
31478	61.5	26.5	100	..	0.8	42	46.5	0.76	10.6	5.0	3.2	5.5	864	447	1219	331
31803	62.0	27.0	100	..	0.5	40	76.0	1.23	13.8	7.6	3.9	6.6	947	538	3576	2666
				Straw												
31477	63.5	27.5	100	..	1.0	45	49.5	0.78	9.8	6.3	3.9	6.6	906	539	1235	717
28532	66.0	28.5	70	30	4.7	50	46.5	0.71	9.0	6.0	2.5	4.6	852	548	717	400
31638(a)	69.0	30.0	100	..	1.4	50	59.0	0.85	14.0	5.3	3.5	7.1	1000+	608	2874	1768
28530	92.0	40.0	75	25	2.9	71	60.5	0.66	12.3	7.2	2.9	4.4	1000+	886	544	423

(a) These samples were exposed, washed and dried blue prints, all other samples were uncoated.

There should be but one grade of brown print paper. This should be of the highest quality obtainable. Brown print paper should be used as soon after coating as possible.

Specifications for blue and brown print papers, the practicability and value of which have been demonstrated by over 5 years' service, are given in Tables III, IV, V and VI.

EXPLANATION OF CONDITIONS AND TESTS

These specifications are drawn on the basis that the tests are to be made at 70° F. and 65 per cent relative humidity. Coated paper should be exposed, washed and allowed to air-dry in single sheets before testing.

Paper varying in weight from that specified must have a bursting strength relative to that stated.

Wet Strength: Tensile strength determined on strips 15 mm. in width and 10 cm. in length, after immersion in water at 70° F. for 20 minutes.

In Table VII are given complete results on ten different uncoated blue and brown print papers for the purpose of showing the relationship between the stock and sizing and the physical qualities of the paper.

High-grade rag stock, properly prepared, produces the best physical qualities. Sulfite stock mixed with rag stock does not give a high holding endurance and lacks durability. Straw stock mixed with rag usually produces a good wet strength and a fair folding endurance, but lacks durability.

Other than the quality of the stock used, one of the most important factors in the manufacture of blue and brown print papers is the character, quality and amount of sizing. Analyses of this class of paper have usually shown a high per cent of rosin or animal size or both. An excessive amount of sizing is to be avoided as it prevents the paper from coating properly. Animal size aids the folding endurance of paper because of its flexibility, while too much rosin size makes the paper brittle and the folding endurance is decreased. The papers which gave the best results on coating with blue print solution are Nos. 28547, 29541 and 28542. Samples Nos. 31631 and 31803 were difficult to coat owing to the large percentage of animal size. For satisfactory coating and durability the paper should not contain over 3 per cent of either rosin or animal size.

Table VIII contains typical results obtained in the examination of various lots of blue print papers, both uncoated and coated. They show how widely the quality of the papers varies and how few papers are of high quality and satisfactory in both dry and wet physical qualities. No direct relationship between the physical qualities of paper in either the dry or wet condition is observable although the same factors in paper making determine the qualities. A great many samples exhibiting very good folding endurance are so low in wet strength as to render them useless for most blue print work, while several papers showing a poor folding endurance have a high wet strength.

CONCLUSIONS

Blue prints in many instances are highly important permanent records which are subjected to most severe

handling in service. It is therefore essential that such papers should comply with strict specifications. Three types of specifications have been prepared which will insure the quality of paper suitable for any particular purpose. Owing to the fact that there are numerous inferior grades on the market the promiscuous purchase of blue print paper without specifications will likely lead to unsatisfactory service.

Only the highest quality paper should be used for brown prints since the coating solution seriously injures the fiber in a short time. Where a permanent record is desired brown prints should never be used.

It has been found in practical use that "thin" and "medium" papers give as good if not better service than "thick" papers, and it is recommended that both for utility and economy light-weight papers be used whenever practicable.

The depth of color, clearness and durability of a print are largely controlled by the methods of coating, and care in printing, washing and drying. For the best results slow-speed coatings should be used and these should be printed at a low temperature and thoroughly washed to remove all soluble salts and then air-dried.

PRECAUTIONS TO BE OBSERVED WITH BLUE AND BROWN PRINT PAPERS

I—All coated papers should be used as soon after coating as practicable; brown print papers will possess their maximum durability only when printed immediately after coating.

II—To insure strength and durability of the printed paper, all coating, printing and drying should be done at the lowest practicable temperature.

III—After printing, the paper should be thoroughly washed by immersion in fresh running water to remove all unfixed acids and other chemicals, which if not removed will cause the print to fade and the paper to become brittle. Prints for permanent records can hardly be washed too thoroughly. This applies especially to brown prints.

IV—The coated paper must be kept in a cool, dry place and be properly wrapped to exclude moisture and light. This is absolutely essential with coated brown print papers.

V—Prints should never be folded. They should be kept flat or rolled, in a dry, dark place.

LEATHER AND PAPER LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

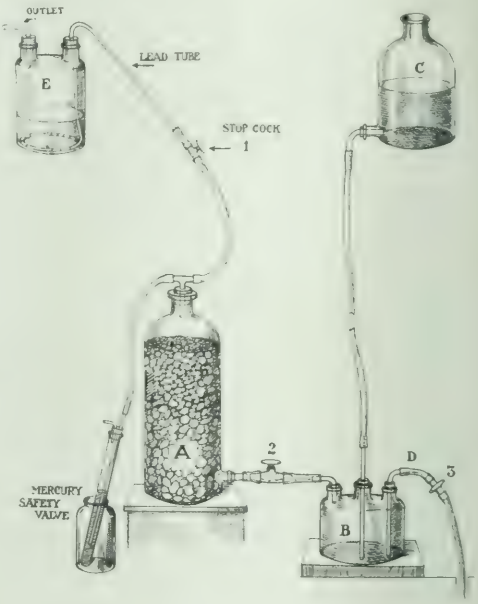
A HYDROGEN SULFIDE GENERATOR

BY LOUIS SATTLER

RECEIVED JANUARY 24, 1918

A great variety of hydrogen sulfide generators have been described. However, it still remained a problem to find one which would satisfy the needs of a laboratory where the gas is used continually in a comparatively large volume. The apparatus here described has given satisfactory service in this laboratory. The construction is apparent from the sketch.

By shortening or lengthening the tube connecting the reservoir *C* and the mixing bottle *B* the gas is delivered at any desired pressure. Furthermore, the capacity of the generator can be readily altered to hold either larger quantities of iron sulfide, *A*, or larger quantities of acid, *C*.



After the aspirator bottle *A* has been filled with iron sulfide, diluted hydrochloric acid (about 50 per cent by volume) is poured into the reservoir bottle *C*. By opening stopcocks 1 and 2 the acid is allowed to flow into the mixing bottle *B*. This bottle should be seven-eights filled. Then stopcock 1 is closed and enough acid poured into *C* so that when stopcock 1 is again opened there are about 3 in. of acid left in the reservoir bottle *C* after *B* is filled.

The waste acid is removed by closing stopcock 2 and opening stopcock 3. The pressure from the reservoir starts the syphon *D*. A Woulff bottle, *E*, is used for washing the gas. This is partly filled with water into which leads a submerged lead coil sealed at the end and perforated with small holes. Any excessive gas pressure is taken care of by a safety device consisting of a glass tube which may be lowered to any depth into mercury.

The generator in this laboratory holds 50 lbs. of iron sulfide and 14 liters of acid. The cost of material was twenty-seven dollars.

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH
NEW YORK CITY

DISTINGUISHING MANILA FROM ALL OTHER "HARD" ROPE FIBERS

By Charles E. Swett

Received December 4, 1917

In the rope industry fibers are classed as "soft," hemp, jute, linen, cotton, etc., and "hard," as manila (musa), sisal (agave), maguey, New Zealand (*Phormium tenax*) and others. In general, the hard fibers are lignified. Among the soft fibers jute also is a lignified fiber, but its physical characteristics place it beside hemp.

The two hard fibers of preëminent importance are manila and sisal.

The distinction between manila and sisal is not easy, except by a practical rope maker and not always by him, especially when they occur together in rope.

When it is desired to estimate the amounts of the two present in a given rope the microscope has to be used. The cross-sections are characteristic but not in all cases satisfactory. For instance, sisal from East Africa is sufficiently different from manila to enable one to separate them, but sisal from Yucatan (henequin) is not always enough different to make it possible to say how much may be present.

The sections are not easy to make and when made may contain thousands of fibers. When it is considered that the field under magnification to 200 diameters is of the order of one millimeter and that a rope of 2 or 3 in. of cross-section may have to be examined it will be understood that some method for differentiating these fibers other than the employment of the microscope would be of great use.

Such a method has been worked out in this laboratory and is here described in some detail.

If the sample is treated with a solution of bleaching powder acidulated with acetic acid, then with ammonia, manila takes a russet-brown color. All other hard fibers turn cherry-red. Thus it becomes possible to distinguish manila from all the others, which is the matter of chief importance.

SOLUTIONS REQUIRED

1. ETHER to pour down a strand to remove most of the spinning oil.

2. BLEACHING POWDER SOLUTION—A clear solution of chloride of lime, containing about 5 per cent of available chlorine, acidulated with acetic acid (30 cc. of bleaching solution and 2 cc. glacial acetic acid).

Acidulation with an acid stronger than acetic will not answer, for example, hydrochloric acid will give no test.

3. WATER to rinse after the above.

4. ALCOHOL to remove water.

5. STRONG AMMONIA.

PRELIMINARY EXAMINATION OF THE SAMPLE

Remove most of the oil by pouring ether down the strand. Wave through the air for a minute or two to remove most of the ether; immerse one end of the sample in the acidulated bleach solution for 20 sec.; rinse first with water, then with alcohol and then immerse in ammonia.

Manila will instantly turn brown.

Sisal, New Zealand, istle, Mauritius, maguey will assume a cherry-red.

When so applied the test is somewhat fugitive, the red color degrading in the course of a few minutes so that it may not be possible to pick out the different colored fibers from the strand. As applied it enables one to say whether the sample is all manila, all non-manila or a mixture. This is all that is required in many instances.

When it becomes necessary to estimate the percentages of manila and non-manila the procedure is as follows:

Apply the test as before but instead of immersing the fibers in ammonia in the last operation, suspend the treated end of the strand above the ammonia for a minute or so. As thus practiced the manila does not assume the brown color as rapidly, but at the end of 2 or 3 min. the color develops and is permanent.

The cherry-red of the non-manila fibers remains for hours and a separation may be made by picking out the red or the brown. A reading glass is of assistance.

When the separation is made as above it is desirable to take the two differently colored strands and apply the test as first described, *i. e.*, by treating the hitherto untreated ends with ether, immersing in bleach acetic solution, rinsing with water and then immersing in ammonia. This serves as a check and as the separation will be closely approximate as a result of the fuming test, the few fibers which may show up as wrongly placed can be removed with ease.

One desiring to practice this test should first work on samples of known origin. With practice it seems to be possible to estimate the manila content of a rope down to a single fiber. As the test is so quickly applied it is the writer's practice to take less than a strand for treatment and then go through the sample taking perhaps 20 or 30 fibers at a time.

The difference between the red and the brown is most evident at the end of 3 or 4 min. after fuming with the ammonia.

The bleach solution made with one part of chloride of lime and seven parts of water, then filtered, may be kept in a stoppered amber bottle away from the light for a long time. When some is to be used it should be poured from the stock solution and acidulated with the acetic acid for present use. Throw away when the tests are done. It will not keep in an acidulated condition.

Chlorine water will not serve, neither will iodine solution or bromine water; nor will any acid tried answer so well as acetic.

Too much emphasis cannot be placed on the fact that hydrochloric or other strong acid is not suitable to replace acetic acid as used in this test. This reiteration is made because, notwithstanding specific instructions, two competent chemists have assumed that because the test failed with hydrochloric acid there was nothing in it. In neither case were the directions followed and when attention was called to this fact no trouble was experienced in securing the appearances described.

Laboratory of Arthur D. Little, Inc.
Cambridge, Mass.

CURRENT INDUSTRIAL NEWS

DIESEL ENGINE BLAST PRESSURE CONTROL

An automatic electrical device, developed by Mirrlees, Bickerton and Day of Stockport, for regulating in accordance with the load the pressure of the air which blows the fuel into the cylinders of Diesel engines, was described by Mr. H. S. Russel before the Diesel Engine Users' Association. The main current passing round a solenoid, controls a finger which moves round the scale of a pressure gauge and which is calibrated to point to that blast pressure which is best for the engine for the amount of power being generated at the moment, its zero or no-load position being the no-load blast pressure. It is provided with platinum contact pieces, as also is the indicating finger of the pressure gauge which is connected to the blast pipe; the two, therefore, act as a single-pole switch, making and breaking a relay circuit which in turn makes and breaks the circuit which operates the throttle valve on the air-compressor inlet. Should the pressure finger stand lower down the scale than the other finger the electrical arrangements are such that the throttle valve, which is normally held closed by a spring, is pulled off its seat. The pressure in the blast pipe then rises rapidly (the compressor always having a substantial margin of capacity) until the pressure finger moves up to and makes contact with the other finger; when this happens the throttle valve closes and remains closed until the fingers come together again. By this device a variation from 550 lb. (no-load pressure) to 950 lb. (full-load pressure) can be obtained in four seconds, and as several seconds are required for the fly-wheel to slow down and the governor admit more fuel the correct pressure is always on the top of the fuel.—A. McMillan.

HIDES AND SKINS FROM VENEZUELA

There are sources of supply of cattle hides not yet fully exploited in Venezuela, in spite of the attention which is being given to developing the meat export trade. Purchasers of deer skins, alligator and jaguar skins, says the *Times Trade Supplement*, are desired, as well as purchasers of cattle hides.

In these times when anything capable of being made into leather is almost sure to repay careful investigation, it would probably be worth the while of the tanner to ascertain what use could be made of the skin of the chiguire or "carpincho." This is a big rodent, about 4 ft. by 3 ft., having a thick skin covered with a brown coat of short, coarse hair. Millions of these animals are to be found in the valleys of the Orinoco and its tributaries and, owing to the damage they do to sugar crops, the Venezuelan Government is desirous of exterminating them.—M.

GERMANY'S COMMERCIAL METHODS

We read in the *Revue Générale de l'Electricité* that the French Government has learned from an authorized source that, in neutral countries, in Spain notably, the Germans are plotting the disorganization of allied enterprises which compete with their own. They are offering very advantageous contracts to the greatest number of men belonging to the allied enterprises to lead those men to abandon abruptly their employment as soon as peace is declared. At the present time the Germans are specially busy with the electrical understandings and they are endeavoring to bring about their stoppage by the lack of experienced hands. German agents have carried out a complete investigation in regard to the whole personnel of the said allied enterprises from laborers to technical staff to whom offers have been made, to come into effect after the war, of situations much more advantageous than those they now hold. The contract ensuring the situation is drawn up either in Germany or Switzerland and signed before a Notary Public. Similar attempts at disorganization are being proceeded with by the enemy in Switzerland.—M.

COAL-MINING MACHINERY FOR ARGENTINA

Owing to the severe lesson learned in Argentina since the outbreak of war in regard to imported coal supplies, the Government is making a determined effort to work the coal deposits that have so far been located. A considerable amount of money has been allocated for this purpose and already orders have been placed for part of the necessary equipment and plant.

Manufacturers of coal-mining plant, hoisting machinery, wire ropes, pumps, fans and iron piping would do well, says the *Times Trade Supplement*, to get into communication with the authorities at Chubut where the best of the coal deposits, so far discovered, are situated. The mines in which the Government is mostly interested are in the territory of Chubut, situated 124 miles from the nearest railway. A line of rails is, however, to be laid down to join up the mines with the track. The quality of the coal is said to be good.

Other deposits are situated in the Provinces of San Juan and Mendoza. So far, however, it has proved anything but a simple matter to obtain delivery of even a modest consignment of apparatus.—M.

UTILIZATION OF NITRE CAKE

In a paper in *Rev. des prod. chim.* the possibility of using nitre cake in connection with the sulfites obtained in phenol manufacture is considered. By combining nitre cake with the residual sulfite it should be possible to obtain 86.5 per cent sodium sulfate together with 5.2 per cent free sulfuric acid, and about 7 per cent alumina and sodium sulfite. This product should be of interest in the manufacture of glass. A certain quantity of phenol should also be recovered at the same time. The percentage of sodium sulfite may be taken as not less than 50 per cent. If the liquor is divided into two parts, the first part may be treated with nitre cake to produce sodium sulfate and sulfur dioxide and the second part may be saturated with the sulfur dioxide obtained from the first part to produce pyrosulfite or metasulfite. The author claims to have actually obtained metabisulfite in this way, and, with efficient cooling, the yield should be quantitative.

A further important use for nitre cake appears to be in the manufacture of magnesium sulfate. The hot nitre cake is conveyed into a trough containing a carbonated magnesium compound such as dolomite or magnesite, the mixture being thoroughly stirred. The cooled mass, which is very spongy owing to the evolution of carbon dioxide, is broken up, washed with boiling water, decanted, filtered and evaporated. The sodium and magnesium sulfates are separated by difference in solubility. It would seem from figures given that this utilization of nitre cake should be remunerative.—M.

ELECTRO-TECHNICAL INDUSTRY IN JAPAN

Japan has been working hard, says *Engineering*, **104** (1917), 684, under favorable conditions during the war, and, among other branches of her industry, that of the electro-technical industry has made important strides. As an example may be mentioned large capacity electric generators of, say, 10,000 kw., which before the war were always imported from England, America and Germany, but which are now made within the country. The aggregate value of electro-technical machines and appliances annually manufactured in Japan has been tripled during the war and now amounts to between $15,000,000 and $20,000,000. The export of electric plant and apparatus also shows a material increase especially to China and Dutch India, and Japan already holds the fifth place in the matter of export of incandescent lamps.—M.

TANNIN AND TIMBER

Communications will be welcomed by the Bureau of Forestry, Manila, says a contemporary, from firms in a position to exploit the very large growth of mangrove in the Philippine Islands. The tannin content of the barks amounts to from 12 to 35 per cent. A completely successful cutch is said to have been made, dry, solid and brown in color, from the mangrove bark obtained in the Archipelago. There are 21 species of mangrove in the Philippine swamps and the potential cutch production is tremendous. Mindoro, one of the larger islands about 100 miles from Manila, appears to offer the most inducement to a firm able to work the mangrove growths for piles, poles and firewood as well as bark. Firewood cutters already operating would be willing to sell the bark. There are over 30,000 acres of mangrove swamps in Mindoro estimated to yield 50,000 tons of bark convertible into about 17,000 tons of cutch.—M.

ALUMINUM GOODS FOR BRAZIL

According to the *Times Trade Supplement* there is here a market for as many articles of light material as can be shipped, all existing stocks, for some months past, having been completely exhausted. The dearth of supply is entirely due to the cessation of shipments of German consignment through neutral ports which continued for some time after the outbreak of war. Although some small shipments of aluminum goods were sent to South America from the United Kingdom, three-fifths of the imports of this class came from Germany and Austria. The demand among the Brazilian and in all the Central American countries is for cheap cooking utensils. German goods, when obtainable, have been invoiced at very low figures against which it has been difficult for other manufacturers to compete, and it might be worth while for manufacturers to send out a full range of samples making the prices as low as possible and allowing a reasonable amount of credit. The value of German trade in these goods amounted in normal times, with Brazil alone, to over $82,500 and with the other countries of South America, to over $85,000. It is, however, worthy of note that both the United Kingdom and the United States purchased these goods from Germany in pre-war days to a considerable extent. Manufacturers may be interested to know that the German goods are "spun" not "cast," this being the chief reason why they can be sold at a cheaper rate. In addition, the South Americans prefer the dull silvery appearance of the German goods to the bright, polished, tin-like appearance of the British goods. The more salable of aluminum hardware articles exported to Brazil include meat dishes, pudding bowls, colanders, pie dishes, forks, spoons, stewpans, milk boilers, kettles, saucepans (with or without lids), spirit stoves.—M.

WIRING SUPPLIES

A fully illustrated list has been issued by the Lamp and Wiring Supplies Department of the British Thomson-Houston Company, Mazda House, London, and deals entirely with wiring installation accessories. It covers the standard types of such appliances as lampholders, switches, wall plugs, ceiling roses, cut-outs, distribution boards, fuse boxes and insulators. Among the items included are porcelain Goliath Edison screw lampholders designed to meet the requirements of the Admiralty and other Government Departments; new designs of brass Goliath holders; standard bayonet and Edison screw holders in both porcelain and brass-case types; the "Quiklok" cover ceiling rose, which has been approved and standardized by the War Office and which, among other advantages over the ordinary ceiling rose, can be wired on the bench and secured in position on the ceiling by a quarter turn of the wrist; interlocking and other types of combination switch plugs; and new patterns of distribution fuse boards and insulators.—M.

PURE BISMUTH

According to an article in the *Journal of the Chemical Society, London*, the determination of minute traces of impurity in bismuth is difficult since the basic salts form amorphous precipitates which obstinately retain other metals as also do the sulfide and oxide. The electrolytic method of separation also fails. The best means of obtaining the pure metal is by crystallizing the normal nitrate from strong nitric acid. Fairly pure bismuth nitrate is dissolved in half its weight of 8 per cent nitric acid and the solution mixed with an equal weight of strong nitric acid. The crystals which separate at 0 to 10° C. are washed with ice-cold nitric acid. The pure nitrate is then converted into the oxide by heating and this is reduced by fusion with potassium cyanide. Further purification is effected by melting the metal under paraffin and removing by means of a glass spoon the first and purest crystals formed. Purified bismuth melts at 271° C., and when pressed into wire the melting point is lowered to 195° C. and its specific electric resistance is then 1.20. Various samples of bismuth sold as pure were found to contain from 0.03 to 0.25 per cent of impurities. The method for testing for impurities is detailed.—M.

CHROMIUM STEEL FOR MAGNETS

Owing to the commandeering of tungsten for military purposes, says *Engineering*, **105** (1918), 18, German electricians found themselves without tungsten for their magnet steels early in the war and experiments on the use of chromium in place of tungsten which had already been projected were accelerated. The research has been conducted at the Reichsanstalt on behalf of the Verband Deutscher Electrotechniker. The preliminary report of 1917 did not give particulars which were, however, communicated to the members of the Verband on inquiry. Krupp's Works supplied 37 specimens of steel containing varying percentages of chromium and carbon. They had been turned into rods and hardened in various ways in the works and were then aged after the method of Stronhal and Barus by repeated heating, cooling and mechanical stress while being tested at intervals in the Reichsanstalt. The unfinished investigation concerns also the temperature coefficient of magnetization and the durability of the steels. It results that on an average, chromium steels which have undergone suitable heat treatment do not rank below tungsten steels. The very best chromium steels, however, are not equal to the best tungsten steels. Technically, chromium steels would thus appear to be quite satisfactory while for special researches their further improvement is desirable.—M.

AN AUTOMATIC CONTROLLER FOR ELECTRICAL HEATING APPARATUS

The *Electrical World* gives an account of a small and compact heating controller for use with electrical heating appliances which has been brought out by the Automatic Electric Controller Company of Seattle. The device is made in two types, one for alternating and one for both alternating and direct current. It consists of a thermostat of copper and iron riveted together and placed immediately over a heating coil connected in series with the load. The heat from the coil causes the thermostat to break the circuit whenever the temperature rises above a certain point. It can be adjusted to operate over a wide range of temperature between 90° and 160° C. by ca using the contact point to move downward and bend the thermostat, thus increasing the temperature requisite to cause the latter to break connection. It is claimed that the device will enable 40 per cent of the heat now used in excess by various implements to be saved, as the exact temperature necessary for any operation can be obtained. The device also acts as a safeguard against excessive current.—M.

MACHINERY FOR KOREA

The completion of the Seishin Kainei Railway in Northern Korea, says a contemporary, opens up hitherto unworked fields of coal, iron and timber. The iron mines in Mosan are now likely to be exploited and it is said that the Mitsubishi Kuhara and Suzuki concerns are all interesting themselves in the development. Investigations are now being made into the possibilities of the Kanhoku coal field. The product so far obtained is not of very good quality but it is hoped that better strata will be reached. The Suzuki Company has sent experts to examine the forests on the banks of the River Tumen in order to see if a large lumber mill would pay. Meanwhile, a state sawmill has been started in Kainei and a pulp manufacturing plant has been erected in Shingishu for the purpose of utilizing the forests on the banks of the Yalu. The timber from this source is also to be turned to account at a paper mill to be erected at New Wiju. This scheme involves an expenditure of $5,000,000. In the first place, a plant will be set up for turning out about 20,000 tons of paper-making material annually and this part of the program is expected to take two years. Seventy miles up the River Yalu a hydro-electrically driven pulp mill is projected while a third part of the developments consists in the erection of yet another factory capable of manufacturing 30,000 tons of pulp a year.—M.

AUTOCLAVES AND HIGH PRESSURE PROBLEMS

According to a paper by Mr. C. E. Stromeyer, Chief Engineer to the Manchester Steam Users' Association, one way out of high pressure difficulties is to discard autoclaves altogether and to allow the chemical process to take place in a long pipe. The inlet portion of such a pipe should be coiled into a vessel containing molten or solid lead heated to the proper temperature or it should be led through vessels with different temperatures; the end of the coil could be led through a cooling vessel. The chemicals, usually two fluids, would have to be forced into one end, either hot or cold, by two plunger pumps of correct volumes acting simultaneously and, if the diameter of the pipe be made sufficiently small to ensure that the critical velocity is exceeded, thorough mixing is bound to take place. A loaded relief valve would have to be provided at the outlet end. Several of these coils are in use and are said to work satisfactorily. It appears that they are always made of iron whereby their use is limited to certain processes. They could, however, be made of lead provided that precautions be adopted of equalizing or nearly equalizing the pressure on the outside and the inside. To do this and at the same time maintain the correct temperature, it may be necessary to place the pipes in closed vessels and make the heating baths of various fluids having suitable boiling temperatures. Possibly the same substances which are used or produced in the pipes might be used as heaters.—M.

SOUTH AFRICAN INDUSTRIAL DEVELOPMENTS

The British Trade Commissioner in South Africa writes that a company has been formed for the manufacture of carbide at Germiston and was expected to begin producing at the end of last October. It is hoped that the factory will be able to produce some 3 tons of carbide per day. The same company is also producing carbon electrodes. A company for detinning purposes has been established at Cape Town. Large quantities of scrap tin have accumulated in different parts of the Union and it is thought that there will be an ample supply of waste tin for the company's purposes. A glass bottle factory is to be reopened at Hatherley, Victoria, as soon as certain technical difficulties have been overcome. The recovery of arsenic, tin smelting and the refining of antimony are among other industries which have also been established in the Union.—M.

UTILIZATION OF WASTE BOOTS

At a meeting of the London Section of the Society of Chemical Industry, a paper on the "Utilization of Condemned Army Boots" was read. The author dealt with the use of waste boot leather for road making, the manufacture of animal charcoal, ammonium sulfate, the production of grease and fatty matters, manure, leather-board, clogs, washers, mats, leather pulp, leather powder, cyanides, glue and size. With regard to the manufacture of leather board, the author said that, in his opinion, although it had been the subject of many patents, it had not met with any measure of commercial success. At the present time, the manufacture of leather-board for use in insoles of boots and the soles of slippers and such like, employing this discarded army footwear for the purpose of pulping, appears to be more attractive than in less strenuous times. On the question of using waste leather for the production of leather pulp, it was stated that this was probably practicable but it would have a powerful competitor for this purpose in the form of waste scraps, cuttings and machine turnings of new leather which is more suitable to work up. The relative prices of the two materials would decide whether this would be a sound commercial proposition.—M.

VEGETABLE WAX FROM COLOMBIA

A wax obtained from the leaves of the wax palm of the Andes, *Ceroxylon andicolum*, used in Colombia for making candles but not yet exported has been examined recently at the Imperial Institute, London, and full particulars are given in the current bulletin of the Institute. The palms occur only in western tropical South America and are said to be exceedingly abundant. The sample examined consisted of fine powdered wax of a pale straw color with a small admixture of vegetable matter. The palm wax when purified is similar in character to carnauba wax which comes from Brazil, and to candelilla wax imported from Mexico, except that its melting point (93° C.) is higher than that of carnauba wax (84° C.) and that of candelilla (70° to 72° C.).—M.

ZINC REFINING IN JAPAN

Interesting particulars have reached us, says the *Eastern Engineering Journal*, regarding the zinc refining industry in Japan. It would appear that the supply of ore for the Japanese zinc refineries is by no means assured. The production of zinc ore in Japan does not exceed 50,000 tons per annum, while the existing Japanese refineries need about three times that quantity if they are to be kept at their full capacity. Further, if all the projects for new refineries and additional plant are realized, the requirements of the industry in the near future for zinc ore will exceed 300,000 tons.—M.

BRITISH BOARD OF TRADE

During the month of December, the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

Brace-fittings (rustless steel)
Buckles for trench coats
Buttons
Carbon brushes for dynamos
Garter-fittings (rustless steel)
Metal polish
Pitch coke
Tie fittings
Whalebone for brushes

Machinery and Plant for:
Die-casting machines
Making noodles
Distillation of peat and lignite
Covering copper wire with India rubber insulation
Manufacture of sugar of milk
Treating and dyeing furs
Making wooden toothpicks
Marking thermometers

—M.

TRADE ASSOCIATIONS

THE CHEMICAL ALLIANCE

Some 200 manufacturers of chemicals met at the Hotel Biltmore, New York City, on Wednesday, February 6, 1918, to organize the Chemical Alliance and its affairs for the coming year.

It was at the suggestion of the U. S. Department of Commerce that the Chemical Alliance was formed and it was incorporated under the laws of Connecticut on July 30, 1917. When organized it was made up of the chairmen of the subcommittees of the Committee on Chemicals and the officers were: *President*, W. H. Nichols; *Vice-President*, Horace Bowker; *Secretary*, J. D. Cameron Bradley. The sub-committees have since been discontinued.

The object of the Alliance as at present organized is to carry on the work begun by these committees and to coöperate with the Government in solving war problems which affect the industry. In the words of the constitution of the Alliance,

"The Chemical Alliance, Inc. is established to promote in all lawful ways the commercial interests of its members, to coöperate with the Government in all matters of national concern, and to secure the advantages to be obtained by mutual coöperation; to acquire and disseminate information concerning trade conditions at home and abroad, credits and other matters of interest; to deal with questions affecting the public safety and welfare, and in general to promote the interests of the chemical industry and all its branches."

The organization is an alliance of all branches of chemical industry and industries related thereto, but only manufacturers are admitted to membership. There are at present nine sections, but a tenth for Oils, Fats and Greases will soon be established. The nine sections already formed with the number of members in each are as follows:

1. Acids—31
2. Coal and Gas By-Products—20
3. Foreign Pyrites—7
4. Electrochemicals—9
5. Fertilizers—61
6. Miscellaneous Chemicals—20
7. Alkalies—12
8. Domestic Pyrites and Sulfur—4
9. Dyestuffs—10

Horace Bowker, president of the Alliance, in addressing the meeting, outlined the general plan for the coöperation of the Alliance with the War Industries Board and emphasized the fact that the Alliance was not the outgrowth of any Association but was brought into existence by war needs to serve the Government as needed by furnishing information, or men, or both.

Mr. MacDowell, representing the War Materials Committee of the War Industries Board, described the functions of that committee and outlined their expectations of coöperating with the Alliance and availing themselves of its service.

Officers for the general organization were elected as follows:

President: Horace Bowker, The American Agricultural Chemical Co., 2 Rector Street, New York City.

Vice-President: Henry Howard, The Merrimac Chemical Co., 148 State St., Boston, Mass.

Secretary-Treasurer: J. D. Cameron Bradley, American Agricultural Chemical Co., 92 State St., Boston, Mass.

Directors: Horace Bowker, American Agricultural Chemical Co., 2 Rector St., New York City; Henry Howard, Merrimac Chemical Co., 148 State St., New York City; Wm. Hamlin Childs, The Barrett Co., 17 Battery Place, New York City; E. R. Grasselli, Grasselli Chemical Co., Cleveland, Ohio; W. D. Huntington, Davison Chemical Company, Baltimore, Md.; D. W. Jayne, The Barrett Co., 17 Battery Place, New York City; A. D. Ledoux, The Pyrites Co., Ltd., 15 William St., New York City; F. A. Lidbury, Oldbury Electro-Chemical Co., Niagara Falls, N. Y.; C. H. MacDowell, Armour Fertilizer Works, Chicago, Ill.; Edward Mallinckrodt, Jr., Mallinckrodt Chemical Works, 3600 N. 2nd St., St. Louis, Mo.; Wm. H. Nichols, General Chemical Co., 25 Broad St., New York City; J. D. Pennock, Solvay Process Co., Syracuse, N. Y.; C. L. Reese, E. I. du Pont de Nemours and Co., Wilmington, Del.; John J. Riker, 19 Cedar St., New York City; A. G. Rosengarten, Powers-Weightman-Rosengarten Co., Philadelphia, Pa.; C. G. Wilson, Virginia-Carolina Chemical Co., Richmond, Va.

The sections elected chairmen and committees as follows:

1. Acids Section: *Chairman:* W. D. Huntington, Davison Chemical Co., Baltimore, Md.; S. B. Fleming, International Agric. Corp., 61 Broadway, New York City; J. M. Goetchius, General Chemical Co., 25 Broad St., New York City; C. F. Burroughs, F. S. Royster Guano Co., Norfolk, Va.; J. H. D. Rodier, Grasselli Chemical Co., Cleveland, Ohio; Chas. M. Butterworth, Pennsylvania Salt Co., Philadelphia, Pa.

2. Coal and Gas By-Products Section: *Chairman:* D. W. Jayne, The Barrett Co., 17 Battery Place, New York City; W. R. Addicks, Consolidated Gas Co., New York City; C. J. Ramsburg, H. Koppers Co., Pittsburgh, Pa.; W. E. MacKay, New England Coke and Gas Co., Boston, Mass.; A. A. Schlesinger, Milwaukee Coke and Gas Co., Milwaukee, Wis.

3. Foreign Pyrites Section: *Chairman:* A. D. Ledoux, Pyrites Co., Ltd., 15 William St., New York City; C. F. Burroughs, F. S. Royster Guano Co., Norfolk, Va.; F. H. Nichols, General Chemical Co., 25 Broad St., New York City; W. H. Mills, Naylor & Co., 120 Broadway, New York City.

4. Electrochemicals Section: *Chairman:* F. A. Lidbury, Oldbury Electro-Chemical Co., Niagara Falls, N. Y.; C. D. Cohen, American Cyanamid Co., 511 Fifth Ave., New York City; F. J. Tone, Carborundum Co., Niagara Falls, N. Y.

5. Fertilizers Section: *Chairman:* C. G. Wilson, Virginia-Carolina Chemical Co., Richmond, Va.; C. F. Burroughs, F. S. Royster Guano Co., Norfolk, Va.; W. D. Huntington, Davison Chemical Co., Baltimore, Md.; C. H. MacDowell, Armour Fertilizer Works, Chicago, Ill.; A. C. Read, Read Phosphate Co., Savannah, Ga.; Albert French, Internat. Agric. Corp., 61 Broadway, New York City; Porter Fleming, Southern States Phos. & Fert. Co., Augusta, Ga.; William Prescott, American Agric. Chem. Co., 2 Rector St., New York City; Frederick Rayfield, Swift & Company, Chicago, Ill.

6. Miscellaneous Chemicals Section: *Chairman:* A. G. Rosengarten, Powers-Weightman-Rosengarten Co., Philadelphia, Pa.; G. P. Adamson, General Chemical Co., 25 Broad St., New York City; Wm. Henry Bower, Henry Bower Chemical Mfg. Co., Philadelphia, Pa.

7. Alkalies Section: *Chairman:* J. D. Pennock, Solvay Process Co., Syracuse, N. Y.; E. H. Hooker, Hooker Electro-Chemical Co., 40 Wall St., New York City; N. E. Bartlett; E. Sargent; Eli Winkler, Columbia Chemical Co., Pittsburgh, Pa.

8. Domestic Pyrites and Sulfur Section: *Chairman:* C. H. MacDowell, Armour Fertilizer Works, Chicago, Ill.; W. N. Wilkinson, Union Sulphur Co., 17 Battery Place, New York City; H. P. Nash, Ladenburg-Thalmann Co., 25 Broad St., New York City; C. G. Wilson, Virginia-Carolina Chemical Co., Richmond, Va.

9. Dyestuffs Section: *Chairman:* C. L. Reese, E. I. du Pont de Nemours & Co., Wilmington, Del.; H. A. Metz, Central Dyestuffs & Chem. Co., Newark, N. J.; M. R. Poucher, du Pont Chemical Co., Wilmington, Del.; R. W. Hochstetter, Ault & Wiborg, Cincinnati, Ohio; August Merz, Heller & Merz, Newark, N. J.; H. D. Ruhm, Marden, Orth & Hastings Co., 61 Broadway, New York City; I. F. Stone, National Aniline Co., New York City; F. M. Fargo, Calco Chemical Co., Bound Brook, N. J.; A. R. Curtin, Middlesex Chemical Co.; J. M. Matthews, Grasselli Chemical Co., New York City

DYESTUFF CONVENTION

On Tuesday, January 22, a large assemblage of manufacturers of and dealers in dyestuffs gathered in Rumford Hall, Chemists' Club, New York City, to discuss the advisability of organizing an association to be devoted to American dyestuff interests.

Mr. H. G. McKerrow outlined the preliminary steps which had been taken in bringing about the meeting, and suggested that specific actions were not essential at this time, but rather a decision as to whether or not such an association is desirable.

The following temporary officers were chosen:

Chairman: Frank Hemingway, Frank Hemingway, Inc., New York.

Treasurer: C. D. Jenkinson, National City Bank, New York.

Secretary: C. C. Bennett, Color Trade Journal, New York.

Upon taking the chair, Mr. Hemingway called attention to the fact that while standardization of dyestuffs was an important topic it constituted only one of many important functions of such an association as is contemplated. He urged that the policy of the association should not be too open in regard to membership, and proposed the appointment of a large committee to determine the qualifications for membership. The importance of coopera-

tion between American, British and French interests was clearly outlined and the speaker concluded with a tribute of appreciation of Mr. McKerrow's work in the preliminary steps which resulted in the gathering.

Mr. McKerrow spoke at length concerning the purpose and possibilities of such an association, discussing the questions of standardization, the need of arbitration in the great mass of now-pending disputes, of adequate tariff protection, and of fair dealing in the industry.

The meeting was then addressed by Benjamin M. Kaye, an attorney who has participated successfully in the organization of several trade organizations, who pointed out that of 500 national associations in commercial lines there was none to represent the dyestuff industry, and that this industry was in need of such organization on account of the character of German competition which would have to be met after the war.

On motion of L. A. Ault, of Cincinnati, each one present rose and stated his business connection. A lively discussion followed as to whether the association should include both manufacturers and dealers. The chairman suggested that it might be well to divide the membership into two classes: active members, the manufacturers, and associate members, the dealers. The further suggestion was made that the associate members have no vote. The opinion of the meeting seemed to be that a physical mixer of dyestuffs should not be considered as a manufacturer, inasmuch as he adds nothing to the amount of dyestuffs produced. To meet this question fairly the dealers retired to another room in the building, and in their absence the manufacturers decided that only straight-out American manufacturers should be eligible for membership, further defining the terms as follows: "an American citizen whose plant is in America and not controlled by outside capital." Thereupon each manufacturer stated the location of his plant. The manufacturers adopted unanimously the principle of active members with voting power, and associate members without the ballot privilege. The question of differentiation between the coal-tar and the natural dyestuff manufacturer was postponed for later consideration.

D. W. Jayne of The Barrett Company gave an interesting account of the proposed Chemical Alliance.

Just before adjournment of the morning session Mr. McKerrow reported that the dealers in their meeting requested that a committee of the manufacturers be appointed to confer with a committee of the dealers. This request was acceded to, and the chairman appointed J. M. Matthews, L. A. Ault and August Merz.

Dr. Matthews reported at the afternoon session that the joint committee of the manufacturers and dealers recommended that the association consist of active members—manufacturers with voting power, and associates—dealers, machinery manufacturers, etc., with no vote, but with a representative on the directorate. Furthermore, that associate members should have control over the qualifications of associate members, and that if an arbitration board should be appointed the associate members should have a representative upon such board. The report was unanimously adopted.

The chair appointed the following committee on organization: J. M. Matthews, L. A. Ault, A. Merz, W. S. Woodward, T. N. Hyndman, H. G. McKerrow, S. R. David.

Dr. Wallace Pierce of the U. S. Conditioning and Testing Laboratory addressed the meeting on the subject of standardization. He considered this matter perfectly practicable, and laid stress upon the need of accurate sampling. It was pointed out that on pure compounds colorimetric methods are satisfactory, and the use of the spectroscope and microscope in the work of standardization was illustrated. Emphasis was put upon the fact that the standard is a unit and not an ideal

An interesting talk was given by Ellwood Hendrick on the early efforts of dye manufacturers in this country, pointing out the good that might have been accomplished if in those days a truer spirit of coöperation had prevailed.

The convention was addressed by A. E. Parker on the subject of patents in relation to the dyestuff industry, and by Bradford Webster on "Arbitration."

On Wednesday morning the convention heard the address of Grinnell Jones of the U. S. Tariff Commission, which follows:

THE TARIFF COMMISSION AND THE DYE INDUSTRY

By Grinnell Jones

It is not necessary before this audience to discuss the history of the tariff law of September 8, 1916, which raised the duties on dyes and other coal-tar products. I shall merely remind you that the legislation creating the United States Tariff Commission forms a part of this same bill. This law charges the Commission with the duty of gathering the facts needed for the consideration of questions of tariff policy and requires that all information at its command shall be put at the disposal of the President and Congress, whenever requested. The Commission recognizes that the dyestuff industry presents one of the most important and complex problems which it will have to consider and is planning to make a report to Congress on this industry.

Last August the Commission sent a questionnaire to many of the leading textile mills asking for a statement in regard to the effect of the dyestuff shortage of 1915 on their business and the extent to which their needs have been met by the growth of the American dyestuff industry. These consumers were also asked to give certain statistical information bearing on the question and to state their opinion in regard to the wisest policy for the country to adopt on the question of the tariff on dyes. Returns have been received from 77 textile manufacturers and a summarized statement of the replies will be published very soon. The Commission is now seeking information from the manufacturers of dyes, intermediates, and other coal-tar products.

The Underwood tariff law levied an import duty of 30 per cent *ad valorem* on dyes, except indigo, alizarin, and dyes derived from anthracene and carbazol, which were on the free list. The act of September 8, 1916, placed an additional duty of 5 cents per pound on the dyes formerly dutiable at 30 per cent *ad valorem* and imposed a duty of 30 per cent upon the dyes formerly on the free list. By the same act coal-tar crudes were put on the free list and intermediates were made dutiable at 15 per cent plus $2^1/_2$ cents per pound. These specific duties of 5 cents in the case of dyes and certain other finished products, and $2^1/_2$ cents in the case of intermediates, were called special duties. The law further provides that these special duties shall remain in force only 5 years, and that they shall thereafter be gradually reduced by one-fifth annually. The law, however, contains another provision, which reads as follows:

" * * * * But if, at the expiration of five years from the date of passage of this Act, the President finds that there is not being manufactured or produced within the United States as much as sixty per centum in value of the domestic consumption of the articles mentioned in Groups II and III (intermediates and finished products) of section five hundred, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected."

The President of the United States has requested the Tariff Commission to ascertain the facts on which executive action under this clause must be based. It has seemed wise not to wait for the expiration of the five-year period before beginning a systematic study of the development and progress of this industry in the United States.

The schedule which has recently been sent to all manufacturers known to us is designed to ascertain the facts needed for

the application of the 60 per cent clause, as well as to secure certain other information which will be helpful to the Commission and Congress in determining the wisest future policy. The Commission is taking a census of the coal-tar products for the year 1917, asking for the quantity and value of the production of each intermediate, dye, or other finished product.

It is, of course, well known in a general way to those familiar with the dye industry that the development of indigo, alizarin, and the vat dyes derived from anthraquinone and carbazol has not kept pace with the development of the azo dyes. Since these branches of the industry are the very ones which under the present law do not get the benefit of the special duty of 5 cents, it is of great importance that the Commission have for the consideration of Congress definite statistical information in regard to the development of the different branches of the industry. For this and other reasons we are asking for detailed information in regard to the production of each separate dye, not simply for grand totals. We hope to publish the totals in as great detail as can be done without revealing the operations of individual concerns. For example, in the cases of aniline and Bismarck Brown there will be so many producers that the total production for the country can be published without revealing the operations of any individual concern. It is believed that this information will be of interest and value not only to Congress but to the producers themselves. In many other cases the publication of the total would reveal the operations of individual concerns. In all such cases the dye or intermediate in question will be grouped with others of a similar character so as to cover effectually the details. In the case of dyes sold under a trade name, whose chemical nature is kept as a trade secret, we are asking that you give us confidentially sufficient information in broad, general terms, to enable us to classify properly each such dye. It is especially important that we be able to distinguish clearly between dyes dutiable at 30 per cent plus 5 cents per pound and those dutiable at 30 per cent only.

You will notice that under the present law it is necessary to ascertain both production and consumption of dyes in the United States. It would be impossible to secure complete returns from consumers themselves. It therefore becomes necessary to regard the consumption in the United States as equivalent to the sales of American manufacturers plus imports minus exports. Although the law requires a comparison of the value of the domestic consumption and production, we are asking for the quantity as a check on the values and also because the quantity is for many purposes a better indication of the growth of the industry than the value.

One of the difficulties which we foresee is the lack of a generally accepted standard of quality and strength of dyes. If, as a result of the deliberations of this association, a generally recognized standard is adopted, the future work of the Commission will be greatly facilitated.

We recognize that it will not be easy to bring together the information called for on the schedule, but rely with confidence on the coöperation of the industry toward enabling the Commission and Congress to deal intelligently with an important public question. Although we have sought and secured the helpful coöperation of a number of representative manufacturers, both large and small, in the preparation of this schedule, we realize that it is capable of improvement. We ask you to do the best you can to supply the information in the form called for this year. We shall welcome constructive criticism which will help us to prepare a better schedule for later use. In making suggestions a clear distinction should be drawn between changes which can be made under the present law and changes which would require an amendment to the law.

The work which the Commission is doing on the special law of September 8, 1916, is not confined to the questionnaire just described. We are also considering very carefully the possibility of improving the law by amendments.

For example, the new act does not repeal all of the provisions of the old law which are in conflict with the intent of the new law. The list of intermediates mentioned by name is capable of much improvement. Such important intermediates as Michler's ketone and dinitrophenol are not mentioned, whereas the relatively much less important nitrotoluylenediamine and monochlorphthalic acid are included. Very little attention appears to have been paid to intermediates for medicinals or photographic chemicals or flavors. Many suggestions have been made to the Commission in regard to changes in the wording of the law. We have prepared a list of such of these suggestions as seem worthy of serious consideration. We shall send a copy of this list to anyone who cares to offer evidence or opinion in regard to the advisability of the proposed changes and we shall welcome any additional suggestions.

The Commission will be glad to arrange for a conference with representatives of the dye industry in the near future. If such a conference appears to be desirable, the Commission will be glad to confer with the officers of this Association, or with any special committee appointed for the purpose of making all necessary plans and arrangements.

. . . . . .

An interesting discussion of various phases of the tariff question followed, and it was agreed that all manufacturers would endeavor to supply the Commission as promptly as possible with the data requested for the preparation of its report to Congress.

The committee on organization reported, recommending that it be continued with power until the first annual meeting, in order that the details of membership, incorporation, committees, etc., might be carefully considered. The powers asked by the committee were as follows:

I—To prepare and file a certificate of incorporation.
II—To prepare by-laws for submission at the annual meeting.
III—To arrange the time and place of the annual meeting.
IV—To entertain and pass upon application for membership.
V—To confer with the Tariff Commission and report at the annual meeting.

The recommendations of the committee were all adopted, and the convention adjourned to meet on March 6, 10 A.M., at the Chemists' Club.

AMERICAN DRUG MANUFACTURERS ASSOCIATION

The seventh annual meeting of the American Drug Manufacturers Association was held at the Waldorf-Astoria, New York City, January 29–30, 1918. The meeting was well attended and was thoroughly representative of the American industries engaged in the manufacture of drugs, medicinal chemicals, biological products, plasters, and surgical dressings. The membership of the Association embraces practically all of the producers of the above supplies of the entire country. These producers have been confronted with many problems, such as embargoes upon their crude materials and upon their shipments of finished products, as well as a shortage of coal resulting in many cases in the closing of factories. In common with other industries, they have stood up as best they could under these circumstances, while at the same time yielding their skilled help, chemists and others, to the ranks of the Army and Navy. How best to meet such conditions and at the same time produce better products in far greater quantities are questions which have been earnestly discussed among the members.

The Association feels that in view of the nature of the products produced embargoes should not apply to its industry and that priority order should be granted to them. It has been difficult in the past to bring this about and the Association has felt that the nature of its products was understood neither by the public at large nor by the transportation officials. One of the important steps suggested at the meeting, therefore, was a move-

ment in the direction of publicity. By this is meant proper publicity. The members of this Association produce what may be called the legitimate drugs and medicines actually used and prescribed by physicians and surgeons in their daily practice. They do not manufacture what are commonly known as "patent" medicines. Proper publicity would therefore naturally be of an educational nature, tending to inform the public and the officials as to the products produced and the method of using them.

The Association has established a committee known as the Committee on Standards and Deterioration, and made up of chemists from its membership. It is their object to study the standards that are now in use, hoping to improve them, and to study the deteriorations that occur, hoping to prevent them. This Committee may be expected to produce results, since it is made up of practical men and provided with ample funds, two quite unusual features for a committee of scientists.

The Association has a very active legislative committee and its work is of importance to the members, keeping them advised of the many laws that are being enacted, proclamations issued, regulations promulgated, new taxes imposed, etc. This committee is one of the strongest features of the entire Association, and its importance should not be overlooked.

The Association passed a resolution urgently requesting the Committee of Revision of the *U. S. Pharmacopoeia* to establish alternative standards for some drugs which, owing to the war, cannot be obtained of present U. S. P. quality.

The Association passed a resolution reaffirming its opposition to any patent legislation discriminating against medical, chemical or pharmaceutical discoveries.

Inasmuch as drug manufacturers of the country are making a united effort to cooperate with the Government in every possible manner, it was thought best to maintain the Association at its highest point of efficiency, and therefore all officers were re-elected.

CHEMISTS IN WAR SERVICE

GOVERNMENT RECOGNIZES THE IMPORTANCE OF CHEMISTRY IN THE WAR

Adequate chemical control of manufacturing plants engaged in the supply of war material is now receiving the careful consideration of the War Department. The experience of both Great Britain and France teaches the necessity of conserving the supply of trained chemists, at no time large, in order that the supplies upon which the winning of the war so largely depends may not be curtailed.

Provision has now been made through an order of the Adjutant General of the Army by which manufacturers of material necessary to the prosecution of the war, who have lost the services of chemists through the first draft, may again obtain the services of these men for war work.

It is announced, also, that provision has been made by which manufacturers threatened with the loss of their trained chemists in the present draft may retain these men. Only those chemists whose services are necessary to war work will be considered and the evidence submitted by the manufacturer must be conclusive.

Manufacturers thus affected should apply to the Chemical Service Section, N. A., New Interior Building, Washington, D. C., for the regulations governing the transfer of men already drafted, or the possible reclassification of men not yet called.

This request must come from the manufacturers; applications from the men will not be considered.

* * *

The following communication with accompanying questionnaires will make clear to the manufacturers the procedure to be observed in requesting transfer of men already drafted or reclassification of men not yet called:

OFFICE OF THE CHIEF OF THE CHEMICAL SERVICE SECTION
1108 NEW INTERIOR BUILDING
WASHINGTON, D. C.

By an order of the Secretary of War the Adjutant General of the Army has authorized the Chief of the Chemical Service Section of the National Army to initiate such measures as are necessary to secure deferred classification for chemists whose services are essential to war industries. Under the Selective Service Regulations such action is limited to a letter of advice to the Local and District Exemption Boards transmitted through the Adjutant General's Office, substantially as follows:

"The Chemical Service Section of the War Department has investigated the status of your company in connection with the production of war material and considers it important that the efficiency of your organization be maintained. In this connection the services of ..... as a technical expert in ..... have been investigated and it is believed that his continued employment in war industries would be to the best interests of the Government. You are therefore advised to apply to the local exemption board for deferred classification in his case on the ground that he is a necessary highly specialized technical expert of a necessary industrial enterprise. Such action, of course, should be taken only with Mr. ..... consent. If he prefers to enter the military service please advise this office of that fact in order that his services may be utilized where most needed."

Under the same order of the Secretary of War the Chief of the Chemical Service Section will initiate action for the return to civil industries of any expert chemist whose service in the industry from which he was taken is of more importance to the Government than are his services in a military capacity. Except in the cases of members of the Reserve Corps, the action taken will consist of a recommendation to the Adjutant General of the Army that the man concerned be discharged from the National Army, National Guard or Regular Army, as the case may be, re-enlisted or re-commissioned in the proper branch of the Reserve Corps and placed upon the inactive list. In the cases of members of the Reserve Corps, the action will consist of a recommendation that the man concerned be placed upon the inactive list.

In order that this office may act intelligently, you are asked to fill out the questionnaire herewith enclosed.

CHEMICAL SERVICE SECTION, N. A.

FORM B

(Please use typewriter in filling in this blank.)

Name of Manufacturer. . . . . .
Address. . . . . .
Full name of Chemist . . . . . (Age . . . . .
Address. . . . . .
A: (To be filled in by manufacturer, *not by chemist*.)
Information regarding chemist.
1. Is he willing to receive deferred classification? Yes
No
2. Serial No. . . . . Liability No. . . . . .
Questionnaire Classification Class . . . Paragraph . . . Date . . . .
Title and address of Local Board . . . . . .
. . . . . .
Has appeal for reclassification been made? Yes
No
Date of appeal . . . Result . . . . . .
3. Length of time chemist has been with your Company . . . . . .
4 Proportion of total hours of the services of the chemist now spent on production* of war materials . . . . . .
5. Education above grade of high school . . . . . .
. . . . . .
6 Experience
Company . . . . . Duration of employment
. . . . . .
. . . . . .

7. Nature of materials in the production* of which said chemist is engaged:
.....
8. Relation of above materials to the war:
.....
9. Statement of the importance of the chemist to the above war work by the officer in charge of the department:
.....
Date..... Signed by.....

NOTE—This is to be addressed to Chief of Chemical Service Section, N. A., New Department of Interior Building, Washington, D. C.

FORM C

(Please use typewriter in filling in this blank)

Name of Manufacturer.....
Address .....
Full name of Soldier.....(Age).....
Camp address.....
A: (To be filled in by manufacturer, *not by soldier*)
Information regarding soldier:
1. Is the soldier in the Regular Army, National Army or Reserve Corps?
2. If the soldier is in the Regular Army or National Army does he desire a discharge with re-enlistment in the Reserve Corps (inactive list) in order to re-enter your employ?.....
3. If the soldier is in the Reserve Corps does he desire to be placed upon the inactive list in order to re-enter your employ?.....
4. Length of time soldier was with your company.....
5. Proportion of total hours of the services of the soldier would be spent on production* of war materials.....
6. Education (above grade of high school)
.....
.....
7. Experience:

Company	Duration of employment
.....	.....
.....	.....

8. Nature of materials in the production* of which said soldier will be engaged:
.....
9. Relation of above materials to the war:
.....
10. Statement of the importance of the soldier to the above war work by the officer in charge of the department:
.....
Date..... Signed.....

NOTE—This is to be addressed to Chief of Chemical Service Section, N. A., New Department of Interior Building, Washington, D. C.

.....

AMERICAN CHEMICAL SOCIETY

WASHINGTON, D. C.

So many hundreds of letters are being received from firms and individuals that it is necessary to print the following, which covers most inquiries.

DEFERRED CLASSIFICATION

Individuals can obtain deferred classification only through the Local Boards or by appeal to the District Boards.

Manufacturers engaged in the production of materials necessary for the war may apply by letter to the Chemical Service Section, National Army, Room 1108, Interior Building, Washington, D. C., for the return to them of necessary trained chemists now in the army and not already transferred to Chemical Service. They may also apply through the Chemical Service Section for deferred classification of trained chemists necessary to the control of their operations who are not yet called. Applications from the men themselves will not be considered. Only those chemists whose services are necessary to war work will be considered. The evidence submitted by the manufacturers must be conclusive.

STUDENTS IN CHEMICAL COURSES

Students taking a regular chemical course may be enlisted in the Engineers Reserve Corps and placed on the inactive list in order to complete their college course. The dean or president of the institution must certify, however, that their standing is such as to warrant the conclusion that they will graduate with a record equal to the first third of the graduates of the previous ten years. This does not apply to students in biological and physiological chemistry as the Chief of Engineers has ruled that such come under the Surgeon General's Office, rather than under the Engineering Department. Students wishing to take advantage of this opportunity to receive their degrees before entering the country's service, should address the Chief of Engineers, War Department, Washington, D. C., asking for the necessary blanks to be filled out for this purpose.

TRANSFERS TO CHEMICAL SERVICE

Transfers to Chemical Service are made by the War Department on request from some division of the army for the particular chemist needed. After the approval of the commanding officer and the Chemical Service Section, the man is transferred. *Remember that the Secretary has no power to transfer you to chemical service. He simply brings your name and qualifications before those who have.*

No one can predict how great this requirement for chemists will be. At present, although nearly a thousand chemists are serving in a chemical capacity, some 300 men, properly classified as chemists, remain in the camps. Accordingly, if you enlist as a chemist before you are called, you will deprive another chemist actually in the army of his opportunity to render chemical service. The industries which supply the army and navy with the sinews of war need chemists and are being seriously handicapped by the depletion of their chemical personnel. Cards giving age, training, experience, etc. (obtained from questionnaires filed with the Bureau of Mines), of all men with chemical training known to be in the army, are kept in the office of the Society. These cards are constantly consulted by those in command needing chemical assistance. Men are chosen not to give the individual an opportunity to serve in a chemical capacity, but to find the man especially qualified for the work in hand. Accordingly, you may or may not be selected. Men with plant experience, research, physical and organic chemists, some analytical chemists, etc., have been in demand. On the other hand, there has been almost no chance to place pharmaceutical chemists, agricultural or food chemists, as the army apparently has little need for this form of chemical service and the Government itself is not manufacturing in these lines.

GOVERNMENT POSITIONS OTHER THAN IN THE ARMY OR NAVY

Chemical positions in the Government service other than those by enlistment in the army and navy are obtainable only through the Civil Service Commission. They do not necessarily exempt the encumbent from military service.

COMMISSIONS

Commissions seek the man. A number of chemists have been commissioned, but in almost every instance it has been by promotion from the ranks for recognized ability, or the particular man has been sought to fill a special place of responsibility or trust for which he was known to be especially fitted. The place was not made for the man, but the man was found for the place, sometimes after long search. A commission carries authority with it and is not lightly awarded whether in the engineering, medical or chemical branches of the service.

IMPORTANT TO ALL CHEMISTS OF DRAFT AGE

Information regarding individuals is obtained from the questionnaire on file in the Bureau of Mines, Washington, D. C. If you have not filled out one of these questionnaires, write to the Bureau of Mines, asking that one be sent you for this purpose.

* Under production is to be included research, development and control work necessary to manufacturing operation.

When once in the army keep me informed by post-card of your military address *and any change in that address*, even should you be sent to France. Although you may not be chosen early among those needed for chemical service, the demand for chemists is constantly increasing, and your country may call you at any time where you are best trained to serve.

It is my duty to *help* place you where you can serve our country best *as the need arises*. It is your duty to keep me informed of your address and to accept any service to which the War Department may assign you, even though you may prefer to fight in the ranks in France.

FEBRUARY 15, 1918 CHARLES L. PARSONS, *Secretary*

NOTES AND CORRESPONDENCE

SPRING MEETING OF THE AMERICAN CHEMICAL SOCIETY

After consultation with the Advisory Committee and other members of the AMERICAN CHEMICAL SOCIETY, the Directors have voted to omit the Spring Meeting of the Society, which was to have been held in St. Louis this coming April. It is felt that the transportation conditions are such that unnecessary travel should be avoided, and also that the chemists of the country are so busily engaged in meeting war needs that their work should not be interrupted for the purpose of conference at this time.

The Annual Meeting of the Society will be held in Cleveland, Ohio, in September.

WASHINGTON, D. C. CHARLES L. PARSONS, *Secretary*
January 29, 1918

WAR RISK INSURANCE FOR CHEMISTS IN MILITARY SERVICE

All chemists in the military service are urged to take out war risk insurance, even if they are assigned to chemical service or are later released from the army for service in the war industries. This is a form of insurance arranged by the War Department at a very nominal rate, which gives adequate protection against death or injury.

RAMSAY MEMORIAL FUND

After the death of Sir William Ramsay in July 1916, a memorial meeting was held in London to commemorate his thirty-five years of service in physical and chemical sciences, education, and public welfare. The gathering of distinguished men, under the chairmanship of Lord Rayleigh, decided

1—To raise a substantial fund as a memorial to Sir William; and
2—To use such fund for the establishment of
(*a*) Ramsay Research Fellowships, tenable wherever necessary facilities might be available, and
(*b*) Ramsay Memorial Laboratory of Engineering Chemistry at the University of London, where Sir William served twenty-six of his most fruitful years of activity.

A committee of prominent men in the physical and chemical sciences in Great Britain, including the leaders of the Coalition Government and Ambassadors then accredited to the Court of St. James, was later organized. Through this general organization, committees were organized in Australia, Canada, Chile, Denmark, Holland, India, Italy, Japan, New Zealand, Spain, Switzerland, and the United States. Correspondence with men of science indicates the formation of national committees also in China, France, and Sweden, and perhaps Russia.

The sum set out to be raised was £100,000. To date something over £300 have already been contributed by residents of the United States.

The merits of the objects of this fund are obvious. The recognition of a man who made so many valuable contributions to our knowledge and who won so many friends through his wonderful friendly sympathy and erudition appeals especially to American men and women.

The Committee expects some generous contributions and will welcome the receipt of other large gifts, but it hopes eepecially to have a great number of small subscribers. The receipt of checks, postal orders, or cash, for one dollar or over, sent to the Ramsay Memorial Fund Association, 50 East 41st St., New York City, will be promptly acknowledged.

UNITED STATES COMMITTEE FOR THE RAMSAY MEMORIAL FUND

Walter Hines Page, *Vice President*	Wm. D. Coolidge	Richard B. Moore
Charles Baskerville, *Chairman*	John H. Finley	Wm. H. Nichols
Wm. J. Matheson, *Treasurer*	Edward C. Franklin	William A. Noyes
Leo H. Baekeland	Frank Hemingway	Henry F. Osborne
Wilder D. Bancroft	Chas. H. Herty	Charles L. Parsons
Marston T. Bogert	Charles James	Ira Remsen
Chas. F. Chandler	George F. Kunz	Theodore W. Richards
Francis W. Clarke	F. Austin Lidbury	Edgar F. Smith
	Arthur D. Little	E. G. Spilsbury
	C. E. K. Mees	Julius Stieglitz
	R. A. Millikan	Milton C. Whitaker

Editor of the Journal of Industrial and Engineering Chemistry:

I am deeply interested in the appeal made by the Committee on the Ramsay Memorial which is to appear in this issue of your journal. Knowing Sir William as well as I did, I cannot imagine a more graceful compliment than that every member of the chemical fraternity should have some part in this work. It would afford me great pleasure if every member of the AMERICAN CHEMICAL SOCIETY should promptly remit something to the fund, realizing that the matter of taking part in it is of more consequence than the amount of the subscription.

NEW YORK CITY WILLIAM H. NICHOLS
February 15, 1918 *President*, American Chemical Society

CHEMICAL RESEARCH IN THE VARIOUS COUNTRIES BEFORE THE WAR AND IN 1917

Dr. Bernhard C. Hesse recently suggested to me that he and probably others would be interested in information regarding the effect of the war on the relative chemical activities of the various nations. I am able to supply information on this subject only in so far as this activity is reflected in the publication of papers and is measured by the number of abstracts published in *Chemical Abstracts*. In peace times such figures would be a fair gauge of chemical research throughout the world; at the present time they are, of course, affected by the fact that much chemical work in the warring nations is kept secret and also by the fact that *Chemical Abstracts* is having great difficulty in getting abstracts of the papers published in Germany and Austria. Nevertheless the figures in the accompanying table are not without considerable meaning. With the exception of the Japanese, German and Austrian literature the field of chemistry was covered thoroughly by *Chemical Abstracts* both in 1913 and in 1917; the Japanese journals were only partly abstracted in 1913 and the German and Austrian literature was covered with only a fair degree of thoroughness in 1917. Inability to get the German and Austrian journals is the reason for the incompleteness in 1917. I believe that the figures in the table give a fair representation to Germany and Austria, however, because the 1917 volume of *Chemical Abstracts* contains in addition to abstracts of most of the current papers (obtained from British, Dutch, Spanish and Swiss journals with abstract sections), a considerable number of abstracts of papers published in 1916, due to the fact that a

large shipment of 1916 German and Austrian journals was received early in 1917.

The table speaks for itself.[1]

Countries	Number of Abstracts in 1913	Number of Abstracts in 1917	Per cent of Total in 1913	Per cent of Total in 1917
United States	3940	4602	21.1	43.9
Great Britain	2741	1560	14.7	14.9
France	2481	794	13.3	7.6
Germany	6539	2065	34.9	19.7
Austria	539	112	2.9	1.1
Italy	905	305	4.9	2.9
Russia	474	264	2.5	2.5
Holland	328	276	1.8	2.6
Norway	15	19	0.08	0.18
Switzerland	226	114	1.21	1.08
Belgium	185	7	0.99	0.06
Sweden	110	64	0.58	0.62
Japan	71	166	0.38	1.58
Spain	34	26	0.18	0.24
Denmark	41	20	0.21	0.19
Other countries	52	89	0.27	0.84(a)
Total	18,681	10,483		

(a) The increase here is due chiefly to the fact that *Chemical Abstracts* is now covering certain South American journals not abstracted in 1913.

Three points of special interest are: (1) The United States and Germany have exchanged places, Germany having been first by a big lead in 1913 and the United States second, and vice versa in 1917; it is to be noted that the lead of the United States in 1917 was greater than the lead of Germany in 1913. (2) Great Britain has maintained her relative position with almost no variation. (3) The number of papers published in the neutral European countries has fallen off considerably.

It will be interesting to see to what extent the various countries will return to their ante bellum positions when the war is over. The effect which the entrance of our country into the war will have on publication here will also be of interest. No marked change was to be noted in 1917; in 1918 I look for further expansion of industrial journals and for contraction of journals devoted to pure science.

Columbus, Ohio
January 31, 1918

E. J. Crane

LICENSES REQUIRED FOR EXPLOSIVES AND THEIR INGREDIENTS

Editor of the Journal of Industrial and Engineering Chemistry:

An Act of Congress (Public Document No. 68, Sixty-fifth Congress) to prohibit the manufacture, distribution, storage, use and possession in time of war of explosives, and the ingredients thereof, provides that a license from the Bureau of Mines is necessary for every person, firm and corporation, to purchase, possess, sell or use any explosive or the ingredients thereof.

Any violation of this Act is punishable by a fine of not more than $5000, or by imprisonment of not more than one year, or both fine and imprisonment.

Selling to a person who has not a license is punishable by a fine of $1000.

The Bureau of Mines has published the following list of articles requiring licenses under this Act.

As the readers of your journal are undoubtedly interested in this subject, I am taking the liberty of calling it to your attention for such publicity as you are able to give it.

In most places the county clerk has been designated as the licensing agent. In Greater New York licenses may be obtained from John R. Healy, Room 1100, Municipal Building, Manhattan, or John F. Dixon, 365 Jay Street, Brooklyn. Application must be made in person. Duly authorized officers of corporations or companies must make application for the company or corporation.

The following commodities are those for which licenses are required:

EXPLOSIVES

Ammonium nitrate
Blasting powder
Caps—blasting, detonating, percussion—all classes
Detonating fuse, or cordeau detonant
Detonators
Dynamites
Electric blasting caps and electric detonators
Fireworks and flashlight powders
Fulminates
Fuse of all varieties
Guncotton
Gunpowder and gunpowder mixtures (except small arm or shot gun cartridges)
Nitrocellulose and nitroglucose
Nitroglycerine (except in official U. S. Pharmacopoeia solution or in form of pills or granules containing not more than 1/100 grain each)
Nitro-glycol, -mannite, -starch, and -sugar
Permissible explosives
Ammonium picrate
Picrates
Picric acid
Smokeless powder (except small arms and shot gun cartridges)
Trinitrotoluol
Trinitrocresol
Trinitronaphthaline
Tetranitroaniline
Tetranitromethylaniline

INGREDIENTS

(List approved January 5, 1918)

The purchase, possession, sale or use of any one of the ingredients herewith listed below in amounts of *one ounce or over* requires a Federal Explosives License.

Bichromates—ammonium, potassium, sodium
Chlorates—barium, potassium, sodium, strontium
Chromates—ammonium, barium, calcium, chrome green, chrome yellow, lead, potassium, sodium
Nitrates—ammonium, barium, copper, ferric, lead, magnesium, nickel, potassium, silver, strontium
Nitric acid—aqua fortis, fuming, nitric acids of all grades and strengths, mixed acids
Perchlorates—perchloric acid, potassium
Perborates—magnesium, sodium, zinc
Permanganates—calcium, potassium, sodium
Peroxides—barium, calcium, magnesium, oxon (cubes and cartridges), sodium, strontium, zinc
Phosphorus

New York City
January 15, 1918

J. R. Healy
Federal Licensing Agent

THE INDEXES TO CHEMICAL ABSTRACTS

The comparative lateness of the appearance of the 1917 Index to *Chemical Abstracts* is such a keen disappointment to the Editor that he would like the privilege of stating to the members of the American Chemical Society that this is not due to a change of policy. The subject index is considered to be the most important part of the journal and more work is being put on it than ever before, but the work is still planned so that normally the index will appear at least as soon as the early part of January. In the case of the 1917 index a combination of unfortunate circumstances, among which are the fuel famine (it struck us in December during the most crucial week) and the traffic congestion (one package of copy was over two weeks in traveling between the printer's office and ours), caused most of the delay. Getting the annual index into the hands of the members by the first of the year, as has been done during the past few years, is a very strenuous task, but one in which we have come to take special pride.

A word regarding the *Decennial Index* is due the members also. Inquiries which are received show that many are anxious for the completion of this index. The task, with all the precautions that are necessary for accuracy, completeness, consistency, and convenience in use, has proved to be a much more time-consuming one than was ever anticipated. We just want to say that the work is being pushed as rapidly as circumstances involved in the nature of indexing, especially subject indexing, our regular work of issuing the journal and the annual indexes, and the policy of not sacrificing quality for speed will permit. One of the things in a subject index most important to be avoided is the scattering of like entries; the proper coördination can be accomplished only in case a limited number of experienced workers handle parts of the task. As a matter of fact, it proved to be desirable for the associate editor and editor, working together, to examine every one of the hundreds of thousands of

[1] Abstracts of papers that could not be certainly associated with a particular country, as, for example, some of the *Communications of the Eighth International Congress of Applied Chemistry*, were not counted.

entries (the organic names excepted) with the abstracts before them and all are being gone over again for such revisions as can be made, only after all the entries have been assembled under the various subject headings. It takes many weeks just to handle the cards. We have indexed subjects, not merely words, and abstracts, not merely titles: the difference is very great.

The second volume of authors, which has been in course of printing since last September, will appear soon. As an example of a source of delay in the case of this part of the index, attention is called to the fact that many times it has been necessary to write letters to authors or to abstractors to whom the original papers are available in order to straighten out discrepancies in the spelling of authors names.

COLUMBUS, OHIO
January 31, 1918

E. J. CRANE

THE UTILIZATION OF NITER CAKE

Under ordinary conditions the disposal of niter cake is a troublesome problem. The best practice has been to add small amounts to the charge of salt and sulfuric acid for making muriatic acid.

Sometimes this addition is in solid form and sometimes the niter cake is stored in a cast-iron tank as it is discharged from the nitric acid retorts and is run into the muriatic pots as wanted.

Before 1914, so far as I can learn, niter cake alone was very seldom used for muriatic acid manufacture. Since that time it has often been impossible to secure a sufficient supply of sulfuric acid and considerable amounts have been and are being made in this way. On the whole, notwithstanding the fact that heat economy is secured by the use of the material direct from the retorts, I am inclined to think the use of cold niter cake the best practice. I have made several thousand tons from this material in this way without serious difficulty.

A patent owned by the General Chemical Company provides for grinding and mixing the materials, but this is quite unnecessary, expensive and, in damp weather, troublesome.

Muriatic acid made from niter cake always contains more sulfuric acid and unless carefully watched, this may run up to 1 or even 2 per cent. If the workmen about nitric acid plants were careful, the cake need not contain more than 27 per cent free acid, but they are not, and large experience has shown that about 32 per cent is better practice. For the same reason, cake should be free from nitric acid and iodine, but practically all muriatic acid made from cake contains both. While most niter cake is free from all but a trace of these undesirables, every little while a clock watcher will dump his fire before iodine shows in the condensing tubes and the resulting cake will be bad. For these reasons I am convinced that where practicable it is desirable to keep the muriatic made from niter cake entirely separate from that made from salt and sulfuric.

This method of working up niter cake is insufficient to take care of the product even in time of peace. In war time what to do with niter cake becomes a serious problem. Near the coast it is dumped in the rivers without any unnecessary display. I believe that not less than 50,000 tons monthly are now thus disposed of near New York. In inland locations the fish wardens are apt to get wise and raise a row.

The du Ponts have succeeded in finding a large number of new uses for niter cake and have organized an agency for disposing of it which has been very successful, notwithstanding which they could probably find a supply for new customers.

It is thus evident that the time is ripe for a process for organizing the disposal of this material in a separate department of the plant where it may be resolved into salt cake or Glauber's salt and free acid and utilized.

It may be objected that salt cake is not a readily marketable product and to some extent this may be true, but the market for this product has greatly enlarged during the last decade and is steadily improving.

My proposal (Application No. 170,607 for U. S. Patent, granted but not yet issued) is to dissolve the cake in water to a solution having a specific gravity of 1.35 and to blow cold air through the solution in proper receptacles well insulated to prevent inflow of heat. The sodium sulfate separates as Glauber's salt in small crystals which are dumped into a centrifugal and washed with a Glauber's salt solution. A very pure salt cake containing less than one-fourth of one per cent free acid may be readily obtained, and a mother liquor containing only a small amount of sodium bisulfate with much free sulfuric acid. This is evaporated, either in a glass apparatus, which I have recently invented, or in Duriron pans, and the resulting mixture used in place of a part of the sulfuric acid in nitric acid making.

For this work ordinary ice apparatus will be found unsuitable. Too much time is required to withdraw the heat, and the crystals are large and enclose mother liquor. I find that although the use of cold air is theoretically less efficient, it is better suited to this purpose. The agitating action is also essential in securing a rapid separation since this solution, like water and all watery solutions, is a poor conductor of heat.

This method of separating crystals is in principle somewhat like the granulation of sugar, and in the massecuite produced the size of crystal may be regulated as in sugar-making. It is clear that this method may often be applied with advantage to other salts. There seems to be no reason why the majority of these salts may not just as well be prepared of regulated crystal size and with great improvement in purity.

LAFAYETTE COLLEGE
EASTON, PA.
January 9, 1918

EDWARD HART

READJUSTMENTS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY TO MEET WAR CONDITIONS

Within two months after the declaration of war by the United States, the Massachusetts Institute of Technology had arranged to allow its advanced classes to anticipate the work of the following year by taking special courses during the summer. A considerable number of juniors availed themselves of this opportunity and in consequence will be graduated early. The chemists, of whom there is a great need in war work, will be graduated in April. Seniors in other courses who were in good standing when they left to enter the service have been given their degrees.

The present junior class, through a readjustment of its program of studies, will drop out practically a term of senior work, will study throughout the summer, and, if they enter the service, will receive their degrees in October. Thus they will be ready for service eight months earlier than they would be normally.

Then, too, the Institute is to admit on February 4th, at the beginning of the second term, a special class of freshmen who will be admitted without entrance examinations, the certificate of the master of the preparatory school that they are mature enough for the work of the Institute being considered sufficient. The response which is being made to this offer of the Institute fully justifies this setting aside of tradition as to time and conditions of entrance. It is expected that this new class will be composed of unusually fine students eager to begin their higher education without delay, in order to be ready as soon as possible to do their part in meeting the growing demand for technically trained men.

DIRECTIONS FOR ASSISTANT EDITORS AND ABSTRACTORS

The Editor of *Chemical Abstracts* has recently published a revised edition of the pamphlet entitled "Directions for Assistant Editors and Abstractors," which gives in a concise form rules on the preparation of abstracts, forms, spellings, nomenclature, etc., which have been adopted in the publications of the AMERICAN CHEMICAL SOCIETY, and have come to be

regarded as representing the usage approved by the Society. The material has been prepared with a great deal of care, and after consultation with those who are interested in the cause of good chemical nomenclature in this country. The rules agree very closely with what is considered the best usage in Great Britain. Copies of the Directions can be obtained by addressing *Chemical Abstracts*, Ohio State University, Columbus, Ohio.

ESTIMATION OF PHENOL IN THE PRESENCE OF THE THREE CRESOLS—CORRECTION

In the article printed under the above title [THIS JOURNAL, 10 (1918), 9] the following corrections should be made:

Page 11, right-hand column, 4th line from the bottom should read: "2.73° C.," in place of "2.75° C."

Page 12, left-hand column, 6th to 10th lines from the top read: "Per cent phenol $= \frac{1.00}{2.73}(T_o - T_{so}) - \frac{1.00}{0.0003367}(G_o - G_{so})$ or, Per cent phenol $= 0.366\ (T_o - T_{so}) - 2970(G_o - G_{so})$ (I) in the case of *o*-cresol + *p*-cresol + phenol mixtures; and, Per cent phenol $= 0.585\ (T_o - T_{so}) - 2780\ (G_o - G_{so})$ (II) in the case of *o*-cresol + *m*-cresol + phenol mixtures" in place of "Per cent phenol $= \frac{1.00}{2.73}(T_o - T_{so}) - \frac{1.00}{0.0003367}(G_o - G_{so})$ (I) or, Per cent phenol $= 0.366\ (T_o - T_{so})$ Per cent phenol $= 0.585\ (T_o - T_{so}) - 2780\ (G_o - G_{so})$ (II)."

Page 17, right-hand column, 5th line from the bottom should read: "3 to 4° C.," in place of "3 to 40° C."

Page 18, right-hand column, 25th line from the top should read: "201° C. (corr.)" in place of "197° C."

G. W. KNIGHT, C. T. LINCOLN, *et al.*

ELECTRIC FURNACE SMELTING OF PHOSPHATE ROCK, ETC.—CORRECTION

The following corrections should be made in the article printed under the above head in THIS JOURNAL, 10 (1918), 35.

Page 37, 2nd col., 11th line from bottom should read: "7800 tons phosphate rock @ $4.50 per ton....$35,100.00."

Page 37, 2nd col., 7th line from bottom should read: "8 laborers @ $2.00 per day (330 day year)....$5,280.00."

Page 37, 2nd col., 3rd line from bottom should read: "Power @ $25.00 per H. P. Y.....$100,000.00."

J. M. CAROTHERS

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington D. C.

Embargoes, idle Mondays and transportation delays have added materially to the burden of those in Washington who are trying to be helpful in speeding up the production of chemicals and in assisting the government to secure its ever-increasing requirements of the so-called war chemical supplies. There has been no retardation, however, of the activities of the many prominent chemists and of those importantly connected with chemical industries, who are busily engaged in Washington. Research is being conducted and various projects carried into effect which, if they could be made public, would give ample basis for spectacular display in newspapers and doubtless would surprise the great majority of the country's chemists. For military reasons, however, the more important things which are being done by chemists in Washington must not be discussed. The care that is being taken to maintain secrecy in connection with some activities is indicated by the fact that the correspondent of THIS JOURNAL has been requested by a high official not to mention in this correspondence the names of certain prominent chemists who are being called into consultation here or who have been assigned to war work in Washington.

Following its first annual meeting in New York, February 6, The Chemical Alliance, Inc., has been able to get down to result-getting work, which was not possible to the same degree prior to a definition of all its policies and a systematic outline of its work.

Chemicals imported during the year just closed were valued at $144,235,400. This compares with $125,813,205 for the year 1916. During December 1917, the value of all imports of chemicals was $14,036,740. This is a decided increase over December of 1916, when the total value of all chemicals imported was $8,487,809.

All chemicals exported during 1917 were valued at $193,255,160. This is a substantial increase over 1916, when the aggregate value of all chemicals exported was $165,286,008. Exports of dyes and dyestuffs more than doubled. In 1917 the value was $16,107,361 as compared with $7,953,986 in 1916 and $2,510,650 in 1915. Sulfuric acid exports in 1917 fell slightly below those of the year preceding. The 1917 exports were 63,542,930 lbs. as compared with 66,463,501 lbs. in 1916. The total value of all acid exports in 1917 was $52,695,640 as compared with $45,015,464 in 1916. The principal increase in the chemicals exported to any single country was to the United Kingdom.

President Wilson has appointed, on recommendation of Secretary of the Treasury McAdoo, the following members of the Assay Commission: Representative Wm. A. Ashbrook, Johnstown, Ohio; Dr. W. F. Hillebrand, Bureau of Standards, Washinton; Dr. Marcus Benjamin, Washington; Will H. Rounds, Sioux Falls, South Dakota; Kenneth M. Simpson, San Francisco; Louis A. Fischer, Washington; Dr. Geo. F. Kunz, New York; John L. McNeill, Durango, Col.; W. P. Morris, New Hampshire; L. V. Bassett, Rock Mount, Salem, Ill.; Samuel Newhouse, Salt Lake City; Calvin Page, Portsmouth, N. C.; A. C. Weiss, Duluth; J. H. O'Neil, Boston; L. W. Nieman, Milwaukee; Martin H. Glynn, Albany; Roy W. Keehn, Chicago; S. B. Amidon, Wichita, Kan.; Robert P. Oldham, Seattle.

Arrangements have been made by the United States Geological Survey to secure weekly reports as to output from all by-product coke manufacturers in the country. From these reports, the Survey is compiling weekly a statement showing to what per cent of capacity plants are being operated. The reports also show the factors limiting production. The last report shows that the plants of the country were operated at 70.6 per cent of capacity. Failure to secure coal caused a loss of 23.8 per cent; repairs to plants, a loss of 2.8 per cent; car shortage and other causes, 2.8 per cent.

Published reports that ample ammonia will be available for ice making next summer forced from the Food Administration an admission that the ammonia shortage is acute and that it is likely to become necessary to commandeer it.

Volunteer chemists are addressing millers and bakers throughout the country on the technical phases of milling requirements and how best to utilize wheat substitutes in "Victory" bread and other war-time doughs. The work is under the direction of the United States Food Administration.

Cancellation of the car-load rate on hydrofluoric and hydrofluosilicic acids from Newell, Pa., to Columbus, Ohio, has been asked by the Baltimore and Ohio Railroad in an application to the Interstate Commerce Commission. The same carrier also has asked permission to increase car-load rates on sulfuric and muriatic acids from Moundsville, W. Va., to points in Maryland, Pennsylvania and West Virginia. Carriers handling imported nitrate of soda, iron pyrites, chrome and manganese ores have requested increased rates from the seaboard to various of the consuming centers.

Exceeding in importance any other circumstance affecting the fertilizer industry is the inability to secure transportation of phosphate rock. Shortage has become so acute that several sulfuric acid plants will be forced to close, owing to their inability to store acid which ordinarily is mixed immediately on manufacture with the phosphate. Even a more serious side to the phosphate rock situation is the fact that fertilizer shipments are being delayed. Since 5,000,000 tons, out of a total movement of 7,000,000 tons of fertilizers, must move before the end of March in order to be available for this year's use, the consequences of any delay at this time are certain to be far-reaching. After one

day's idleness on the part of fertilizer factories, the Fertilizer Committee of The Chemical Alliance was able to secure their exemption from the fuel order.

Difficulty is being experienced in the administration of the federal explosives act, due to a very general lack of knowledge as to just what the bill provides. Trade in ingredients is giving the most trouble.

The government has under consideration the erection of an acetic acid plant. While some sites in the United States are being considered in this connection, it is regarded as probable that arrangement will be made to secure the erection of a large addition to an existing plant in Canada. Shreveport, La., has been considered as a possible site for the plant. An unlimited amount of natural gas is available near that Louisiana city. If an entirely new plant is erected, it is estimated that its cost will be $6,000,000.

Garabed T. K. Giragossian is greatly in fear that infringers upon his plan to produce energy without expense are going to rob him of the fruits of his work. Mr. Giragossian wrote a lengthy letter to the Speaker of the House of Representatives preparing Congress, apparently, for a delay in placing his work before the Commission. An extract from the letter is as follows:

"I wish that the Government and the public as well should be the judicial tribunal to conclude as to the originality of my work prior to the verification of my claim as designed. Thus I expect that the scientific commission's finding will include the originality of the work under the instructions of the Government given beforehand. Then nobody can, at least morally, challenge and charge the commission with partiality, favoritism etc., in rendering their certificate and thus obscure my achievement.

"I cannot believe that the spirit of our Congress will tolerate or forgive that I should divulge the secret of my work to any person or commission so long as there exists a legal opportunity by which infringers can drag me into court in order to contest the originality of my work or so long as there may be the faintest possibility that my work may be the prey of patent sharks or that infringers may have a legal loophole to pounce upon me and to snatch the fruit of my lifelong struggle.

"I am at the disposal of our Government at any time. If I may be commanded to select the authorized commission I am willing to do so when I am notified and given legal unequivocal and tangible assurance that I will be recognized as the original discoverer of my work as prescribed above. It is inconceivable that our Congress will tolerate the delay of the advent of this work on account of the fantastic claims or palmistic phraseology of willful obstructors and impostors."

The bill concerning the Garabed discovery was agreed to in conference without difficulty and has been signed by the President.

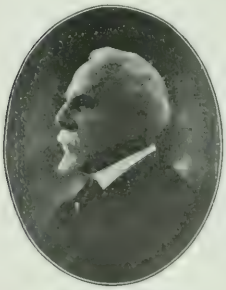
Representatives of the Bureau of Chemistry are holding meetings with mill, grain and elevator men throughout the country to demonstrate methods of preventing explosions of grain dust.

One of the hitches in the effort to reach an agreement with Norway regarding the commodities which were to be exported to meet the Norwegian requirements arose over calcium carbide, calcium nitrate, ferrosilicon and molybdenite. While Norway needs calcium carbide as an illuminant and calcium nitrate as a fertilizer, each of these chemicals would be of important use to Germany in the making of munitions. In the same way, Norway is in great need of ferrosilicon and molybdenum for its domestic use, but as these materials are of first importance in the manufacture of implements of war, the United States War Trade Board drew stringent conditions under which these and other products were to be furnished to Norway. The provisions were more drastic than Norway was prepared to accept.

OBITUARIES

CHARLES CASPARI, JR.

Charles Caspari, Jr., whose death took place last October, was born in Baltimore in 1850. His father, a former pupil of Wöhler, had for political reasons fled from Germany in 1848, but inspired in his son an intense longing for a German university career. This longing was never satisfied: when still quite young the boy was thrown upon his own resources, yet lived to prove once more that a distinguished career may result far less from the advantages, financial and educational, by which one may be surrounded in youth, than from such gifts, natural and acquired, as ambition, perseverance and a trained reason. In his effort to prepare himself for a scientific career, he used every available minute that could be spared from the monotonous work upon which his livelihood as a drug clerk depended: he studied in omnivorous fashion; he perfected himself in methods of analysis; he prepared everything that he was likely to be called upon to dispense; he got into communication with all who could assist him and answer his questions; and, in order to clarify and coördinate his knowledge, he wrote articles and even textbooks and treatises of formidable scope. He thus became a writer of clear, fluid English, accurate and concise. With intense pride in his profession, he would not tolerate for a moment anything that savored of slovenliness in technique. At nineteen he was graduated from the Maryland College of Pharmacy; ten years later he became Professor of Pharmacy in that institution and held this post until his death. When appointed Food and Drug Commissioner for Maryland, he began at once a course of constructive administration, the aim of which was not prosecution, but instruction and inspiration. Outside his own State, also, he soon attracted notice, and one by one responsibilities were placed upon him. For twenty-eight years he was a powerful influence in the American Pharmaceutical Association. His work upon the successive editions of the Pharmacopoeia, of the National Formulary of the National Dispensatory, was of great value.



CHARLES CASPARI, JR

Dr. Caspari was extraordinarily modest and unselfish; he was straightforward, truthful and unafraid. For anything that suggested display or insincerity, he had nothing but contempt. He feared no one, for he demanded of himself a higher standard of craftsmanship than he could expect from others. For honest failure he felt sympathy, and—a true friend—forgave many failings and enjoyed apparently above all else the pleasure of adding, as he had opportunity, to the happiness of those about him. He was one whom it was a privilege to have known, and a blessing to have known well.

WYATT W. RANDALL

JOSEPH PRICE REMINGTON

Dr. Joseph Price Remington, Dean of the Faculty in the Philadelphia College of Pharmacy and a member of the American Chemical Society of many years' standing, died at Philadelphia, January 1st, in his seventy-first year.

Prof. Remington was best known to the scientific world by the fact that since 1901 he has been the chairman and the vitalizing force of the Committee of Revision of the United States Pharmacopoeia. Under his energetic yet judicious control, this work, which sets the standards and gives the method of preparation of crude drugs and compounded medicines for the druggists and the physicians of the country, has achieved a position as the most accurate and complete of the Pharmacopoeias of the world. A comparison of the *U. S. Pharmacopoeia* with those of the most advanced European countries is

entirely in favor of our national work, and the pharmaceutical and medical journals of Europe have conceded this with practical unanimity.

The passage of the National Food and Drugs Act in 1906 gave additional force to this publication by making it the legal standard in all questions of purity and strength of such articles entering into the preparation of foods and medicines as came within its scope. The whole administration of the food and drug adulteration regulations of the Bureau of Chemistry at Washington and of the various state food commissions was therefore based upon the purity and strength standards of the *U. S. Pharmacopoeia*. The added responsibility thrown upon the Committee of Revision during the last decade in view of this important connection imposed new labors in conducting extensive correspondence and investigations, all of which Prof. Remington undertook with unflagging zeal. At a memorial meeting held in Philadelphia on January 4th, Dr. Wiley testified in strong terms to the constant support Prof. Remington had given at all times to the Government officials in their work of the enforcement of the Food and Drugs Act and the raising of the standards of these products so essential to the Nation's health.

Hardly less important to the profession of pharmacy and medicine was his connection with the U. S. Dispensatory, which is an encyclopedic commentary upon the drugs and medicines which are in current use or known to science, and is a recognized authority in the courts and in the U. S. Patent Office. Of this work he had been since 1880 the pharmaceutical editor and the responsible supervising head.

He also published in 1885 his "Practice of Pharmacy," a very complete textbook which has had a very large circulation and which has gone through a number of editions.

Prof. Remington was born March 26, 1847, in Philadelphia, the son of a well-known physician. After completing a high school education he entered a wholesale drug house where he spent four years, during which time he attended the Philadelphia College of Pharmacy, graduating in 1866. He then spent three years under Dr. E. R. Squibb, of Brooklyn, N. Y., the founder of the present firm of E. R. Squibb & Sons, where he had exceptional opportunities for becoming a skilful chemical analyst and also learned manufacturing methods. Following this he spent three years in the chemical works of Powers & Weightman in Philadelphia. This was certainly laying a sound foundation for his subsequent career and explains the broad grasp he had in after-life of both chemical and pharmaceutical subjects.

In 1874 he succeeded Prof. Procter, whose assistant he had been for several years, as Professor of Theory and Practice of Pharmacy in the Philadelphia College of Pharmacy, a connection only to be severed by death after forty-four years of continuous service.



JOSEPH PRICE REMINGTON

He was a pleasing and popular lecturer and made many warm friends among the thousands who were his pupils during this long period of years.

Besides his active membership in the American Chemical Society and the English Chemical Society, the American Philosophical Society and the Academy of Natural Sciences of Philadelphia, and the Chemists' Club of New York, he had been elected to honorary membership in many pharmaceutical and medical societies in this country and abroad and had taken part as delegate in international pharmaceutical and medical congresses.

To those who had the privilege of intimate personal contact with Prof. Remington, the loss now experienced is a great one because of his cheerful disposition, his unfailing courtesy and kindly consideration for all who were brought into contact with him. To the writer it means the breaking of a close friendship extending through forty years. He is glad to be privileged to extend this inadequate tribute to his memory.

SAMUEL P. SADTLER

PERSONAL NOTES

Dr. Glenn V. Brown, professor of chemistry at Bucknell University, has been granted leave of absence and is now connected with the Jackson Laboratory of the du Pont Company.

Dr. W. L. Evans, a captain in the Ordnance Department, is organizing a large staff for research work and routine tests in the War Department.

Mr. Burton G. Wood, formerly of the Monsanto Chemical Works of St. Louis, is now chief chemist of the Intravenous Products Company of St. Louis, manufacturer of organic arsenic products.

Chancellor Samuel Avery, of the University of Nebraska, has been given leave of absence in order that he may go to Washington to accept the position of chemist with the National Council of Defense.

The United States Civil Service Commission announces open competitive examinations for metallurgical chemists, salaries $1600 to $2400 a year, and assistant metallurgical chemists at $1000 to $1600 a year, for men only. Applicants should apply at once for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C. On account of the urgent needs of the service, applications will be received until further notice.

Mr. Russell Hayworth, formerly with the Citizens Gas Company, of Indianapolis, is now with the Ordnance Department as engineer of tests, Curtiss Manufacturing Company, St. Louis, Mo.

Mr. E. Colonna de Giovellina, former instructor in chemistry at the Vancouver Academy, and who had been appointed research chemist of the Whalen Pulp and Paper Mills, Ltd., has been ordered to report to the First Depot Battalion of the Canadian Expeditionary Force.

Dr. J. I. D. Hinds, of Lebanon, Tennessee, has been appointed chemist of the geological survey of Tennessee. Dr. Hinds succeeded Dr. Paul C. Bowers, who has been called to Washington for government service.

Mr. A. G. Stillwell has accepted a commission as Captain in the Ordnance Reserve Corps and is now stationed in Washington, assigned to research work in the Toxic Gas Division. Before leaving New York Mr. Stillwell incorporated his business under the title, The Stillwell Laboratories, Inc. His former assistant, Mr. E. C. Moffett, is now manager and will carry on the work.

Prof. Chas. H. LaWall, of the Philadelphia Section, of the A. C. S., has been appointed Dean of the Philadelphia College of Pharmacy, succeeding the late Dr. Joseph P. Remington. He has also been nominated for the Chair of Theory and Practice of Pharmacy in the College.

Mr. G. W. Roark, assistant chemist in the Chemical Section of the Agricultural Experiment Station at Iowa State College, Ames, Iowa, has been appointed chief chemist of the Federal Chemical Company's plants and will have his offices at Louisville, Kentucky.

Dr. J. A. Wilkinson, formerly associate professor of chemistry at Iowa State College, Ames, Iowa, has been appointed Captain in the Design Section, Gun Division, and is now located at Washington, D. C.

Dr. Philip A. Shafer, of Washington University, has been called to the national service.

The Short Course in Ceramic Engineering at the University of Illinois closed its two weeks' program on Saturday, January 19th. The program of lectures was carried through as planned and those in attendance at the course expressed themselves as thoroughly satisfied with the results of their attendance. In addition to the lectures given by members of the University staff, the following lectures from outside contributed largely to making the Course a successful one: Mr. A. V. Bleininger, of the Pittsburgh Laboratory of the U. S. Bureau of Standards; Prof. C. B. Harrop, of the Department of Ceramic Engineering, at Ohio State University; and Mr. Dwight T. Farnham, Industrial Engineer, of St. Louis, Mo.

Mr. A. E. Blake, for several years research chemist at Mellon Institute, Pittsburgh, Pa., has been appointed sales engineer for the Surface Combustion Company of Long Island City, N. Y., and is in charge of the new office for the Pittsburgh district at 547 Union Arcade, Pittsburgh, Pa.

Dr. Frank Austin Gooch, professor of chemistry and director of the Kent Chemical Laboratory of Yale University, will retire at the end of the present year. Dr. Gooch will be succeeded by Prof. Bertram Borden Boltwood, since 1910 professor of radio-chemistry.

Mr. Albert Sauveur, professor of metallurgy and metallography of Harvard University, has been granted a leave of absence so that he may continue his research work for the French government.

Prof. Sterling Temple of the department of chemistry of the University of Minnesota has gone to Washington, where he is to engage in work in the Ordnance Department.

Prof. E. V. McCollum, head of the department of chemistry of the school of hygiene and public health of Johns Hopkins University, delivered the Packard lecture before the American Pediatric and Rush Societies of Philadelphia on February 12. The subject of the lecture is "Growth."

Prof. Charlotte Fitch Roberts, since 1894 head of the department of chemistry at Wellesley College, died on December 5, 1917, in her fifty-eighth year.

Dr. F. H. Thorp has been appointed lecturer in industrial chemistry at the Massachusetts Institute of Technology.

At a conference of cereal chemists and representatives of the U. S. Food Administration held in the Chemists' Building, New York City, on February 12, 1918, Dr. J. A. LeClerc, of the Bureau of Chemistry, Washington, D. C., gave a report of work which has been going on in the Bureau for the past five years on the use of wheat substitutes in breadmaking.

Mr. Robert J. Anderson, formerly chief chemist for the Cleveland Metal Products Company, is now engineer of tests of ordnance material, War Department, and is stationed at the Brier Hill Steel Company, Youngstown, Ohio.

Mr. R. S. Dean has been made acting head of the department of metallurgy at the University of Pittsburgh.

Dr. H. S. Adams is now superintendent of the New Brunswick laboratories of E. R. Squibb & Sons.

Mr. Harry Eastwood, formerly assistant engineering chemist, City of Chicago, is now with the Milton Manufacturing Company, Milton, Pa. He is also engineer of tests for the Ordnance Department.

Mr. Raymond E. Kirk, former instructor in chemistry at Iowa State College, Ames, Iowa, has been appointed chief inspector for the U. S. A. and is now with the Atlas Powder Company, Webb City, Missouri.

Dr. William H. Warren, formerly of Wheaton College, Norton, Mass., has been appointed Captain in the Quartermaster Reserve Corps and is now in Washington.

Dr. David Klein, State Food Analyst of Illinois, has received a Captain's commission in the Sanitary Corps of the United States Army.

Simmons College announces the appointment for the second half of the college year of Mrs. Kenneth L. Mark as instructor in chemistry.

Mr. Ellwood Hendrick, of New York City, has joined the staff of *Metallurgical and Engineering Chemistry* as consulting editor.

Dr. Gorham W. Harris has been appointed temporary head of the chemistry department of Simmons College.

Dr. L. F. Goodwin has been appointed professor of industrial chemistry and chemical engineering at Queen's University, Kingston, Canada. Dr. Goodwin served with the Second Battalion Canadians in France and Flanders. He was also employed as technical adviser to the British War Office for several months and then transferred to Ottawa where he served for a year in a similar capacity to Sir Sam Hughes, then Minister of Militia and Defense.

Dr. Katharine Blunt, of the Home Economics Department of Chicago University, has been granted a leave of absence for the winter quarter. She has been called to Washington by the Food Administration as one of the members of the committee of university instructors appointed to plan the introduction of conservation courses into universities and colleges.

The Manitoba Chemical Society was organized at Winnipeg on January 15 to provide facilities for the exchange of ideas and discussion of chemical subjects and to afford a medium for recommendations to the authorities in regard to chemical problems of national interest. The following officers were elected: J. W. Shipley, secretary; E. L. C. Foster, treasurer; M. A. Parker, F. J. Birchard, H. S. Davis and F. Pugh members of the executive committee.

Mr. H. K. Richardson gave an illustrated talk on "A Chemist's View of the Native Industries of China" at a joint meeting of the New York sections of the American Electrochemical Society, the Society of Chemical Industry and the American Chemical Society, held at the Chemists' Club on March 1.

Mr. Emil Illich, of the chemical laboratory of the National Lead Company, has joined the aviation corps and is now stationed at Camp Grant, Rockford, Ill.

Mr. William Simonson, of Cincinnati, aided by Cincinnati capitalists, is organizing a company for the manufacture of nitrates, ammonia and dyestuffs. The chemical will be manufactured by a process invented by Mr. Simonson, claimed to greatly reduce the cost of production. It is understood that the projectors of the enterprise are considering the location of the plant at or near Muscle Shoals, Ala., where the Government is building its $30,000,000 nitrate plant.

The following committee has been appointed to raise $2,000,000 for a new chemistry building for Cooper Union: V. G. Bloede, H. C. Enders, J. C. Olsen, Alfred Spice, P. C. Walsh, Jr., Maximilian Toch, H. A. Metz, S. A. Samuels and E. R. Hewett, Treasurer, Cooper Union, New York City.

Dr. John E. Teeple has resigned the position of chief of the Chemical Section of the U. S. Signal Corps, which position he has held during the past month.

It is reported that Prof. W. A. Konantz, a research chemist in the College of Pharmacy of the State University, Iowa, has discovered a method by which pure phenacetin, meeting all requirements for medicinal use, can be produced at less than half its present cost.

Doncko L. Milic, an Austrian, until recently general manager of the chemical department of Madero Bros., was arrested and held in bail for examination on February 21 accused of fraudulently substituting salicylic acid for quinine which had been ordered for military hospitals in Italy. Following this arrest, on February 18, receivers took charge of the Madero Bros.' business when an involuntary petition in bankruptcy was filed in the Federal District Court, New York, by three creditors.

Dr. Isaac Strauss, who is said to be connected with a chemical company that manufactures toluol, is detained at Ellis Island.

Miss Helen Updegrapf, Newark, Del., a graduate of Cornell University, has been appointed assistant chemist at the Delaware College Experiment Station, Newark, succeeding Prof. A. C. Whittier, resigned.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"(a)

YEAR	PAT. NO.	PATENTEE	ASSIGNOR	PATENT	APPLICANTS
1911	986,148	Ehrlich & Bertheim	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Derivatives of oxyarylarsinic acids	Dermatological Laboratories, Philadelphia Takamine Laboratory, Inc., N. Y. Farbwerke Höchst Co., N. Y. Diarsenol Co., Inc., Buffalo
1913	1,059,983	Ehrlich & Bertheim	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Alkali compounds of dioxydiaminoarsenobenzene	Dermatological Research Laboratories, Philadelphia Takamine Laboratory, Inc., N. Y.
1913	1,078,135	Ehrlich & Bertheim	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Preparation from alkali salts of the 3,3-diamino-4,4-dioxyarsenobenzene	Dermatological Research Laboratories Takamine Laboratory, Inc., N. Y.
1914	13,848 *Reissue*	Korndörfer & Reuter	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Derivatives of diaminodioxyarsenobenzene	Dermatological Laboratories, Philadelphia Takamine Laboratory, Inc., N. Y. Diarsenol Company, Inc., Buffalo, N. Y.
1905	782,729	Emil Fischer	C. Merck, Darmstadt	C-C-Dialkylbarbituric acid	Abbott Laboratories, Chicago
1913	1,081,897	Ehrlich & Bertheim	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Medicinal preparation	Takamine Laboratory, Inc., N. Y. Diarsenol Co., Inc., Buffalo
1909	924,664	Karl Irmhoff of Bredeney, near Essen on the Ruhr, Ger.	.....	Sewage treatment apparatus	Pacific Flush-Tank Co., N. Y. (Principal office at Chicago)
1910	978,889	Karl Irmhoff of Bredeney, near Essen on the Ruhr, Ger.	.....	Treating sewage	Pacific Flush-Tank Co., N. Y. (Principal office at Chicago)
1913	1,053,396	Karl Irmhoff of Bredeney, near Essen on the Ruhr, Ger.	.....	Sewage purification	Pacific Flush-Tank Co., N. Y. (Principal office at Chicago)
1913	1,056,548	Karl Irmhoff of Bredeney, near Essen on the Ruhr, Ger.	.....	Process of drying sludge	Pacific Flush-Tank Co., N. Y. (Principal office at Chicago)
1913	1,057,154	Karl Irmhoff of Bredeney, near Essen on the Ruhr, Ger.	.....	Settling-tank	Pacific Flush-Tank Co., N. Y. (Principal office at Chicago)
1906	812,554	Alfred Einhorn, Munich	Farbw. vorm. Meister, Lucius & Bruning, Höchst on the Main	Alkamine esters of paraamino benzoic acid	Rector Chem. Co., Inc., N. Y. Farbwerke Höchst Co., N. Y. The Abbott Laboratories of Chicago Calco Chemical Company, Bound Brook, N. J.
1908	892,166	E. Lankes and K. Schwarzler, Munich, Germany	.....	Process of preparing printers' overlays and underlays	R. P. Andrews Paper Company, Washington, D. C.
1904	777,201	Gottfried R. A. Gutmann, Hamburg, Germany	Alfred Gutmann Actiengesellschaft für Maschinenbau of Altona, Ottensen, Germany	Sand blast machine	Hoeval Manufacturing Corp., N. Y. (Exclusive license)
1906	821,776	Carl F. W. Zöller, Altona, Ottensen	Alfred Gutmann, Actiengesellschaft für Maschinenbau	Means for removing dust	Hoeval Manufacturing Corp., N. Y. (Exclusive license)
1913	1,081,592	P. Ehrlich & A. Bertheim, Frankfort on the Main	Farbw. vorm. Meister, Lucius & Bruning, Höchst on Main	Medicinal preparation	Diarsenol Co., Inc., Buffalo
1914	1,116,398	P. Ehrlich & A. Bertheim	Farbw. vorm. Meister, Lucius & Bruning	Dihydrochloride of diamino dioxyarsenobenzene	Diarsenol Co., Inc., Buffalo
1907	T.M. 61,678	P. Beirsdorf & Company, Hamburg	.....	Tooth paste and tooth powder	Lehn and Fink (exclusive)
1906	T.M. 50,868	Heinrich Böhr and Company, Selingen, Ger.	.....	T. M. for pocket knives	Boker Cutlery & Hdwe. Co., 101 Duane St., New York (exclusive)
1906	T.M. 54,700	H. Boker & Co.	.....	Scissors and knives	Boker Cutlery & Hdwe. Co., 101 Duane St., New York (exclusive)
1903	T.M. 40,115	E. Merck of Darmstadt	.....	A certain named chemical product	The Abbott Laboratories of Chicago
1904	T.M. 42,942	Ungarische Gummiwaren Fabriks Acktienger-Budapest, Hungary	.....	Rubber and asbestos packing	Another Packing Co. of Philadelphia
1911	Copyright registration 3,163, class A, XXC	Langenscheidtsche Verlagsbuchhandlung (Prof. G. Langenscheidt), Schöneberg, Berlin	.....	Pocket dictionary of Greek and English languages	David McKay, Philadelphia
....	Copyrights for German periodicals and books				Clinton Harby Levy, 2 Duane St., New York
1911	1,008,864	Max Ruping	Hulsberg & Cie. m. b. H., Berlin, Germany	Impregnation of wood, etc.	Lembcke, Von Bernuth Co., Inc., 171 Madison Ave., New York
1907	12,707 *Reissue* original patent No. 709,799 (1902)	Max Rüping	Hulsberg & Cie. m. b. H., Berlin, Germany	Method of impregnating wood	Lembcke, Von Bernuth Co.
1909	931,579	Diedrick A. M. Doublet, Einsbuttel near Hamburg	.....	Sand blast blower	Hoeval Manuf. Corp., N. Y.
1911	995,394	Robert Zahn, Planen, Ger.	.....	Jacquard embroidering machine	Robert Reinen Importing Co., Gregory Ave & Hackensack Plank Road, Weehawken, N. Y.
1910	976,760	Carl Auer von Welsbach, Vienna, Austria	Treibacher Chemische Werke Gesellschaft, m. b. H. of Treibach, Austria-Hungary	Pyrophoric mass	Lindsay Light Co., Chicago
1906	837,017	Carl Auer von Welsbach	.....	Pyrophoric alloy	Lindsay Light Co., Chicago
1907	868,294	Robert Schmidlin, Höchst on the Main	Farbwerke vorm. Meister, Lucius & Bruning	Process of producing phenylglycol and its homologues	E. I. du Pont de Nemours & Co., Wilmington, Del.
1901	680,395	Johanness Pfleger, Frankfort on the Main	Deutsche Gold and Silber Scheide Anstatt vorm. Roessler, Frankfort on Main	Process of making indoxyl derivatives	E. I. du Pont de Nemours & Co., Wilmington, Del

(a) This is a list of the applications which have been made to date. Additions to the list will be published as they occur.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT" (*Concluded*)

YEAR	PAT. NO.	PATENTEE	ASSIGNOR	PATENT	APPLICANTS
1906	818,992	Oscar Bally & Max Henry Isler, Mannheim	Badische Anilin & Soda Fabrik, of Ludwigshafen on the Rhine	Anthracene dye and process of making the same	E. I. du Pont de Nemours Co
1905	787,859	R. H. Scholl, Karlsruhe Oscar Bally, Mannheim	Badische Anilin & Soda Fabrik, of Ludwigshafen, on the Rhine	Anthracene compound and process of making the same	E. I. du Pont de Nemours Co.
1911	1,003,268	Richard Just and Hugo Wolff, Ludwigshafen on the Rhine	Badische Anilin and Soda Fabrik, Ludwigshafen	Anthracene dye and process of making the same	E. I. du Pont de Nemours Co.
1905	796,393	Oscar Bally, Mannheim	Badische Anilin & Soda Fabrik	Anthracene coloring matter and process of producing the same	E. I. du Pont de Nemours Co.
1904	753,659	Rene Bohn, Mannheim	Badische Anilin & Soda Fabrik	Anthracene derivative and process of making the same	E. I. du Pont de Nemours Co
1903	739,145	Rene Bohn, Mannheim	Badische Anilin & Soda Fabrik	Anthracene dye	E. I. du Pont de Nemours Co
1913	1,055,701	Rene Bohn, Mannheim	Badische Anilin & Soda Fabrik	Pigment and process of making the same	E. I. du Pont de Nemours Co.
1903	724,789	Rene Bohn, Mannheim	Badische Anilin & Soda Fabrik	Blue dye and process of making the same	E. I. du Pont de Nemours Co.
1913	1,063,173	Christian Rampini, deceased, by Wm. E. Marland, administrator	Badische Anilin & Soda Fabrik	Producing aminoanthraquinones and derivatives thereof	E. I. du Pont de Nemours Co.
1908	906,367	Oscar Bally, Mannheim Hugo Wolff, Ludwigshafen	Badische Anilin & Soda Fabrik	Anthracene dye and process of making the same	E. I. du Pont de Nemours Co
1910	961,612	Max Henry Isler and Hugo Wolff	Badische Anilin & Soda Fabrik	Anthracene compound and process of making it	E. I. du Pont de Nemours Co.
1902	711,377	Max Bazlen, Ludwigshafen	Badische Anilin & Soda Fabrik	Solid alkaline hydrosulfites and process of making the same	E. I. du Pont de Nemours Co.
1909	931,958	Louis Haas, Heidelberg	Badische Anilin & Soda Fabrik	Sulfur dye and process of making the same	E. I. du Pont de Nemours Co.
1905	795,755	Max Bazlen	Badische Anilin & Soda Fabrik	Process of making stable dry hydrosulfites	E. I. du Pont de Nemours Co.

Manufacturers of chemicals and various other products who use acetate of lime in their processes, are being asked to answer a somewhat lengthy questionnaire which is being sent out to producers of acetate of lime under government direction. The questionnaire is the direct result of the recent action of the government in seizing the entire output of that commodity and which consumers will be able to obtain for their private uses only through a government permit. Inability of the government to obtain sufficient quantities of the acetate has led to this action, the material being vitally needed for the making of military explosives.

American scientists have placed a new medical discovery at the disposal of the Allies in Europe. It is expected that the new product, phenolsulfonephthalein, will be a vital factor in minimizing diseases among our troops in France. It is reported that the drug was discovered by the chief of the department of chemistry of Johns Hopkins University, and after tests in the physiological department and by the pharmacologists of that institution, was found to be the most efficient of all diagnostic agents for tracing defects in the functioning powers of the kidney.

A plant for the manufacture of alcohol, to cost not less than $3,000,000, is in process of erection adjoining the West Virginia Pulp and Paper Company plant, at Luke, Md. The entire output is to go to the United States Government, which is furnishing the funds to build.

It is reported that a chemical plant costing $1,000,000 is to be constructed by the Federal Government at Mechanicsville, N. Y., to utilize the by-products of paper manufacturing plants of the West Virginia Pulp and Paper Company. The Government is to manufacture acetone, which is to be used to mix with varnish for coating aeroplane wings.

It is reported that a Spanish firm is manufacturing wool from cork, which it is claimed may be substituted for natural wool in the manufacture of mattresses, pillows and quilts. The material is stated to be cleaner and lighter than wool. It is first treated with chemicals to remove any resinous substances and to render it flexible and less likely to break.

The *Oil, Paint and Drug Reporter* states that more sulfuric acid was produced in the United States in 1917 than in any previous year, and that a moderate estimate shows that the increase in the production of acids of all strengths in 1917 over that in 1916, stated in terms of 60° Bé. acid, amounted to at least 600,000 tons.

According to advices from headquarters of the du Pont de Nemours Powder Company, the production of potash at Columbus Marsh, Ney County, Nevada, is to begin at once. Preliminary drillings on the marsh gave brines carrying $3^1/_2$ per cent soluble potash, and it is hoped to increase this by tapping the bottom of the prehistoric lake at a depth of 4,000 ft.

The Great American Chemical Products Company, New York, N. Y., the company which is being formed by druggists throughout the country, has begun the operating of four preliminary plants in the Greater New York district, and will shortly operate two more, at Buffalo and Bound Brook.

Plans have been completed for the plant of the Collinwood Chemical Company, Collinwood, Tennessee, the new company which will manufacture alcohol and acetate of lime for the government. The plant will cost in the neighborhood of $2,000,000 and will have a daily capacity of 2700 gals. of wood alcohol, 52,000 lbs. of acetate of lime and 12,375 bushels of charcoal. The plant, which will be finished September 1 and will cover twenty-five acres, will produce a quantity of tar, creosote, wood preservative and wood oils, in addition to the alcohol, charcoal and acetate of lime. The product which the government will take is to be manufactured into war munitions.

The big German dye factories at Ellesmere Port, on the Mersey River, England, were recently sold to Col. Brotherton, of Leeds, England. The concerns involved were the Badische Anilin und Sodafabrik, the Farbenfabriken vorm. Fr. Bayer & Company, and the Actiengesellschaft für Anilinfabrikation of Berlin. The plant was built nine years ago to conform with the British patent laws and is described as presenting the most modern ideas in construction of a chemical works. It is ideally located for deep water transportation, ocean-going steamers being able to dock outside of the works. It conforms largely to the construction of similar works on the Rhine River in Germany.

A resolution has been introduced in the House by Representative Mason, of Illinois, which will prove of interest to the chemists of the country, as it provides for an investigation to show whether chemical processes are being used to foist upon the country food that is without nutritive value. After citing these charges the resolution authorizes the Secretary of Agriculture to make a full and complete investigation to cover the following subjects:

First, what cereals are treated chemically or otherwise so as to deprive them of any of their food values before they are used in bread, biscuit, crackers, cake, pastry, and so forth.

Second, what, if any, of the cereals that have been treated chemically or otherwise in a manner to reduce their food values are ground in the mills of this country and mixed with wheat, corn, rye, barley, buckwheat, or other cereals before the same are sold to the consumer.

Third, what, if any, of the by-products of the cereals are treated chemically or otherwise in a way to deprive them of their food value or in a way that makes their use deleterious to public health and are used in the manufacture of bread or other food products.

Fourth, what, if any, mineral oils are being used as a substitute for animal fats and whether the use of such products is a fraud upon the consumer and whether the same is deleterious to the public health.

Turkey is developing its textile industry, and new textile plants aggregating a capital stock of $1,000,000 have been started there within the last few months.

The Marden, Orth and Hastings Corporation, of New York, have acquired control of the Buttercup Oil and Car Company, Louisville, Ky. The latter is one of the largest producers of cottonseed oil in the country, and its already large and diversified output of such products will be increased by the new owners.

In an address before the Delaware Section of the A. C. S. at Wilmington, on February 8, Mr. C. M. Barton, vice president of the duPont Nitrate Company, stated that his concern has developed a process for extracting potash from nitrate ores and has made large profits from it. The Company is drawing on Chilean nitrate ores for the purpose and has communicated the process to allied interests producing nitrate ores in Chile, enabling them to increase their output of potash greatly.

The recently organized Dyestuffs Association of America has appointed the following committee to consider the various points of tariff recommendations for a conference with the Government Dye Commission: J. Merritt Matthews, August Merz of Heller & Merz, R. T. Dicks of Dicks, David Co., and H. G. McKerrow of E. F. Drew & Co., all of New York; L. A. Ault of the Ault & Wiborg Co., Cincinnati; and C. B. Althouse of the Althouse Chemical Co., Reading, Pa.

At the suggestion of the War Trade Board, upwards of fifty representatives of the leading crushers and importers of castor oil and castor beans held a meeting in New York on January 12. The meeting was held for the purpose of forming an association to coöperate with the Government in securing adequate supplies of castor oil for the lubrication of aeroplane motors. Large quantities of this oil have already been absorbed by the Government, but, to insure the necessary supplies in the future, the organizing of factors in the trade for the purpose of controlling the industry was deemed necessary. The following committee of five members was chosen for the task of organizing the association as a membership corporation: A. C. Trask, of Marden, Orth & Hastings Corporation, *chairman;* Leonidas J. Calvocoressi, of Ralli Bros., Irving R. Boody, of Balfour Williamson & Co., Frederick A. Marsh, of Baker Castor Oil Co., and Howard Kellogg, of Spencer, Kellogg & Sons Co.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

NATIONAL MUSEUM

Mineral Industries of the United States: Coal Products, an Object Lesson in Resource Administration. C. G. Gilbert. Bulletin 102, Part 1. 16 pp. Paper, 10 cents. Published November 17, 1917.

Mineral Industries of United States: Sulfur, an Example of Industrial Independence. J. E. Pogue. Bulletin 102, Part 3. 10 pp. Paper, 5 cents. Published November 7, 1917.

SMITHSONIAN INSTITUTION

Administration and Activities of Smithsonian Institution. A. H. Clark. Publication 2450. From Report for 1916. 22 pp.

The Earth, Its Figure, Dimensions, and Constitution of Its Interior. Articles by T. C. Chamberlin, H. F. Reid, J. F. Hayford and F. Schlesinger. Publication 2457. From Report for 1916. 30 pp.

Petroleum Resources of United States. R. Arnold. Publication 2459. From Report for 1916. 15 pp.

Present Problem of Evolution. M. Caullery. Publication 2462. From Report for 1916. 15 pp.

PUBLIC HEALTH SERVICE

The Standardization of Anti-typhoid Vaccine. G. W. McCoy. Hygienic Laboratory Bulletin 110, Part 1. Published November 1917.

A Colorimetric Method for the Estimation of the Cresol or Phenol Preservative in Serums. E. Elvove. Hygienic Laboratory Bulletin 110, Part 2. Published November 1917.

Toxicity of Certain Preservatives Used in Serums, Viruses and Vaccines. J. P. Leake and H. B. Corbitt. Hygienic Laboratory Bulletin 110, Part 3. Published November 1917.

Observations on the Significance of Anti-sheep Amboceptor in Human Serum, with Reference to Complement Fixation Test for Syphilis. M. H. Neill. Hygienic Laboratory Bulletin 110, Part 4. Published November 1917.

Public Health Laboratory Specimens: Their Preparation and Shipment. H. E. Hasseltine. Public Health Reports, **32**, 2016–2032 (November 30, 1917). This paper has been prepared for the purpose of furnishing brief, concise instructions relative to the preparation and shipment of specimens for laboratory examination in order that the best results may be obtained.

Arsphenamine (Salvarsan): Licenses Ordered and Rules and Standards Prescribed for Its Manufacture. Public Health Reports, **32**, 2071–72 (December 7, 1917). The Federal Trade Commission, on November 30, 1917, issued orders for licenses to manufacture and sell the product heretofore known under the trade names of "salvarsan," "606," "arsenobenzol," and "arsaminol" to the following named manufacturers: Dermatological Research Laboratories, of Philadelphia; Takamine Laboratory, Inc., of New York; and Farbwerke Hoechst Co. (Herman A. Metz Laboratory), of New York. The drug will be manufactured and sold under the name of "arsphenamine." The rules and standards, prescribed by the United States Public Health Service, were promulgated by the Federal Trade Commission, November 22, 1917.

Appropriations for City Health Departments. P. Preble. Public Health Reports, **32**. 7 pp. Published December 7, 1917. Summary of expenditures of 330 cities in the central and eastern United States for public health work.

Mitigation of the Heat Hazard in Industries. J. A. Watkins. Public Health Reports, **32**. 11 pp. Published December 14, 1917.

Industrial Efficiency. F. S. Lee. Public Health Reports, **33**. 7 pp. Published January 11, 1918. "The bearings of physiological science thereon: A review of recent work."

WATERTOWN ARSENAL

Report of Tests of Metals and Other Materials Made in Ordnance Laboratory at Watertown Arsenal, Mass., Fiscal Year 1916. 132 pp. Cloth, 75 cents.

INTERNAL REVENUE COMMISSIONER

Alcoholic Medicinal Preparations. Treasury Decision 2544. 6 pp. This is a revision of Treasury Decision 2222, covering a list of alcoholic medicinal preparations for sale of which special tax is required.

Distilled Spirits. Treasury Decision 2576. 3 pp. This covers instructions relative to sale and use of distilled spirits for other than beverage purposes under the food-control act of August 10, 1917, and the act of October 3, 1917.

GEOLOGICAL SURVEY

Gold, Silver, Copper and Lead in Alaska in 1916. A. H. BROOKS. From Mineral Resources of the United States, 1916, Part I. 13 pp. Published November 20, 1917. Mines Report. A summary of the production statistics for these metals will appear later.

Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1916. C. W. HENDERSON. From Mineral Resources of the United States, 1916, Part I. 28 pp. Published November 23, 1917. Mines Report. (See summary later.)

Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1916. C. G. YALE. From Mineral Resources of the United States, 1916, Part I. 53 pp. Published December 3, 1917. Mines Report. (See summary later.)

Gold, Silver, Copper, and Lead in South Dakota and Wyoming in 1916. C. W. HENDERSON. From Mineral Resources of the United States, 1916, Part I. 14 pp. Published November 21, 1917. Mines Report. (See summary later.)

Gold, Silver, Copper, Lead and Zinc in Arizona in 1916. V. C. HEIKES. From Mineral Resources of the United States, 1916, Part I. 37 pp. Published December 21, 1917. Mines Report. (See summary later.)

Gold, Silver, Copper, Lead and Zinc in the Eastern States in 1916. J. M. HILL. From Mineral Resources of the United States, 1916, Part I. 9 pp. Published December 18, 1917. Mines Report. (See summary later.)

Gold, Silver, Copper, Lead and Zinc in Montana in 1916. V. C. HEIKES. From Mineral Resources of the United States, 1916, Part I. 32 pp. Published December 22, 1917. Mines Report. (See summary later.)

Mica in 1916. W. T. SCHALLER. From Mineral Resources of the United States, 1916, Part II. 18 pp. Published November 28, 1917. The total value of the domestic mica (muscovite) produced and sold in 1916 was $594,391, the highest value recorded by the United States Geological Survey. The value of the sheet mica produced in 1916 was exceeded by the production in 1906, 1909, 1910 and 1913. Except for 1912, 1914 and 1915 the quantity of sheet mica produced was the smallest since 1904.

The run of mine mica is sold either in bulk at so much per ton or on contract at a fixed price per ton. The prices paid represent the value of the mica as it is taken from the mine and not the value of the finished cut mica ready for the trade. The finished cut mica brings a much higher price, as it is ready to be used and has had a considerable amount of money spent on it. It is obviously inconsistent to add together the value of mica of two greatly different classes, yet this procedure is the only one that can at present be followed. The total production for the United States in 1916 of cut sheet mica was 315,174 lbs., valued at $110,693, an average price of $1.30 per lb. The total production of uncut sheet mica, which includes an estimated percentage of the sheet yield of run-of-mine mica, was 550,089 lbs., valued at $113,792, or an average price of only $0.21 per lb. Yet this uncut mica needs only to be cut in order to have its value materially increased.

The figures of production of mica in the United States, as reported to the United States Geological Survey, do not show any noteworthy change in the quantity (9,102 short tons) produced in the two years 1915 and 1916, as compared with the quantity (9,821 short tons) produced in the two years immediately preceding 1914. In 1914 the production was 4,008 short tons. Neither was there any significant change in the same years in consumption, that is, production plus imports minus exports. About 80 to 90 per cent of the total domestic consumption of mica is mined in the United States, the remainder being imported from Canada and India, either direct or through England. The imports have decreased, those for 1912 and 1913 amounting, to nearly 2,500 short tons and those for 1915 and 1916 amounting to about 1,500 short tons. In 1914 the imports were 611 short tons. In round numbers 11,000 short tons of mica were consumed in 1915 and 1916, as against 12,000 short tons in 1912 and 1913. In 1914 approximately 5,000 short tons were consumed.

Fluorspar and Cryolite in 1916. E. F. BURCHARD. From Mineral Resources of the United States, 1916, Part II. 17 pp. Published December 14, 1917. The total quantity of domestic fluorspar reported to the Survey as sold in 1916 was 155,735 short tons, valued at $922,654, an increase in quantity of 18,794 short tons and in value of $158,179, representing nearly 14 per cent of the quantity and nearly 21 per cent of the value of the product marketed in 1915. The average price per ton for the whole country, all grades of fluorspar, gravel, lump, and ground considered, was approximately $5.92 in 1916, compared with $5.58 in 1915, an increase of about 6 per cent. This value represents the selling price on board cars or barges at railroad or water shipping points.

As usual, the bulk of the fluorspar sold was in the form of gravel spar, the quantity in 1916 amounting to 133,651 short tons, or nearly 86 per cent of the total. Two grades of spar, gravel and lump, showed important increases in 1916 over all preceding years, but ground spar did not show as large an output as in 1915, the decrease in quantity having been more than 29 per cent in 1916. The general average price of domestic fluorspar declined steadily from 1912 to 1915, largely as a result of improvements in methods of milling and handling large quantities of spar in the Illinois-Kentucky district, and this price was lower in 1915 than at any time in the last 10 years; but in 1916, as predicted in this chapter in Mineral Resources for 1915, an increase in price was to be expected. The average price of all grades of spar increased in 1916, the ground spar $1.58 and the gravel and lump 42 and 43 cents per ton, respectively.

The imports of fluorspar into the United States entered for consumption in 1916 were 12,323 short tons, valued at $54,000, compared with 7,167 short tons, valued at $22,878, in 1915. This represents an increase of about 72 per cent in quantity and of 136 per cent in value. The price assigned to the imports in 1916 averaged $4.38 a ton, as compared with $3.19 a ton in 1915, an increase of $1.19 a ton, or about 37 per cent. The imports of fluorspar in 1916 were equivalent to about 9.2 per cent of the domestic production of gravel spar, as compared with nearly 6.3 per cent in 1915. The average reported price of imported spar at dock, exclusive of the duty, was equivalent to about 82 per cent of the average price of domestic gravel spar at mines or nearest shipping points in 1916, compared with 65 per cent in 1915. According to the prices reported, including the duty of $1.50 a ton but excluding freight charges, the average cost of imported spar to the consumer was $5.88 a ton in 1916, compared with $5.34 for domestic gravel spar at the mines or mills, in 1915, the cost of the imported material, including the duty of $1.50 a ton, was $4.69, compared with $4.80 for domestic gravel spar. The freight charges on domestic spar to points where it is consumed are generally higher than on foreign spar from the docks to eastern steel plants, so that a slight advantage in price still may be enjoyed by the imported spar at eastern steel plants. Foreign spar is, however, not generally of so high grade as the mechanically treated spar from Illinois and Kentucky and since fluorspar is of value chiefly according to its purity, purchasers should find that the purer American spar is more efficient and consequently cheaper in the end. Recently difficulties in getting supplies of fluorspar from American mines

when needed, on account of freight embargoes, lack of cars, difficulties of transportation on Ohio River, and labor troubles, have led steel manufacturers to accept readily whatever foreign spar was available.

No cryolite is produced in the United States, the entire supply used in this country being imported from Greenland.

The quantity of cryolite reported to have been imported for consumption in the United States in 1916 was 3,857 long tons, valued at $165,222, as compared with 3,940 long tons, valued at $82,750, in 1915. The average price per ton declared in 1916 was apparently $42.84, as compared with $21 in 1915. Cryolite is imported free of duty.

The annual imports of cryolite, beginning in 1894, are shown in a table, according to the records of the Bureau of Foreign and Domestic Commerce. They range from a minimum of 36 long tons in 1910 to 12,756 long tons in 1894, but are mostly between 1,000 and 6,000 tons a year. There are wide variations in average price per ton reported during this period, such as $10.58 in 1898 and $65.08 in 1910. The latter figure may be an error, as there seems to be no especial reason for so high a value in 1910, unless the shipment may have consisted of the white grade of cryolite. In 1916, in keeping with the increased prices of most mineral products due to the demands of war and especially of those dependent upon ocean transportation to centers of consumption, the price rose to $42.84 a ton or more than 100 per cent as compared with that of 1915.

Sand and Gravel in 1916. R. W. STONE. From Mineral Resources of the United States, 1916, Part II. 13 pp. Published December 21, 1917. The quantity of glass sand produced in the United States passed the 1,000,000-ton mark in 1905; in 1916, for the first time, it exceeded 2,000,000 tons. There has been a tendency in the last few years for the average price per ton to decrease, the lowest price being 85 cents in 1915, but there was a strong recovery in 1916 to 97 cents.

It is believed that the production in 1917 will be considerably greater and that the average price per ton will exceed $1, as an increased output is promised by larger demands and new uses for glass. As a structural material glass has an increasing use—for example, in the larger window area demanded in new office, factory, and school buildings.

The effect of the war in Europe on the molding-sand industry in the United States is very apparent. Reports of production made to the United States Geological Survey show an increase of 30 per cent in 1916 over 1915. This great increase was caused by the demand for vast supplies of machinery and munitions for shipment abroad and also for manufacturing and mining machinery for domestic use, all of which required molding sand for casting the metal. The production in 1916 exceeded 4,500,000 tons for the first time and the average price per ton, 69 cents, was the highest yet recorded.

The total production of grinding, polishing, and blast sand in 1916 was 1,370,354 short tons, valued at $889,651. This was an increase of about 40 per cent in quantity and 100 per cent in value over the production of 1915.

Pennsylvania was the largest producer of fire or furnace sand, which is a highly refractory silica sand used for lining and patching reverberatory and other furnaces, cupolas, and ladles used to contain molten metal. It is also used for making runners for pig-iron casting. Although the quantity produced in 1916 as reported to the Survey was less than in 1915, the total value was more than double that of the earlier year. The average price per ton in 1915 was about 34 cents; in 1916 it was 90 cents, and considerable quantities brought well over $1 a ton.

The grand total of sand and gravel produced in the United States in 1916 shows an increase of more than 12,000,000 short tons and in value of more than $6,600,000.

Zirconium and Rare-Earth Minerals in 1916. W. T. SCHALLER. From Mineral Resources of the United States, 1916, Part II. Published December 22, 1917. In 1869 a small output of zircon and in 1883 a much larger quantity was reported to have been mined. Small quantities were produced from 1903 to 1907, and then intermittently to 1911. For the last five years no production of zircon in this country has been reported to the United States Geological Survey. In view of the large production of natural zirconium oxide from Brazil it seems doubtful whether for present purposes there will be an active demand for zircon. This report also discusses in detail the occurrence and uses of cerium, yttrium, and lanthanum.

Magnesite in 1916. C. G. YALE AND H. S. GALE. From Mineral Resources of the United States, 1916, Part II. Published January 16, 1918. The production of magnesite in the United States in 1916 far exceeded that of any preceding year. The increase was due to the larger demand for refractory magnesite products and to the decline in imports. Though more magnesite was used in the United States in 1916 than in 1915, the use of the mineral has now been greatly curtailed by its relative scarcity and high cost. Owing to its use in the steel and copper industries, magnesite is an important though a minor war commodity, and the need for it in these industries is so great that its lack has at times been viewed with serious apprehension.

The most important development of the year 1916 was the opening in eastern Washington of large deposits of a coarsely crystalline magnesite that is like marble or dolomite in texture but is essentially magnesite in composition. Early in 1917 this material was being shipped at the rate of several hundred tons a day, and calcining furnaces were in course of erection to prepare magnesia for use in making refractory material and, it is said, also for use in cement mixtures. Coming at a time when the sources of supplies abroad are cut off, the discovery of these deposits appears to be most fortunate. The deposits are large and it appears that they will afford a supply of uniform character by relatively cheap methods of mining. It is, perhaps, too soon to say just how well the material is suited for refractory or other uses, but the present indications are that it is proving to be very satisfactory.

The crude magnesite produced and sold or treated in the United States in 1916 amounted to 154,974 short tons, valued at $1,393,693, as compared with 30,499 tons, valued at $274,491, in 1915. In 1916 California produced 154,259 tons, valued at $1,388,331, and Washington 715 tons, valued at $5,362.

Mineral Springs of Alaska. G. A. WARING. With a Chapter on the **Chemical Character of Some Surface Waters of Alaska** by R. B. DOLE AND A. A. CHAMBERS. Water Supply Paper 418. 109 pp. Paper, 25 cents. This short report brings together the available analyses of Alaskan surface waters in order that they may serve as a nucleus for amplifying the rather meager knowledge now at hand regarding the chemical composition of streams in a subpolar region.

Annual Report of the Director. G. O. SMITH. 176 pp. This is the thirty-eighth annual report and covers the fiscal year ending June 30, 1917. A brief review of the important activities of the service is given, but principally the report deals with administrative details.

Anticlines in the Southern Part of the Big Horn Basin, Wyoming: A Preliminary Report on the Occurrence of Oil. D. F. HEWETT AND C. T. LUPTON. Bulletin 656. 188 pp.

Oil and Gas Possibilities of the Hatchetigbee Anticline, Alabama. O. B. HOPKINS. Bulletin 661-H, from Contributions to Economic Geology, 1917, Part 2. 33 pp. Published December 11, 1917. "The object of the present work is to show more in detail the location and extent of this anticline, to point

out in a general way the areas that are most deserving of tests with the drill, and to give those interested in exploratory drilling for oil and gas information regarding the geology of the area, the character of this fold, and the occurrence and depth of possible productive oil sands."

COMMERCE REPORTS—JANUARY, 1918

South China provinces, which years ago had ceased to cultivate **indigo**, are now raising more than enough for their own needs. (Pp. 3 and 197)

New large plants are to be erected in Norway for the production of **carbide, cement** and **steel, chrome leather,** and **superphosphate.** (Pp. 10 and 36)

All the **tin, copper, zinc** and **nickel ores** smelted in Swansea, Wales, are imported, the only mineral product of Swansea being coal. The British government has subsidized the importation of zinc concentrates from Australia. (P. 38)

Mineral products of South Africa include diamonds, asbestos, coal and ores of copper, tin, gold, silver, chromium, iron and tungsten. (P. 51)

A company has been organized in Sweden for the utilization of the enormous **peat** deposits by the Wielandt process of distillation, by which a coke is produced which is excellent for domestic use, as well as for electric iron smelting. By-products include **ammonium-sulfate, wood alcohol, acetic acid, tar, motor fuels, lubricating oils, creosote, hard** and **soft paraffin** and **pitch.** (P. 65)

Coal veins are to be worked in Sweden, which are too thin to pay in normal times. As the coal ashes contain about 4.4 lbs. **vanadium** per ton of coal, it is hoped to recover this vanadium for steel production. (P. 66)

Cultivation of Ceara **rubber** in East Africa is increasing. The "ceara" plant, unlike the "Hevea," can be tapped only for five or six years. The rubber is coagulated by acid and is shipped without washing. The rubber is valuable, though inferior to Para. (P. 68)

New industrial enterprises in Sweden include the recovery of waste fats for **soaps,** etc., electrolytic production of **aluminum** and the manufacture of **dyestuffs** on a large scale. (P. 87)

The capital stock of all the large German dye companies has been greatly increased, in order to provide capital for the enlargement of the **nitrogen** plant of the Badische Anilin and Soda Fabrik. (P. 88)

The **orange-oil** industry of Jamaica has increased greatly in recent years. The oil is extracted by hand, by a simple device for pricking the oil cells of the rinds. The oranges are then used as stock food. (Pp. 90–4)

The Italian government has taken over all stocks of **alcohol** and of raw materials such as molasses, damaged cereals, refuse figs, etc. (P. 108)

In Italy, miners' safety lamps, chiefly portable electric, are required in the **sulfur mines,** on account of accumulations of hydrogen sulfide. Numerous cases of poisoning by hydrogen sulfide occur. (P. 133)

A large **white lead** factory has been erected in Australia to use the stack process. A basic sulfate white lead plant is also in operation. (P. 151)

Practically all the **musk** of commerce, used so extensively as a basis of perfumes, is obtained from Tibet from the abdominal sac of the male musk deer. Among efforts to synthesize musk, that of Baur was most nearly successful in imitating the odor, although his compound, produced from benzene and a tertiary butyl alcohol, is entirely different in composition from true musk. (Pp. 156–8)

The manufacture and sale of **oleomargarine** is now permitted in Canada. (P. 179)

Pig iron is now being produced from iron sands of New Zealand. (P. 184)

Essential oils produced in large quantity in Spain are spike, rosemary, thyme, fennel, sage, juniper, pennyroyal, and geranium rose. There are several large steam distilleries, as well as hundreds of small producers. The best grades of oil are refined by vacuum distillation. (P. 189)

Increased cultivation of **castor beans** in Trinidad is urged to meet the greatly increased demands for use as airplane motor **lubricant.** (P. 248)

In London, **grease** and **oil** are being removed from parts of motor busses, trunks, etc., by means of hot 3 per cent caustic soda, instead of by kerosene as formerly. Oil so recovered can be again used as motor oil. Grease and oil recovered from waste, rags, etc., is used as fuel in Diesel engines. (P. 264)

The National Institute of Industrial Chemistry, at Montevideo, Uruguay, is now successfully operating a factory for the manufacture of a large number of **chemicals.** (P. 358)

The total aggregates of **rubber** plantations in 1916 was about 2,000,000. Even with maximum anticipated production, a shortage of rubber is expected within a few years. (P. 377)

Molybdenum ore is now being shipped from South China to Canada and the United States. (P. 390)

SPECIAL SUPPLEMENTS ISSUED IN JANUARY

Portugal—11*b*
Malta—20*a*
British West Indies—22*b*
Canada—23*d*
French West Indies—28*a*
St. Pierre Miquelson—37*a*
Brazil—40*b*
Colombia—42*b*
Paraguay—45*a*
Uruguay—47*b*
Venezuela—48*a*
British India—50*b,c*
China—52*h,i*
Dutch East Indies—53*a*
Japan—55*c*
Australia—60*b*
British South Africa—66*b*
British West India—67*a*
Tunis—79*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

TRINIDAD—Sup. 22*b*
Balata
Mangrove bark
Copra
Divi divi
Gold
Hides
Logwood
Asphalt
Petroleum

QUEBEC—Sup 23*d*
Albumen
Aluminum
Asbestos
Wood alcohol
Ammonium sulfate
Bone black
Calcium carbide
Calomel
Creosote
Formaldehyde
Chloride of lime
Magnesite
Soda ash
Sodium cyanide
Toluol
Chrome ore
Copper ore
Explosives
Grease
Iron and steel
Leather
Barite
Dolomite
Paper stock
Graphite
Sulfur ore
Wood pulp
Zinc ore

BRAZIL—Sup 40*b*
Castor oil
Balsam
Copaiba
Cream of tartar
Glycerine
Cyanide
Ipecac
Potash
Hides
Manganese ore
Platinum
Wolframite
Mica
Monazite
Rubber
Sugar
Beeswax
Carnauba wax

PORTUGAL—Sup. 11*b*
Antimony
Beeswax
Ergot
Glycerin
Gum copal
Tartar
Hides
Rubber
Manganese ore
Mercury
Sulfur ore
Cork

COLOMBIA—Sup 47*b*
Balsam
Divi-divi
Dyewoods
Gold
Hides
Ipecac
Indigo
Platinum
Rubber
Silver
Sugar
Mangrove extract

CHINA—Sup 52*b*
Antimony
Beeswax
Albumen
Cantharides
Camphor
Aniline dyes
Indigo
Galls
Licorice
Musk
Rhubarb
Benzoate of soda
Turmeric
Gold
Hides
Pig iron
Bean oil
Cottonseed oil
Rape seed oil
Peanut oil
Soya bean oil
Wood oil
Linseed
Vegetable tallow
Zinc ore

GLASGOW—308
Acids
Ammonium sulfate
Corundum
Creosote oil
Sodium cyanide
Leather
Paper stocks

VENEZUELA—Sup 48*a*
Balata
Chicle
Copaiba
Copper ore
Divi-divi
Hides
Rubber
Sugar

BRITISH INDIA—Sup. 50*b*
Nux vomica
Senna
Indigo
Turmeric
Hides
Lemon grass oil
Coconut oil
Castor oil seeds
Copra
Rubber

BURMA—Sup. 50*c*
Hides
Paraffin
Cutch
Teak
Rubber
Lac

JAPAN—Sup 55*c*
Antimony ore
Bronze powder
Alum
Glycerine
Gum camphor
Indigo
Menthol
Sulfur
Vegetable wax
Copper
Crucibles
Gold
Gold leaf
Hides
Iridium
Manganese ore
Matches
Vegetable oils
Fish oil
Graphite
Agar-agar
Tungsten ore
Zinc dust

BOOK REVIEWS

The Distillation of Resins. By VICTOR SCHWEIZER. Translated by H. B. STOCKS, F.I.C., F.C.S. Second English Edition. Scott, Greenwood & Son. Price, $2.52.

The true title for this book would better read: "Elementary Treatise on the Distillation of Rosin, Manufacture of Illuminating Gas from Rosin, Rosin Oils, Lubricants, Resin Soaps and Resinates, Varnishes, Lamp Blacks and Pigments, Printers' Inks, Typewriter Ribbons and Carbon Papers." There are one or more chapters on each subject, and necessarily, each chapter is very limited.

The title page shows the book to be the second English edition, and one might readily draw the conclusion that a great deal of material and many cuts had been retained from the former edition, which must have been published many years ago, as much of the material contained in the book may be regarded as almost obsolete. The book contains a short, concise description of the oleo and gum resins.

Another chapter is devoted to colophony and its properties.

Chapter 5 is devoted to the manufacture of illuminating gas from resins, an obsolete and expensive method for the manufacture of illuminating gas.

The apparatus described for the manufacture of rosin oil is crude and is more nearly comparable with what one might expect to put up for small laboratory experimental operations, rather than for large manufacturing work.

On page 88, in speaking of the lime to be used in the manufacture of "Patent Lubricants," the author makes the statement: "The lime used must be pure. This is easily tested by slaking it. Pure lime rapidly absorbs large quantities of water, soon breaks up, evolves much heat and forms a very soft powder."

On page 89, in speaking of "Patent Lubricants," the author says: "Fillings are also added in many cases to cheapen the product or to increase its consistency, but these are inactive bodies having no lubricating power of their own."

Chapter 10, on the manufacture of resin soaps and resinates, is crude in the extreme, and gives only an elementary or experimental idea of the true processes.

In describing the operations used for burning oils in lampblack chambers, the author makes the following statement on page 131: "Occasionally a sudden break in the satisfactory working may occur * * * * This is always to be traced to a quick change in the barometric pressure, which can be proved by consulting a barometer at intervals."

One might make numerous other criticisms.

For instance, the illustrations on pages 38 and 181, Figs. 10 and 64, are identical in every respect, and each one covers about a half page.

It is to be doubted whether any modern ink manufacturer would be successful by using the methods or formulas recommended in this book. The same would apply to typewriter ribbons. The following statement appears on page 195, in speaking of the material used: "Choose a thin but closely woven material of which both warp and weft must be silk (cotton tape is, however, usually employed)."

A further statement that may be questioned appears at the bottom of the same page. It reads: "As, moreover, most coal-tar dyes are soluble in glycerine, which must always enter into the composition of a typewriter ink, the maker has a fairly free hand in his choice of a dye." Several points of this statement could be sharply questioned.

The reader of this book may profit in that he will gain a very elementary, although in some respects certainly an incorrect, knowledge of the manufacture of a large number of things, about each one of which a book several times the size of this volume could be written.

A. B. DAVIS

The Chemistry of Farm Practice. By T. E. KEITT, Chemist of South Carolina Experiment Station, and Professor of Soils, Clemson Agricultural College, S. C. John Wiley and Sons, Inc., New York, 1917. xii + 253 pp. 81 figures. Price, Cloth, $1.25.

This book furnishes the knowledge of the fundamentals of chemistry required for intelligent agriculture and applies this knowledge to the art of agriculture and to the problems of the agriculturist. Its scope has not been limited to the study of soils, fertilizers and manures, although these subjects are given careful consideration. It also discusses in as non-technical language as possible such subjects as feeds, nutrition, sanitary water, boiler water, and insecticides, subjects in which not only the farmer, but the suburban resident is interested.

As a textbook, it should prove useful in high schools, in farming communities and in short courses in agricultural colleges where instruction in the chemistry of farm practice should be given. As in such cases it would not be possible to give the usual formal course in general chemistry, followed by technical agricultural chemistry, the essential principles of chemistry have been given in the first few chapters, a combined textbook being thus provided.

There are some inaccuracies in statement incidental to a first edition, for example:

Page 3. "An atom does not remain free or uncombined."

Page 16. "Two molecules of hydrogen chloride are expressed 2HCl **** A molecule of sulfuric acid is H_2SO_4."

Page 26. "The stronger bases attack metals such as aluminum and zinc, producing thereby water as one of the products of the reaction."

Page 27. "What is left of the acid after its hydrogen is removed is the acid radical."

Page 27. "There are four classes of salts * * * * (1) Normal Salts * * * * * (2) Acid Salts * * * * * (3) Basic Salts * * * * (4) Neutral Salts."

Page 30. "Persulfuric acid, $H_2S_4O_8$."

Page 30. "H_2SO_2, hyposulfurous acid."

Page 30. "Sodium hyposulfite, Na_2SO_2."

Page 36. "The three compounds of carbon * * * * * * * * * * are carbon dioxide, carbonates and the carbohydrates."

The author has done his work well and the book will serve a useful purpose.

W. A. WITHERS

An Introduction to Theoretical and Applied Colloid Chemistry. By DR. WOLFANG OSTWALD. Authorized translation by DR. MARTIN H. FISCHER, Eichberg Professor in the University of Cincinnati. John Wiley & Sons, Inc., New York, 1917. Price, $2.50.

This book contains a series of lectures delivered on this side of the ocean during the winter of 1913–1914 and attempts "to give a general survey of modern colloid chemistry as a pure and as an applied science and in a form readily intelligible to the general reader," making "its first appeal to such readers as have heard little or nothing of colloid chemistry."

FIRST LECTURE—Fundamental Properties of the Colloid State. Colloids as Examples of Dispersed Systems. Methods of Preparing Colloid Solutions.

SECOND LECTURE—Classification of the Colloids. The Physico-Chemical Properties of the Colloids and Their Dependence upon the Degree of Dispersion.

THIRD LECTURE—The Change in State of Colloids.

FOURTH LECTURE—Some Scientific Applications of Colloid Chemistry.

FIFTH LECTURE—Some Technical Applications of Colloid Chemistry.

The author adheres to the lecture form, which may make the book seem a little weak to those who attended the lectures themselves, actually saw the experiments and felt the influence of the lecturer's personality. The broad field is, however, ably covered by well chosen typical examples and experiments and the book will fulfill its purpose as a "propaganda sheet for colloid chemistry."

The translation is excellently done.

REMARKS OF THE ADVOCATUS DIABOLI

Throughout the book the author maintains his own views on most points, without presenting divergent views adequately or at all. His claim that a book of this type is new, is rather naïve. He does not always apportion credit or priority properly, but seems to be more familiar with the work of contributors to the *Kolloid Zeitschrift* (of which he is editor) than with the work of certain authors, published in the English language. In an addendum to the preface the author says: "If this volume, born of two continents, is thus sent into the world from the trench and from the midst of artillery fire, I hope that I shall not therefore be charged with cheap coquetry. Convinced as I am of the justice of my Fatherland and its power to carry matters to a victorious conclusion, equally convinced am I that the bond of science which is common to all people can never be destroyed, and certainly not by war; and that it is this bond which must finally serve to bind together and so to protect all mankind from such experiences as the present."

Just before this he says: "War is a temporary and pathological phenomenon appearing in the organism of mankind; it is a means to an end; and there exist treasures, like science and art, unshatterable and everlasting."

And just to think that this was all written from Champagne in March 1915, when the very artillery he speaks of was wrecking the Cathedral at Rheims!

JEROME ALEXANDER

The Chemistry of Colloids. By PROF. RICHARD ZSIGMONDY. Translated by ELLWOOD B. SPEAR, Associate Professor of Inorganic Chemistry, Massachusetts Institute of Technology. John Wiley & Sons, Inc., New York, 1917. Price, $3.00.

This is an authorized translation of Prof. Zsigmondy's "Kolloidchemie-ein Lehrbuch" published in 1912, with which are included several chapters by the translator, entitled "Industrial Colloidal Chemistry," and a chapter on "Colloids in Sanitation" by Prof. John F. Norton.

In the preface to the German edition (not included in the translation) the author gives the purpose and scope of his book, which may be briefly summarized as follows:

The rapid development of colloid chemistry has brought to light a great many isolated facts demanding coördinations and generalizations which, unless care be exercised, may actually do violence to the facts themselves. The author, therefore, rather than aiming at completeness, takes up with great thoroughness researches and facts of general significance, especially those bearing on electrical properties and on the theory of peptization.

The general section includes a terse but comprehensive introduction, a chapter on Classification ably upholding Zsigmondy's views, a chapter on the Properties of Colloids, and one on Theory (especially of peptization). In the special section the inorganic colloids are treated with much greater completeness than are the organic colloids. The translation is in the main well and conscientiously done, and the book will certainly be welcome and useful to everyone interested in colloid chemistry.

REMARKS OF THE ADVOCATUS DIABOLI

Certain errors in the German original are unfortunately perpetuated by the translator, thus Szillard instead of Szilard, Lysalbinic instead of Lysalbinic; on page 4 sodium stearate is spoken of as being a crystalloid in *alkaline* solution, whereas *alcoholic* solution is meant and is actually referred to in the section on soaps, p. 188.

There are quite a few misprints and some rather serious and inexcusable errors in translation: Zsigmondy's own "star dialyzer" is illustrated on p. 35 with the caption "Stern's dialyzer" and is so referred to later on, on p. 136, which is quite surprising, as Zsigmondy himself read the translation; on p. 81, electrolytic solutions instead of solutions of electrolytes; on p. 115, Fig. 19, emulsion instead of emulsin; p. 143, Fig. 23, lettering in text at variance with that in diagram (o_1 omitted from diagram); p. 151, benzopurple instead of benzopurpurin; p. 162, reference to Graham omitted, others therefore mismarked, etc.

Again while using the preferential spelling gelatin, the translator inconsistently uses the less desirable pepsine, sulfide, chlorine, cathion, etc., instead of pepsin, sulfid, chlorin, cation, etc. Although Zsigmondy's "Zur Erkenntnis der Kolloide" is very frequently referred to and in fact largely contributed to the make-up of this book, no mention is made of the English translation, although this was published by the same publishers under the title "Colloids and the Ultramicroscope."

In conclusion, the added chapters are hardly up to the high standard of the German original.

JEROME ALEXANDER

Allen's Commercial Organic Analysis. Vol. IX. Fourth Edition. P. Blakiston's Son & Co., Philadelphia, Pa. Price, $5.00, net.

The new edition of this valuable treatise has just been received and brings up to date the articles appearing in the preceding eight volumes. Not only have the articles by original writers been revised, but material appears from the pens of eleven new collaborators. The subject matter covers a wide range of organic compounds and products, with concise methods for the detection and estimation of impurities and adulterations. In addition, this volume contains a complete index of all volumes of the set. This book is a timely addition to our chemical literature and should be in the library of all those interested in the subjects treated.

ALLEN ROGERS

Standard Methods of Chemical Analysis. A Manual of Analytical Methods and General Reference for the Analytical Chemist and the Advanced Student. Edited by WILFRED W. SCOTT, Research Chemist, General Chemical Company. xxxi + 898 pp. Illustrated. Second Edition, Revised. D. Van Nostrand Co., New York, 1917. Price, $6.00.

The first edition of this book was published early in 1917 and was reviewed in THIS JOURNAL, 9 (1917), 917. A few changes have been made in the text, and new tables added. Those faults to which attention was called in the former review have been corrected, for the most part, but the Editor has not had opportunity to read over the entire book and correct certain very obvious misprints. These, however, do not seriously affect the value of the book and it will doubtless continue to have a good sale.

W. T. HALL

Laboratory Guide of Industrial Chemistry. By ALLEN ROGERS. Second Edition. D. Van Nostrand Co., New York. Price, $2.00, net.

The first edition of this manual was reviewed in THIS JOURNAL, 1 (1909), 50. The new edition has been well revised, 54 pages of new material added, and the price increased from $1.50 to $2.00.

The book is, as a whole, thoroughly practical and teachable. The chapters on Leather and Soap Manufacture are especially valuable, as would be expected by anyone knowing of the author's success in teaching these subjects at Pratt Institute.

RALPH H. MCKEE

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Bacteriology: A Compend on Bacteriology. R. L. PITFIELD. 3rd Ed. 12mo. 279 pp. Price, $1.25. P. Blakiston's Son & Co., Philadelphia.

British Standard Specifications for Cast Iron Pipes and Special Castings for Water, Gas and Sewage. Price, 1s. Crosby Lockwood & Son, London.

Chemical Constitution of the Proteins. R. H. A. PLIMMER. New Ed. 8vo. 174 pp. Price, $1.80. Longmans, Green & Co., New York.

Chemical Physiology: Directions for a Practical Course. W. CRAMER. 3rd Ed. 8vo. Longmans, Green & Co., New York.

Chemistry: Eléments de chimie. Métalloides. F. G. M. CLASSE. 3rd Ed. 16mo. 121 pp. A. Mame et fils, Paris.

Chemistry: Handbook of Chemistry and Physics. CLEVELAND RUBBER CO. 1918 Ed. 482 pp. Price, $2.00. Cleveland Rubber Co., Cleveland.

Chemistry: A Laboratory Manual of General Chemistry. H. G. BYERS. 8vo. 129 pp. Price, $2.25. Charles Scribner's Sons, New York.

Commercial Algebra. G. WENTWORTH. 12mo. 266 pp. Price, $1.12. Ginn & Co., Boston.

Cotton and Other Vegetable Fibers. ERNEST GOULDING. 8vo. 241 pp. Price, 6s. John Murray, London.

Engineering: American Stationary Engineering. W. E. CRANE. 12mo. 311 pp. Price, $2.00. Norman W. Henley Publishing Co., New York.

Engineering Mathematics. C. P. STEINMETZ. 3rd Ed. 8vo. 321 pp. Price, $3.00. McGraw-Hill Book Co., New York.

Grinding: Precision Grinding Machines. T. R. SHAW. 8vo. 221 pp. Price, 10s. 6d. Scott, Greenwood & Son, London.

Industrial Engineering: Present Position and Post-War Outlook. F. W. Lanchester. 8vo. 61 pp. Price, 1s. Archibald Constable Co., London.

Iron and Steel: The A. B. C. of Iron and Steel with a Directory of Iron and Steel Works and Their Products of the U. S. and Canada. A. O. BRACHERT. 2nd Ed. 4to. 344 pp. Price, $5.00. Penton Publishing Co., Cleveland.

Kinematics of Machinery. A. W. KLEIN. 8vo. 227 pp. Price, $2.50. McGraw-Hill Book Co., New York.

Linseed Oil: The Chemistry of Linseed Oil. J. N. FRIEND. 8vo. 103 pp. Price, 2s. 6d. Gurney & Jackson, London.

Machinery's Encyclopedia: a Work of Reference Covering Practical Mathematics and Mechanics, Machine Construction and Operation, Metallurgy and Kindred Subjects. Comp. and Ed. by ERIK OBERG AND F. D. JONES. 7 Vol. Price, $36.00. Industrial Press, New York.

Manganese Deposits: Les Gites de fer et de manganèse des environs de Grachaux. E. FOURNIER. 8vo. Dodivers, Besancon.

Milk: The Examination of Milk for Public Health Purposes. JOSEPH RACE. 8vo. 224 pp. Price, $1.75. John Wiley & Sons, Inc., New York.

Mine Supplies: The Efficient Purchase and Utilization of Mine Supplies. H. N. STRONCH. 8vo. Price, 6s. Chapman & Hall, London.

Mineral Industry during 1916. Ed. by G. A. ROUSH. 8vo. 939 pp. Price, $10.00. McGraw-Hill Book Co., New York.

Mining: List of Books on Mining, Geology, Mineralogy, Assaying, etc. 81 pp. Gratis. Free Public Library, Butte, Mont.

Mining: Materials for the Study of Mineral Products of Russia. 6 vol. 8vo. Price, 2s. 6d. Imperial Academy of Sciences, Luzac.

Pharmaceutical and Chemical Arithmetic Including Weights and Measures. J. W. STUCKER. 4th Ed. 12mo. 147 pp. Price, $1.50. The Author, Philadelphia.

Science: General Science. C. H. LAKE. 12mo. 438 pp. Price, $1.25. Silver, Burdett & Co., Boston, Mass.

Steel and Its Heat Treatment. D. K. BULLENS. 2nd Ed. 8vo. 483 pp. Price, $4.00. John Wiley & Sons, Inc., New York.

Varnish Plants: Monthly Cost Accounting for Varnish Plants. E. W. STOREY. 8vo. 51 pp. Price, $1.25. Philadelphia Press and Pub. Co., Philadelphia.

Water: Fresh Water Biology. H. B. WARD AND G. C. WHIPPLE. 8vo. 111 pp. Price, $6.00. John Wiley & Sons, Inc., New York.

Water Supply Engineering. A. P. FOLWELL. 8vo. 484 pp. Price, $3.50. John Wiley & Sons, Inc., New York.

RECENT JOURNAL ARTICLES

Artificial Silk: Development of Artificial Silk Industry. L. P. WILSON. *Textile World Journal*, Vol. 53 (1918), No. 29, pp. 25–27.

Cellulose: The Estimation of Cellulose in Wood. B. JOHNSEN AND R. W. HOVEY. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 5, pp. 87–93.

Chemistry in Medicine in the 15th Century. J. M. SHELLMAN. *The Scientific Monthly*, Vol. 6 (1918), No. 2, pp. 167–175.

Chrome Brick in Copper Reverberatory Furnace. F. R. PAYNE. *Mining and Scientific Press*, Vol. 116 (1918), No. 2, p. 60.

Condensers: Analysis of the Condenser Problem. D. D. PENDELTON. *The Iron Trade Review*, Vol. 62 (1918), No. 3, pp. 214–215.

Dyestuff Manufacture. Methyl Violet B. ISIDOR MILLER. *Color Trade Journal*, Vol. 2 (1918), No. 1, pp. 18–23.

Electrical Industry: Some Developments in the Electrical Industry during 1917. JOHN LISTON. *General Electric Review*, Vol. 21 (1918), No. 1, pp. 4–52.

Ferromanganese and Spiegeleisen. G. C. STONE. *Engineering and Mining Journal*, Vol. 105 (1918), No. 2, pp. 75–76.

Fertilizer Industry and its Power Requirements. J. E. MELLET. *General Electric Review*, Vol. 21 (1918), No. 2, pp. 96–110.

Filter-Press. D. R. SPERRY. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 3, pp. 140–143.

Flotation: Effect of Addition Agents in Flotation. M. H. THORNBERRY AND H. T. MANN. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 2, pp. 71–77.

Flotation: Progress of Flotation in 1917. H. A. MEGRAW. *Engineering and Mining Journal*, Vol. 105 (1918), No. 2, pp. 99–102.

Flotation: Scientific Nominalism and Flotation Physics. D. H. NORRIS. *Mining and Scientific Press*, Vol. 116 (1918), No. 5, pp. 161–165.

Graphite Mining in New York. D. H. NEWLAND. *Engineering and Mining Journal*, Vol. 151 (1918), No. 3, p. 151.

Lead: Metallurgy of Lead. H. O. HOFMAN. *Engineering and Mining Journal*, Vol. 105 (1918), No. 2, pp. 93–94.

Metallurgical Ferroalloys in 1917. R. J. ANDERSON. *Engineering and Mining Journal*, Vol. 105 (1918), No. 4, pp. 191–193.

Molybdenum: Reduction of Molybdenum. C. H. HUMPHREYS. *The Mining American*, Vol. 77 (1918), No. 1874, p. 11.

Nickel-Copper Steel Direct from Sudbury Ores. F. H. MASON. *Mining and Scientific Press*, Vol. 116 (1918), No. 2, pp. 57–58.

Oil: The Extraction of Oil from Shales. J. H. GALLOUPE. *The Mining American*, Vol. 77 (1918), No. 1873, pp. 6 and 16.

Oil and Gas Fields of Illinois. H. A. WHEELER. *Engineering and Mining Journal*, Vol. 105 (1918), No. 4, pp. 181–184.

Ore: Pressure in the Formation of Ore Deposits. STEPHEN TABER. *Mining and Scientific Press*, Vol. 116 (1918), No. 4, pp. 128–130.

Paper: Book Paper Probe to Proceed. EVERETT ANDREW. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 3, pp. 43–46.

Paper: Coated Papers. R. B. FOULIS. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 5, pp. 109–110.

Phosgene. C. S. WEHRLY. *Color Trade Journal*, Vol. 2 (1918), No. 1, pp. 8–10.

Potash: Italian Leucitic Lavas as a Source of Potash. H. S. WASHINGTON. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 2, pp. 65–71.

Potash: The Recovery of Potash as a By-Product in the Cement Industry. W. H. ROSS AND OTHERS. *The American Fertilizer*, Vol. 48 (1918), No. 2, pp. 35–36.

Pyrites in the Sulfite Mill. A. W. G. WILSON. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 5, pp. 95–108.

Pyrrhotite Deposits in Southwest Virginia. J. A. VAN MATER. *Engineering and Mining Journal*, Vol. 105 (1918), No. 4, pp. 198–199.

Sea-Water for Flotation. *Mining and Scientific Press*, Vol. 116 (1918), No. 5, pp. 167–168.

Silver in 1917. EDWARD BRUSH. *Engineering and Mining Journal*, Vol. 105 (1918), No. 2, pp. 47–50.

Spelter: Recovery of Spelter and the Treatment of Retort Residues. E. M. JOHNSON. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 3, pp. 138–139.

Steel: Analysis of Electric Steel Making. J. A. MATHEWS. *The Iron Trade Review*, Vol. 62 (1918), No. 4, pp. 175–176.

Sugars Other than Cane or Beet. C. L. TELLER. *The American Food Journal*, Vol. 13 (1918), No. 1, pp. 23–24.

Sulfuric Acid Situation in the U. S. L. S. SKINNER. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 2, pp. 82–85.

Textiles: War Testing of Textiles by Bureau of Standards. E. D. WHITE. *Textile World Journal*, Vol. 53 (1918), No. 28, pp. 100 and 167.

Toluol: Intensive Toluol Production. F. E. LICHTENTHÄLER. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 3, pp. 143–145.

Tungsten Industry. F. W. HORTH. *Engineering and Mining Journal*, Vol. 105 (1918), No. 4, pp. 90–91.

X-Ray: A New Radiation Type Hot-Cathode Roentgen-Ray Tube. W. D. COOLIDGE. *General Electric Review*, Vol. 21 (1918), No. 1, pp. 56–60.

MARKET REPORT—FEBRUARY, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON FEB 1

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal	
Alum, ammonia, lump	100 Lbs.	4.00 @	4.50
Aluminum Sulfate, high-grade	Lb.	2¾ @	3
Ammonium Carbonate, domestic	Lb.	11 @	11¼
Ammonium Chloride, white	Lb.	15¼ @	16
Aqua Ammonia, 26°, drums	Lb.	19½ @	20
Arsenic, white	Lb.	16¾ @	1
Barium Chloride	Ton	65.00 @	85.00
Barium Nitrate	Lb.	9½ @	11
Barytes, prime white, foreign	Ton	40.00 @	45.00
Bleaching Powder, 35 per cent	100 Lbs.	2.50 @	3.00
Blue Vitriol	Lb.	9 @	9½
Borax, crystals, in bags	Lb.	7¼ @	8
Boric Acid, powdered crystals	Lb.	13¼ @	15
Brimstone, crude, domestic	Long Ton	nominal	
Bromine, technical, bulk	Lb.	75 @	85
Calcium Chloride, lump, 70 to 75% fused	Ton	27.50 @	30.00
Caustic Soda, 76 per cent	100 Lbs.	5.50 @	5.75
Chalk, light precipitated	Lb.	4¾ @	5
China Clay, imported	Ton	17.50 @	30.00
Feldspar	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered	Ton	nominal	
Fuller's Earth, domestic	Ton	20.00 @	30.00
Glauber's Salt, in bbls	100 Lbs.	1.50 @	3.00
Green Vitriol, bulk	100 Lbs.	1.15 @	1.25
Hydrochloric Acid, commercial, 20°	Lb.	3½ @	4
Iodine, resublimed	Lb.	4.25 @	4.30
Lead Acetate, white crystals	Lb.	15¾ @	16
Lead Nitrate	Lb	nominal	
Litharge, American	Lb	10 @	10½
Lithium Carbonate	Lb.	1.50	
Magnesium Carbonate, U. S. P.	Lb.	18 @	20
Magnesite, "Calcined"	Ton	40.00 @	65.00
Nitric Acid, 40°	Lb.	8½ @	9
Nitric Acid, 42°	Lb.	9¾ @	10
Phosphoric Acid, 48/50%	Lb.	26	
Phosphorus, yellow	Lb.	1.60 @	1.70
Plaster of Paris	Bbl.	2.00 @	2.50
Potassium Bichromate, casks	Lb.	45 @	47
Potassium Bromide, granular	Lb.	1.35 @	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	45 @	55
Potassium Chlorate, crystals, spot	Lb.	41 @	42½
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%	Lb.	83½ @	84
Potassium Iodide, bulk	Lb.	3.75 @	4.00
Potassium Nitrate	Lb.	28 @	30
Potassium Permanganate, bulk	Lb.	4.00 @	4.10
Quicksilver, flask	75 Lbs	125.00 @	135.00
Red Lead, American, dry	Lb.	10 @	10½
Salt Cake, glass makers'	Ton	30.00 @	35.00
Silver Nitrate	Oz.	55½ @	56½
Soapstone, in bags	Ton	10.00 @	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.90 @	2.95
Sodium Acetate	Lb.	16 @	17
Sodium Bicarbonate, domestic	100 Lbs.	2.50 @	3.00
Sodium Bichromate	Lb.	25 @	25½
Sodium Chlorate	Lb.	24 @	25
Sodium Cyanide	Lb.	40 @	43
Sodium Fluoride, commercial	Lb.	17 @	18
Sodium Hyposulfite	100 Lbs.	2.50 @	3.00
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.50 @	4.60
Sodium Silicate, liquid, 40° Bé	100 Lbs.	1.30 @	1.35
Sodium Sulfide, 60%, fused, in bbls	Lb.	5	
Sodium Bisulfite, powdered	Lb.	8 @	10
Strontium Nitrate	Lb.	23	
Sulfur, flowers, sublimed	100 Lbs.	nominal	
Sulfur, roll	100 Lbs.	nominal	
Sulfuric Acid, chamber 66° Bé	Ton	45.00 @	50.00
Sulfuric Acid, oleum (fuming)	Ton	75.00 @	80.00
Talc, American white	Ton	15.00 @	18.00
Terra Alba, American, No. 1	100 Lbs.	1 17½	
Tin Bichloride, 50°	Lb.	55 @	56
Tin Oxide	Lb.	75 @	80
White Lead, American, dry	Lb.	9 @	9½
Zinc Carbonate	Lb.	25 @	30
Zinc Chloride, commercial	Lb	10½ @	11
Zinc Oxide, American process XX	Lb.	13½ @	14

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	80 @	82
Acetic Acid, 56 per cent, in bbls	Lb.	11 @	11½
Acetic Acid, glacial, 99½%, in carboys	Lb	35 @	36
Acetone, drums	Lb	nominal	
Alcohol, denatured, 180 proof	Gal.	69 @	70
Alcohol, sugar cane, 188 proof	Gal.	4.85 @	5.00
Alcohol, wood, 95 per cent, refined	Gal.	1.35 @	1.37
Amyl Acetate	Gal.	5.10 @	5.25
Aniline Oil, drums extra	Lb.	26 @	28
Benzoic Acid, ex-toluol	Lb.	5.50 @	5.75
Benzol, pure	Gal.	35 @	40
Camphor, refined in bulk, bbls	Lb.	85 @	88
Carbolic Acid, U. S. P., crystals, drums	Lb.	54 @	57
Carbon Bisulfide	Lb.	7½ @	8
Carbon Tetrachloride, drums, 100 gals	Lb.	15½ @	16
Chloroform	Lb.	63 @	65
Citric Acid, domestic, crystals	Lb.	75 @	78
Creosote, beechwood	Lb	1.90 @	2.00
Cresol, U. S. P.	Lb.	18 @	20
Dextrine, corn (carloads, bags)	Lb	7½ @	8½
Dextrine, imported potato	Lb.	18 @	20
Ether, U. S. P. 1900	Lb.	27 @	30
Formaldehyde, 40 per cent	Lb.	20 @	21
Glycerine, dynamite, drums included	Lb.	63½ @	64
Oxalic Acid, in casks	Lb.	45 @	46
Pyrogallic Acid, resublimed, bulk	Lb.	3.15 @	3.25
Salicylic Acid, U. S. P.	Lb.	1.05 @	1.15
Starch, cassava	Lb.	—	
Starch, corn (carloads, bags) pearl	100 Lbs.	6.30 @	6.45
Starch, potato, Japanese	Lb.	10¾ @	11
Starch, rice	Lb.	8 @	10
Starch, sago flour	Lb.	6½ @	7¼
Starch, wheat	Lb.	5 @	7
Tannic Acid, commercial	Lb.	55 @	60
Tartaric Acid, crystals	Lb.	75 @	77

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	58 @	62
Black Mineral Oil, 29 gravity	Gal.	25	
Castor Oil, No. 3	Lb.	29 @	29½
Ceresin, yellow	Lb.	14 @	18
Corn Oil, crude	100 Lbs.	18.65 @	18.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½ @	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.25	
Menhaden Oil, crude (southern)	Gal.	— @	—
Neat's-foot Oil, 20°	Gal.	2.87 @	3.05
Paraffin, crude, 118 to 120 m. p.	Lb.	8 @	8¼
Paraffin Oil, high viscosity	Gal.	38 @	39
Rosin, "F" Grade, 280 lbs.	Bbl.	7.15 @	7.20
Rosin Oil, first run	Gal.	35 @	—
Shellac, T. N.	Lb.	59 @	60
Spermaceti, cake	Lb.	30 @	31
Sperm Oil, bleached winter, 38°	Gal.	2.35 @	2.36
Spindle Oil, No 200	Gal.	36 @	37
Stearic Acid, double-pressed	Lb.	27¼ @	28½
Tallow, acidless	Gal.	1.58 @	1.60
Tar Oil, distilled	Gal.	33 @	34
Turpentine, spirits of	Gal.	48 @	48½

METALS

Aluminum, No. 1, ingots	Lb.	37 @	40
Antimony, ordinary	Lb.	13¾ @	13¾
Bismuth, N. Y.	Lb.	3.30 @	3.35
Copper, electrolytic	Lb.	23½ @	—
Copper, lake	Lb.	nominal	
Lead, N. Y.	Lb.	6¾ @	7
Nickel, electrolytic	Lb.	55 @	56
Platinum, refined soft	Oz.	108.00	
Silver	Oz.	86½ @	90
Tin, Straits	Lb	nominal	
Tungsten (WO_3)	Per Unit	20.00 @	26.00
Zinc, N. Y.	Lb.	8 @	8¼

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.40 @	7.50
Blood, dried, f. o. b. Chicago	Unit	6.50 @	6.55
Bone, 3 and 50, ground raw	Ton	30.00 @	32.00
Calcium Cyanamid	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian	100 Lbs.	—	
Castor Meal	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works	Unit	nominal	
Phosphate, acid, 16 per cent	Ton	18.00	
Phosphate rock, f. o. b. mine:	Ton	nominal	
Florida land pebble, 68 per cent	Ton	3.25 @	3.50
Tennessee, 78–80 per cent	Ton	5.50 @	6.00
Potassium "muriate," basis 80 per cent	Ton	345.00 @	350.00
Pyrites, furnace size, imported	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	6.40 &	7.10

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | APRIL 1, 1918 | No. 4

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY, M. C. WHITAKER

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.

Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**

Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- The Chemistry Rainbow 254
- The Parting of the Ways 254
- What's in a Name? 255
- Camp Followers 255
- Organization within the Dyestuff Industry 256
- Wood Waste 256
- Important Notice 256

PRODUCT PATENTS 257

ORIGINAL PAPERS:
- Sulfite Turpentine. A. W. Schorger 258
- The Effect of Incomplete Distillation on the Yield of Products in the Destructive Distillation of Birch R. C. Palmer 260
- The Influence of Moisture on the Yield of Products in the Destructive Distillation of Hardwood. R. C. Palmer and H. Cloukey 262
- The Effect of Catalyzers on the Yield of Products in the Destructive Distillation of Hardwoods. R. C. Palmer 264
- Some Experiments on the Pulping of Extracted Yellow Pine Chips by the Sulfate Process. Otto Kress and Clinton K. Textor 268
- The Production of Nitric Acid from Nitrogen Oxides. Guy B. Taylor, Julian H. Capps and A. S. Coolidge. 270
- Influence of Time of Harvest, Drying and Freezing of Spearmint upon the Yield and Odorous Constituents of the Oil. Frank Rabak 275
- Carbonation Studies. II—The Carbonation of Distilled Water. Harrison E. Patten and Gerald H. Mains 279
- Examination of American-Made Acetylsalicylic Acid. Paul Nicholas Leech 288
- The Determination of Arsenic in Insecticides by Potassium Iodate. George S. Jamieson 290

LABORATORY AND PLANT:
- Notes on Sodium Cyanide. W. J. Sharwood 292
- A Comparison of the Proximate and Mineral Analysis of Desiccated Skim Milk with Normal Cows' Milk. Everhart P. Harding and Hugo Ringstrom 295
- An Improved Automatic Pipette-Washing Device. Aubrey Vail Fuller 297

ADDRESSES:
- Methods of Gas Warfare. S. J. M. Auld 297
- The Consumption and Cost of Economic Poisons in California in 1916. George P. Gray 301
- The Debt of Preventive Medicine to Chemistry. George W. Goler 303

WILLIAM H. NICHOLS MEDAL AWARD:
- Introductory Address. Charles H. Herty 305
- Presentation Address. William H. Nichols 305
- Acceptance of Medal. Treat B. Johnson 306
- The Development of Pyrimidine Chemistry—Medal Address. Treat B. Johnson 306
- Message from Prof. Bogert 312

CURRENT INDUSTRIAL NEWS:
- The Ekenberg Peat Process; Norwegian Iron Industry; Magnetic Separations and the Rarer Metals; New Source of Alcohol; New Rust Prevention; Transvaal Deposits of Chrome Ore and Magnesite; New Oil Nuts; Catalytical Bleaching of Oils; Gas-Heated Isothermal Room; Magneto Ignition; Detachable Engines for Ships; Synthetic Materials; Insulating Material; Laminated Belting; British Board of Trade. 312

SCIENTIFIC SOCIETIES:
- Tentative Standard Methods for the Sampling and Analysis of Commercial Fats and Oils 315
- Saving Fats from Garbage 320
- American Institute of Mining Engineers 321
- American Electrochemical Society 321
- Calendar of Meetings 321

NOTES AND CORRESPONDENCE:
- Revised Statement from the Chemical Service Section; Preparedness Census; Government Control of Platinum; Platinum Resolution by the Argentine Chemical Society; Licensing of Fertilizer Industry Ordered; Research Information Committee; Dyestuffs Association; Food in War Time; Meeting War Conditions at Rensselaer Polytechnic Institute 321

WASHINGTON LETTER 325

UNVEILING OF THE PORTRAIT OF HERMAN FRASCH 326

PERSONALS 327

INDUSTRIAL NOTES 329

GOVERNMENT PUBLICATIONS 331

NEW PUBLICATIONS 333

MARKET REPORT 334

EDITORIALS

THE CHEMISTRY RAINBOW

After all, the hammer is a strictly constructive tool if used with constructive intent. It has been frequently used in these columns, but always with the hope of aiding to some extent the erection of that great structure of national equipment of men and resources which constitutes the contribution due from this mighty nation to the welfare of the human race in the present world conflict. It is helpful, however, to get away from the sound of the hammer occasionally and to note what progress has been made—not for the sake of indolent satisfaction, but to gain strength and soundness of judgment for more vigorous blows. For this reason there are recorded here, without regard to sequence, the following notes:

1—The Chemical Service Section of the National Army has reached France and is now located in its research laboratory, a remodeled factory building placed at its disposal by the French Government. Major Hamor writes that all are well.

2—Platinum has been commandeered by the Government. The campaign begun at Kansas City a year ago is ended. The metal can now hold up its head with justifiable pride, because of its functional metamorphosis from vainglorious adornment of the *nouveau riche* to the more appropriate rôle of catalyst in acid manufacture. What about that scrap platinum, odds and ends, lying about your laboratories? Every little bit helps.

3—Toluol has been taken over and is being made available in gradually increasing quantities. (This is not one of the bright tints in the rainbow.)

4—The recovery of spruce turpentine, a new industry, proceeds apace.

5—Work is now in full swing on the compilation of statistics for the census of chemical imports other than dyestuffs. A publication is here assured which has finally enlisted the hearty, sympathetic and enthusiastic support of many departments of the national government. The lines of its conception and the thoroughness of execution of the work insure a publication which will furnish the world a model of its kind.

6—Lieutenant Colonel Wm. H. Walker has been promoted to a Colonelcy and, attached to the Ordnance Department, is now at the head of one of the most important undertakings of the Government. May his "pep" never grow less!

7—Professor M. T. Bogert has donned the khaki and as Lieutenant Colonel will head the Chemical Service Section of the National Army on this side.

8—Practically all of the chemists in the National Army have now been transferred from camp to the laboratories of the Government or the industries, where their highest service to the country can be rendered.

9—The membership of the AMERICAN CHEMICAL SOCIETY continues to grow so rapidly that Secretary Parsons has within the past month ordered a further increase in the issue of each of the journals.

10—A new championship series is on! Talk about running up big scores—the Delaware Works of the General Chemical Company boasts in the March number of *The General Chemical Bulletin* that in proportion to the size of its executive and technical staff it has a larger membership in the AMERICAN CHEMICAL SOCIETY than any other plant. Reading the tabulated score we notice that runs were made by two superintendents, one assistant superintendent, and four foremen, in addition to the chemists of the staff. Some scoring machine that! On with the game! Spring is here and baseball is in the air. Away with the hammer! Let's try the bat awhile. We hereby apply for the position of "official scorer" in this new form of sport.

Already we have exceeded the number of primary colors in our chemistry rainbow. What difference does that make? Let the physicists revise their listings of the tints. All together for America!

THE PARTING OF THE WAYS

The Chemists' Club of New York is an unique institution. Nowhere else in the world have chemists such an organization with such complete club house accommodations. In addition to its resident membership it carries on its roll a large number of non-resident members. Visiting chemists have given up the hotel habit and nightly tax its housing facilities to the limit. Outside of Washington it is probably the greatest center of activity in chemistry in this country today.

For these reasons the Club cannot be considered a purely local affair, but rather a national institution, and being such it must measure up to the national standard of straight-out Americanism. We are on the threshold of nation-wide suffering and loss such as this country has never before known. The day of wrath is soon to come in our land, and with the Trustees of the Club rests the responsibility of setting our house in order in anticipation of that day whose coming no human being can now prevent.

It is natural that the Club should number among its members many German chemists, for such have constituted an important group among the working chemists in America. With the exception of one recent unfortunate undertaking the German element in the Club has, for the most part, quietly absented itself from the club building, thereby lessening the chance of friction which might so easily develop in these days. So unobtrusive, too, and so kindly has been the attitude of those who still frequent the Club

that nothing but equally kindly personal feelings have been engendered by such association. We are not moved in this writing by any personal animus, but do wish to emphasize the fact that men's emotions are changing with the gradual lengthening of the casualty lists, that, with the news, certain to come in the near future, of Hun atrocities practised upon American soldiers, feelings will be aroused which will brook no companionship nor association with those whose allegiance lies with that country whose ruthless ambition has plunged the human race into a world war.

Within the walls of the Club building there now frequently gather chemists enlisted in our army, or connected in a civilian capacity with the military branch of the Government. No restraint should be placed upon their intercourse by the presence of alien enemies. In the rooms of the Club many important committees meet. Should a watchful eye be needed in an American club? In the library works of reference need to be consulted. Should this room be a common meeting ground for Americans and Germans? Should any of its laboratory space be rented to an alien enemy while there are American chemists unable to secure quarters in its building because of the limited number of rooms available for laboratory purposes?

In forbidding the employment of German waiters in the dining room the Trustees have taken one highly desirable step, particularly in view of the recent incident, narrated to us, of an American chemist recognizing in the waiter of a Wilmington hotel dining-room his former German university professor of chemistry. It is no time to take chances: that is one of our outstanding national failings, and again and again we pay the penalty. The Trustees should make the Club an American institution throughout. To do this would require dropping from its membership list every alien enemy and sympathizer, and dismissing from its service any employee whose allegiance or heart-interest lies with those with whom we are at war.

Why should the vote of an alien enemy be in any degree determinative of the policies of the Club or the personnel of its officers? Yet as members, even though absenting themselves, this power is conferred in proportion to their number.

If it be argued that the elimination of alien enemies would not fully remedy the evil because of the possible presence of naturalized citizens who masquerade behind their naturalization papers, our only reply is—hunt these down with every agency the country furnishes and with all celerity forbid them the doors of the Club.

Finally, if it be argued that this drastic action would seriously impair the finances of the Club, we would reply that the argument would admit of only one interpretation, namely, that the Club had sold its birthright. On the other hand should this policy really prove a serious strain on the finances of the Club, and this fact become known, we are confident that there would be a rush of new non-resident members from among loyal American chemists which would tax the energies of the membership committee and more than make good any deficiency in the Club's finances.

We are at the parting of the ways. If the Chemists' Club is an American institution—make it truly such.

WHAT'S IN A NAME?

The answer to this question in so far as it applies to acetylsalicylic acid (popularly known as aspirin) is the difference between eighty-eight cents, the price the druggist must pay for every one hundred tablets of Bayer aspirin, and forty cents, the cost of an equally pure American product. Naturally, this difference in cost is passed on to the individual consumer.

That no scientific justification exists for this difference in cost is clearly shown in the contribution by Dr. Paul Nicholas Leech, of the Chemical Laboratory of the American Medical Association, page 288 of this issue.

On the other hand, the excess profit fully warrants the extensive and shrewdly-worded advertising campaign now in progress, a campaign which must eventually fail, because in the first place, it is contrary to the prevailing spirit of modern advertising, the motive of which is constructive rather than destructive, and, in the second place, it appeals merely to the temporary ignorance of the public at large, and has no basis in fact.

We have been informed that the Custodian of Alien Enemy Property has taken charge of the stock interests of alien enemies in the company conducting this propaganda. Surely the Custodian will not care, even in a trustee capacity, to continue as a participant in a misleading campaign whose sole purpose is the perpetuation of a monopoly hitherto enjoyed under full patent protection.

CAMP FOLLOWERS

It was to be expected that along with the great development of the chemical industries which has characterized this war period the "camp follower" would appear. The army of industrial chemists has won victory upon victory. For the first time in our history the details of the campaigns have been widely heralded by the daily press; much publicity has been given to large earnings. Popular interest has attached to the doings of the chemist.

To take advantage of such a state of mind is the normal activity of certain promoters who are ever alert to fleece the unwary public whenever "a good thing" appears. There is nothing novel in this situation. The oil industry has known its meaning, so too the mining world has been particularly susceptible to such influences. Stock companies have been organized with enormous authorized capital, prospectuses issued on fairy-like propositions and shares offered to the public at ridiculously low figures. The

bait is usually so apparent that it would seem no one would bite—and yet some always do. The losses are pocketed, and shame and regret serve as cloaks to conceal the rawness of the deal.

At present chemical industry is afflicted with a transfer of such activities to its field. The mails are being flooded with literature, even the daily papers are yielding their advertising columns to the announcement of get-rich-quick chemical processes whose impossibilities are too apparent ever to delude chemists. There are those, however, to whom it does not occur to turn to a chemist for advice before investing in a so-called chemical enterprise.

Here is an opportunity for public service which the chemist must embrace, a service of exposure due the public and due the continued healthy growth of chemical industry. We may have something more specific to say on this matter in a later issue if, meanwhile, the duly constituted authorities have not dispersed these money sharks, here dignified by the term "camp followers."

ORGANIZATION WITHIN THE DYESTUFF INDUSTRY

Efforts made during the past two months to organize the dyestuff industry developed the fact that two distinct interests were involved, the manufacturers and the dealers. At the preliminary meeting it was evident that a strong desire existed among the manufacturers to confine the membership to this class alone, but a compromise was effected whereby the dealers were admitted to associate membership without voting power. Thinking it over, the manufacturers decided that this policy was not sound and that the membership should be confined to manufacturers. The second meeting, held on March 6, developed a most unusual situation, the dealers insisting that they be included in the organization, while the manufacturers said, "Nay, nay." Of course the manufacturers' fight was won from the outset. No one could compel them to be part of an organization whose composition was not to their liking.

Unfortunately for the dealers the two main arguments put forward in behalf of their contention were neither good strategy nor popular propaganda. First, the plea for general harmony implied that, lacking such harmony, the dealers would be forced into Teutonic arms after the war is over, a position no body of loyal Americans could contemplate at the present time with any degree of satisfaction on the one part or admiration on the other. Second, the threat that, unless admitted, the dealers might as a safeguard to their own interest oppose before Congress a tariff sufficiently high to protect the American against the German industry was so amazing that it suggested that, although some of the leading dealers may not have been conscious of the fact, German agents may have been the real promoters of this argument. The joke is that those who put forward the latter argument failed to realize the fact as we see it that sentiment in Congress favoring the thorough guarding of the American dyestuff interest exceeds even that of the country at large, for Congress has fully grasped the idea that the dyestuff industry is not only an economic necessity as a key industry, but, more important still, that it constitutes an invaluable reserve for high explosives manufacture.

Perhaps, after all, these arguments were simply childishness.

WOOD WASTE

In this issue we have segregated a number of contributions dealing with wood as the raw material of certain lines of chemical industry. The topic is especially timely in view of the need of acetic acid for the aviation program, spruce turpentine for munitions, and paper for the daily chroniclers of the stirring events of the war.

There is now in progress within the organization of the AMERICAN CHEMICAL SOCIETY a campaign for the constant discussion of national wastes, and the subject of wood waste is certainly a preëminently suitable topic. According to A. D. Little, "two-thirds of the tree is at present wasted either as litter in the field or as mill waste." According to the same authority 6.48 per cent of the tree is stump, the name carrying with it the idea of sheer waste.

Is it too great a tax upon the imagination to conceive a vision of the mounting financial liabilities of this war converted into actual assets through the focussing of the thought and attention of chemists upon the subject of national wastes? By no means.

IMPORTANT NOTICE

In the March issue of THIS JOURNAL, page 237, there was published a communication from J. R. Healy, Federal Licensing Agent for Greater New York, regarding "Licenses Required for Explosives and Their Ingredients." Mr. Healy pointed out the necessity, under the recent Act of Congress, of securing licenses from the Bureau of Mines or authorized agents and gave a list of explosives and ingredients of explosives requiring license, the latter when purchased in amounts of one ounce or more

We are informed by dealers that many orders for these products, especially the ingredients of explosives, are being received without license attached. Endless trouble is therefore accumulating for all concerned. For this reason we urge upon all who are responsible for the ordering of chemicals a careful reading of the notice in the March issue.

To those who have been accustomed to order potassium chlorate, lead nitrate, etc., without any thought save the cost of the article, the trouble involved in securing licenses may seem like a further evidence of red tape, but chemists above all others will at once recognize the absolute necessity of such a law at this time.

If explosives or ingredients of explosives are to be purchased licenses must be secured.

PRODUCT PATENTS

By K. P. McElroy

Once in every so often somebody of a guileless turn of mind asks me what a "product patent" is and it rather peeves me, for one can't define the non-existent. There is not, never was, and likely never will be a "product patent:" a patent on a product as a product. The law does not authorize any such patent. We who concern ourselves with patents, like other specialists, have an argot of our own, and our words and phrases are not always what they seem. We are much interested in certain legal relationships between a process and its product; and we chatter considerably of product claims, and even of product patents, when we are really talking about claims for a composition or for an article. And the innocent bystander, taking our vocabulary for his own, goes away with the impression that a patent can be had on some disembodied ghost of a "product;" and then he comes around and bothers me with his mental nebulosities.

The statute under which we work says nothing about a product, but it does define as patentable "any new and useful art, machine, manufacture or composition of matter." Four statutory classes are established and anything patentable must be included in one of these four classes. An "art" is a process or method: a way of doing things; and it always results in a product. This product may be a machine or a manufacture or a composition of matter. It is not patentable unless it is one of the three. Conversely, any machine, or any manufacture or any composition of matter is a product; it is a product of some "art." A process may be novel and the product old, as in a new way of making flapjacks; or both the process and the product may be new. In the latter event the process and the product may be, and usually are, the result of the same mental inventive act; but since they are in separate statutory classes they are, legally, different inventions and must be separately patented; either as different claims in the same patent or as claims in separate patents—the product of course being claimed as what it is, as a machine or a manufacture or a composition. Being separate inventions, each must stand on its own legs; and the patentability of the one is in no way affected by the patentability of the other. No matter whether the product is a machine, or an article or a composition, to be patentable it must be novel in and of itself, and irrespective of any novelty in the process by which it is produced. A composition may be a mechanical mixture or a chemical compound; and it may be novel because things are brought together which were never brought together before, or because they are assembled in a new way (as in a coated granule) or because, though old in make-up, the composition is in a new condition or state; because it has some different form, or characteristic, or property. It does not matter wherein the novelty resides as long as the composition is new and useful. But if it is new, then the novelty must be capable of being pointed out in some way; there must be a test or a characteristic which can be utilized to show that the alleged new composition is indeed new; it may be because it is pink, or is soluble in alcohol, or has a particular melting point or almost anything. If there is no test and no characteristic which will differentiate it from an old thing which the public has the right to use, then it is the same as the old thing. As a matter of common sense, if the new thing cannot be differentiated from the old thing then there is no difference. And it cannot be made different by talking about its past history; by reciting differences in the process by which it is made. That particular experiment in patent law was made by the Badische at the time of the alizarine synthesis when it claimed "artificial" alizarine as a new composition. The Supreme Court remarked, in effect (Cochrane *vs.* Badische, 111 U. S. 293), that if the new artificial alizarine was exactly the same thing as the old natural alizarine then it was exactly the same thing and calling it "artificial" did not make it different. Of course, sometimes we have to characterize substances by adjectives which look a little process-y because they happen also to be past preterits of verbs, as in talking of a boiled ham or a fried egg or wrought iron, but this does not militate against the general proposition that a thing to be patentable must be differentiated from old things by stating its properties or its characteristics; and that it must be new in itself and not new because of the process by which it was made, *i. e.*, it is not made novel by being a "product."

I regret to say that the nebulous-minded gentlemen with their misconception of "product patents" instead of merely infesting my office, are getting into print and into Congress. And in this there is a certain danger. Mrs. Malaprop was a very pleasant lady; but it was not safe to entrust any business to her. In the present mood of Congress and the people, a proposition to revise the multiplication table, if backed by a good patriotic showing, might slip through. And these gentry wish to abolish "product patents" feeling in some vague way that this will hurt Germany and help us. I do not see how it will do either; but I am somewhat hampered by my inability to grasp exactly what they mean by a "product patent" anyway. If they mean "product" in its legitimate ordinary sense, then the proposition is an absurdity because it is to abolish all patents save patents on processes. For everything that man can make is a product, and it is a product of a process of making: perhaps a patentable process and perhaps an unpatentable one; but still a process.

However, being something of a mind-reader, albeit my education in this line was somewhat neglected, I surmise that what is actually meant is the abolition of patents on the products of really-and-truly chemical processes. If this be so, it leaves intact two more of our statutory classes since a machine and a manufacture are commonly products of mechanical or

physical methods; but it makes the fourth class, the composition of matter, look like the remnants of the shell-shot cathedral at Rheims, with patentability hanging on by an eyelash. It is not abolished—not all of it; just most of it. Some compositions will be patentable and some not—those whose pedigree is in any way tainted with the "chemical." A little chemistry will damn a thing quite as effectually as a great deal since courts will not draw distinctions between much and little, that being purely a "question of degree." The alibi of the guiltless inventor would have to be absolute, and there might be some difficulty of proving it in the absence of any universally accepted definition of "chemical." At present neither I nor anybody else can write an impeccable definition of the word, one which would stand fire in court. I do not even know, for example, whether dissolving sugar in water is a "chemical" process.

Shifting the anathema to "chemical compound" does not help any, since if a chemical compound is something resulting from chemical action (which is as good a definition as any) we come out the same hole we went in, with the additional burden of defining a "compound." In a general way I know what a compound is; we all do. It is a body composed of two or more elements united in definite proportions, which, however, is just as true of type metal as of aniline; or, for that matter, of any good uniform grade of cast iron.

I fear me that any attempt to sort out the chemical goats from the physical sheep in the composition of matter class would prove like the task of hunting polar bears in purgatory—"apt to be arduous in detail and disappointing in result." There are too many hybrids, goatish sheep and sheepish goats. It would be simpler to abolish the whole class at one fell whack. But I do not understand anybody wants to do this. So far as I understand, the chemist is the only chap it is meant to ostracize; and even he may escape if he does not have intelligence to know what is happening when he stews two things together.

Despite the present popularity of class legislation, being a hidebound Republican I do not like it; and as a chemist I object to being the class if the legislation is discriminatory against me. To deprive the chemist of his reward for his labor by taking away his "product" claim (whatever that "product" claim may be) is the same to him as depriving the machinist of his claim to his machine or the weaver to his new article in the way of a fabric. It is not good equity; and moreover it is not good sense. The object of the patent laws is to promote the progress of science and the useful arts, and that they have fulfilled their mission is beyond a peradventure. Why stop now and stop in a single science? For 125 years (to be exact, since Feb. 21, 1793) the chemist has been as much entitled to look forward for reward for what he did as anybody else; he read his title just as clear as did the machinist. Maybe I am biased, and very likely I am, but I can't, for the life of me, see wherein there is any legal or equitable difference between the standing of the chap who puts together an alkyl radical and an aryl radical to make a new drug or a new dye and the man who puts together levers and keys to make a new typewriter. That the product of one is sold in a bottle and the product of the other in a box is not material. Any argument that seeks to discriminate between them is as lop-sided as a crane; and I don't like being on the wrong side of the lop. It is at least as much an object to the public to encourage the chemist by patents as it is to encourage the machinist. Both are human and, commonly, poor, and neither is going to strain his ingenuity working nights unless he sees a patent ahead.

Running through all this "product patent" talk like a rotten streak in a mushy banana, is the idea that the chemist who creates a new drug or dye that becomes a public necessity as soon as its creation and existence are known to the public is guilty of creating public necessities to his own profit, and he ought to be discouraged; or if he won't be, then he should not be allowed to make the profit—which sounds like a curious piece of mental perversion, worthy of the gentleman who habitually stood on his head to peel the apple dumplings; but I am not gilding the lily any in reproducing it—far from it; I am merely condensing and Englishing certain actual arguments which have been made.

WASHINGTON, D. C.
February 18, 1918

ORIGINAL PAPERS

SULFITE TURPENTINE

By A. W. SCHORGER

Received February 5, 1918

During the recovery of the sulfur dioxide, in the manufacture of pulp by the sulfite process, a small amount of oil collects on the surface of the liquor in the separator and is known as sulfite turpentine. The oil varies in color from pale yellow to black and is frequently strongly impregnated with sulfur dioxide. Various mills have reported a recovery of 0.36 to 1.0 gal. of turpentine per ton of pulp. The species of wood employed in order of their importance are spruce, balsam, and hemlock. It has been reported that no oil is obtained from cooking hemlock.

The United States produced 1,027,000 tons of sulfite pulp in 1909 and Canada produced 470,948 tons in 1916. The present annual production in the two countries exceeds 1,500,000 tons. Granting a recovery of only 0.5 gal. per ton, there should be available annually about 750,000 gal. of this turpentine.

Klason[1] appears to have first called attention to

[1] *Ber.*, **33** (1900), 2343; cf. Kondakow and Schindelmeiser, *Chem.-Ztg.*, **30** (1906), 722; Kertesz, *Ibid.*, **40** (1916), 945.

the fact that the oil so obtained consists mainly of *p*-cymene and not of terpenes. The only reference found to the American oil is the statement of Herty and Graham[1] that sulfite turpentine consists mainly of cymene.

Cymene does not appear to be employed for any specific purpose. Verley[2] used it as the basis of a synthetic violet-like perfume. Dinesman[3] prepares thymol by a method unlikely to compete with the natural product; 2-Br-*p*-cymene is transformed to the 3- or 5-sulfonic acid. After elimination of the bromine by long heating in an autoclave with zinc dust and ammonium hydroxide, the cymene sulfonic acid is fused with potassium hydroxide to obtain thymol. In a previous paper[4] the writer has shown that by the action of aluminum chloride on cymene there are formed diisopropyl, benzene, toluene, *m*-xylene, and 1-methyl-3,5-diisopropyl benzene. The yield of toluene may amount to 40 per cent of the weight of the cymene, but this reaction cannot be employed economically except when very unusual prices prevail for toluene. Cymene also yields toluene by "cracking" processes.[5]

EXAMINATION OF THE OIL

Oils from three widely separated mills were distilled, using a 12-in. Hempel column with the following results:

Obtained from	Composition of Wood Per cent	Distillate: Up to 175° Per cent	175°–176° Per cent	176°–177° Per cent	177°–178° Per cent	178°–182° Per cent	Residue Per cent
Niagara, Wis..	Spruce 100	1.11	7.76	84.03	...	...	6.65
Erie, Pa.....	Spruce 90						
	Balsam 10	7.66	15.18	39.60	33.66	...	3.74
Berlin, N. H..	Spruce 65						
	Balsam 35	0.43	2.57	22.00	19.00	35.00	8.81

The older oils when distilled usually give off considerable hydrogen sulfide. The distillation data indicate that the cymene content is greatest when all spruce is cooked.

IDENTIFICATION OF CYMENE

Characteristic of cymene is the barium salt $(C_{10}H_{13}.SO_3)_2Ba.3H_2O$, sparingly soluble in water from which it crystallizes in shiny plates. The salt is best prepared as follows: To 50 g. of cymene in a flask are added 100 g. of fuming H_2SO_4 (10 per cent free SO_3). Shaking develops considerable heat and the solution is complete in about 10 min. The liquid is cooled, poured into a separating funnel, and about one-third of its volume of cold water added. On rotating the funnel carefully two layers are formed, the upper consisting of cymene sulfonic acid, and the lower of dilute sulfuric acid free from sulfonic acid. The cymene sulfonic acid should be dissolved in about 5 liters of boiling water, neutralized with barium carbonate, and the $BaSO_4$ filtered off. After removal of the salt of the 2-sulfonic acid, the filtrate contains the salts of the 3-sulfonic acid and disulfonic acid that can be separated with alcohol.[6] The yields of the three salts from 50 g. of cymene were 79.9 g., 14.6 g., and 4.2 g., respectively.

When 35.4 g. of the anhydrous barium salt of the 2-sulfonic acid were heated with an equal weight of PCl_5 and the amide formed by heating with ammonia in the ordinary way, the yield of the cymene sulfamide was 18.93 g. (70.7 per cent of theoretical). The amide, recrystallized from water, melted at 114°.

The cymene was also oxidized to *p*-oxyisopropyl benzoic acid, m. p. 155°. As good results are obtained when only half of the amount of $KMnO_4$ given by Wallach[1] is used. This method is somewhat tedious and the yields are poor.

Cymene has been found to react readily with chlorosulfonic acid and when an approximately pure cymene is present this offers a superior means of identification. With the terpenes chlorosulfonic acid reacts with explosive violence. An equal volume of chlorsulfonic acid is gradually added, with constant shaking, to the cymene. The mass foams considerably, but the reaction soon completes itself with only a slight rise of temperature. The chlorosulfonic acid is separated by pouring into a separating funnel containing water, extracted with ether, and the ether extract washed with water to remove inorganic acids. After evaporation of the solvent the cymene chlorosulfonic acid is transformed to the sulfamide by heating with concentrated ammonia on the steam bath. The sulfamide is recrystallized from hot water, using a little animal charcoal. The method is rapid and the yields are excellent.

SULFAMIDE OF *p*-OXYISOPROPYLBENZOIC ACID—Ten grams of cymene sulfamide were oxidized by heating on the steam bath with 30 g. of potassium permanganate in 2 liters of water. The manganese sludge was filtered off, the filtrate evaporated to dryness and extracted with hot 95 per cent alcohol. The alcohol was evaporated and the residue extracted with hot commercial absolute alcohol. On cooling, the potassium salt of *p*-oxyisopropylbenzoic acid sulfamide was deposited as warty masses. The salt was dried at 110° for 48 hrs. and the potassium content determined as follows:

0.4950 g. salt gave 0.1403 g. K_2SO_4.

Calculated for $C_3H_6(OH).C_6H_3 < \begin{matrix} SO_2.NH_2 \\ COOK \end{matrix}$: K = 13.18. Found: K = 13.13.

CARVACROL FROM CYMENE

The annual importation of thymol has been about 6000 lbs.[2] In their physiological and antiseptic properties thymol and carvacrol appear to be very similar. A number of iodine compounds,[3] such as "aristol" and "annidalin," prepared from thymol, are reputed to possess very strong antiseptic properties. A similar compound,[4] "iodocrol," prepared from carvacrol, has been made in this country for several years.

The 2-sulfonic acid of cymene can be easily prepared, but the fusion with alkali as carried out on a

[1] THIS JOURNAL, **6** (1914), 803.
[2] German Patent 101,128 (1897).
[3] German Patent 125,097 (1901).
[4] *J. Am. Chem. Soc.*, **39** (1917), 2671.
[5] Rittman, British Patent 13,100, September 13, 1915.
[6] Claus, *Ber.*, **14** (1881), 2140.

[1] *Ann.*, **264** (1910), 10.
[2] Hood, U. S. Department of Agriculture, *Bulletin* **372**.
[3] Messinger and Vortmann, *Ber.*, **22** (1889), 2316; **23** (1890), 2754; Bayer & Co., German Patent 49,739.
[4] U. S. Patent 561,531 (1906); cf. Bayer & Co., German Patent 53,752 (1889).

small scale gave very poor yields of carvacrol. It is very probable, however, that satisfactory yields could be obtained from larger apparatus capable of more careful control.

CARVACROL—The calcium and barium salts of cymene sulfonic acid were made in the manner described above. The calcium salt is much more soluble than the barium. The sodium salt was prepared by decomposing a weighed amount of the barium salt with sodium carbonate in aqueous solution and evaporating to dryness after filtering off the barium carbonate.

The fusion was carried out by placing the sulfonic acid salt in a nickel dish on a sand bath and adding the alkali dissolved in a minimum amount of water, and gradually raising the temperature of the fused mass to about 300°, with constant stirring. This temperature should not be exceeded. The melt was dissolved in water, acidified, and distilled with steam. The carvacrol was extracted with ether and weighed after evaporation of the solvent. The yields of carvacrol are given in the following table:

YIELDS OF CARVACROL FROM CYMENE SULFONIC ACID

Fusion No.	Salt — Kind	Salt — Wt Grams	Alkali — Kind	Alkali — Wt Grams	Temp of Fusion	Carvacrol Yield Gms.	Carvacrol Yield % Theoretical
1	$(C_{10}H_{13}SO_3)_2Ca\ 2H_2O$	10.00	KOH	30	300°	2.45	41.0
2	$(C_{10}H_{13}SO_3)_2Ca.2H_2O$	10.00	K_2CO_3	30	300°	0	. .
3	$(C_{10}H_{13}SO_3)_2\ Ba\ 3H_2O$	10.00	NaOH	30	350°	0	. .
4	$C_{10}H_{13}SO_3Na$	7.64	KOH	30	300°	0.61	8.0
5	$C_{10}H_{13}SO_3Na$	7.64	NaOH	30	350°	0	. .
6	$(C_{10}H_{13}SO_3)_2Ca\ 2H_2O$	10.00	KOH	30	290°	1.10	18.4
8	$C_{10}H_{13}SO_3Na$	7.64	KOH	7.5	300°	0.91	18.8
9(a)	$(C_{10}H_{13}SO_3)_2Ca\ 2H_2O$	10.00	KOH	8.8	300°	3.16	52.9
10(a)	$(C_{10}H_{13}SO_3)_2Ca.2H_2O$	10.00	KOH	8.8	300°	1.68	28.9
11(a)	$(C_{10}H_{13}SO_3)_2Ca\ 2H_2O$	10.00	NaOH	6.4	290°	0.74	12.4

(a) Crucible covered during the fusion.

Other fusions conducted under different conditions gave only small yields of carvacrol and served to show the great difficulty of duplicating results. This is illustrated by Fusions 9 and 10 made under identical conditions.

IDENTIFICATION OF CARVACROL—The carvacrol obtained was identified as follows: 2.5 g. of the phenol were dissolved in dilute KOH and made up to 1.5 liters. Six grams of KNO_2 were then added and after it had dissolved the solution was strongly acidified with sulfuric acid. In a short time the carvacrol nitrite rose to the surface in a flocculent condition. The nitrite crystallized very readily, using hot 50 per cent alcohol, but after several crystallizations the compound was still impure and melted at about 147°.

It was found that the nitrite was insoluble in petroleum ether and this property afforded an easy means of purification. The carvacrol nitrite was dissolved in a minimum amount of chloroform which was slowly dropped, with stirring, into a considerable volume of petroleum ether. The precipitate was finally crystallized from alcohol. The pale yellow needles melted at 153–4°. When heated slowly they melted at 150–152°.

SUMMARY

Sulfite turpentine, consisting largely of cymene, can be used for the production of carvacrol and toluene.

FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

THE EFFECT OF INCOMPLETE DISTILLATION ON THE YIELD OF PRODUCTS IN THE DESTRUCTIVE DISTILLATION OF BIRCH

BY R. C. PALMER

Received October 17, 1917

OBJECT OF TESTS

In most hardwood distillation plants a certain amount of the wood comes out of the retorts after distillation as "brands" or "bones," that is, pieces incompletely charred. When a plant finds it necessary for economic reasons to use wood that has been insufficiently seasoned or wood excessively wet with rain or snow, it is difficult to complete the distillation in the required 24 hours. Under such conditions the amount of brands is likely to be large, amounting to as much as 8 or 10 per cent of the charge. Usually the brands are redistilled, although they are not considered as new raw material. There is no agreement among operators as to what yields are obtained by distilling the wood in two stages, that is, whether there is actually any gain or loss in products by this procedure. To the knowledge of the author, the literature reveals no data on this point. A few experiments were therefore made to determine just what effect incomplete distillation had on the yield of products in the destructive distillation of hardwood and how yields from stopping the distillation and then redistilling the residue compared with the yields from a single operation.

EXPERIMENTAL PROCEDURE

Yellow birch cord wood reduced to pieces about $2^1/_2$ in. by $2^1/_2$ in. by 16 in., not very well seasoned, was distilled in a semi-commercial laboratory retort holding about 50 lbs. of wood. The temperature in the empty retort was raised to about 340° C. and a specially constructed basket containing the wood was then quickly introduced. The start of the distillation was then similar to the start of a commercial distillation where a new charge is placed in a retort immediately after drawing out the hot charcoal from a run that has just been completed. The distillations were carried on according to the best practice of temperature control, that is, regulating the fire so that the rate of rise of temperature in the retort was decidedly decreased after the tar began to be formed. One run was made in which the distillation was normally carried to completion. In two other runs the fire was turned off when it was obvious from the amount of distillate, temperature, etc., that the distillation was not complete. Different stopping points were selected for the different runs. As the distillation had not reached the point of marked exothermic reaction in these runs it was checked very quickly after the fire was turned off.

After cooling to room temperature the retort was opened and all brands were separated from charcoal. Any stick which was brown in color, or which could not be readily fractured by a moderate blow with a hammer, was considered a brand. All the brands from incomplete distillations were allowed to remain out of doors during a heavy rain until they had absorbed water to about 3^1 per cent of the dry weight and were then completely distilled as if they were normal wood.

The crude pyroligneous acid liquor from each run was weighed, measured and separated in a clear acid and settled tar, and the clear acid liquor was then analyzed for total acid (calculated as acetic), acetic acid, formic acid, wood alcohol and dissolved tar.

RESULTS

The results of the tests in percentage of the dry weight of wood distilled are given in Table I. Runs 2 and 3 which were made on fresh wood and Run 4 which was made on the brands obtained in Runs 2 and 3 have been combined by calculation to show the total yields obtained by the complete distillation of the original wood. The yields from this calculation and the yields from Run 1 indicate the effect of a two-stage distillation compared to a single normal operation.

TABLE I—YIELD FROM THE DISTILLATION OF BIRCHWOOD AT DIFFERENT STAGES OF COMPLETION(*a*)

Run No.	Charcoal	Brands	Tar: Settled	Tar: Dissolved	Tar: Total	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol
1 Complete distillation..	42.30	0	5.52	5.28	10.80	5.52	4.92	0.44	1.41
2 Wood incomplete.....	17.66	48.00	1.93	2.91	4.84	4.53	3.92	0.48	0.885
3 Wood incomplete.....	10.77	62.96	0.87	1.73	2.60	3.44	2.99	0.36	0.447
4 Brands from 2 and 3 completely distilled...	54.50	0	4.99	4.29	9.28	2.96	2.56	0.30	1.45
Runs 2, 3, and 4 as one run.....	44.49	0	4.17	4.69	8.86	5.59	4.86	0.59	1.46

(*a*) The yields are given in per cent of the dry weight of the wood or brands distilled.

As will be noted, the distillation in two steps gives from 20 to 25 per cent less tar.

The yield of acetic acid is about 2.4 per cent lower for the double operation. The total acid, calculated as acetic, is practically the same. This is due to the fact that while the acetic acid yield is somewhat lower the yield of formic acid is about 30 per cent higher for the two-step operation. The distillation in two steps gives about 4 per cent more charcoal and 2.8 per cent more alcohol. Considering all the products it is apparent that, except for the tar, there is no appreciable loss or gain in valuable products recovered when brands are redistilled.

AMOUNT AND ORDER OF FORMATION OF PRODUCTS AT DIFFERENT STAGES OF DISTILLATION

An examination of the yield data obtained by stopping the distillation in order to make brands gives an indication of the order in which the products are formed in the destructive distillation of hardwood. The yields of each product in the incomplete runs calculated in percentage of the total obtained in a single distillation are given in Table II. When the same data are shown graphically, the percentage of total production being given as one axis against the per cent of wood left as brands as the other, the results presented are of both scientific and practical interest.

TABLE II—PROPORTION OF TOTAL PRODUCTION WHEN DIFFERENT AMOUNTS OF BRANDS ARE LEFT IN THE RETORT(*a*)

Run No.	Charcoal	Brands	Tar: Settled	Tar: Dissolved	Tar: Total	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol
1...	100.0	0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2...	41.75	48.00	34.9	55.1	44.8	82.0	79.7	100.0	62.8
3...	25.48	62.96	15.7	32.7	24.1	62.3	60.7	81.7	37.1

(*a*) The yield from a single complete distillation (Run 1) is taken as 100 per cent.

From a scientific standpoint the data are of interest in throwing some light on the order and amount of the different products formed at different stages in the distillation. The acids are the first of the valuable products to be formed[1] and it is especially interesting to note that the formic acid is formed more rapidly than the acetic. The total amount of formic acid is obtained when more than 45 per cent of the wood is left as brands. The charcoal curve does not begin at 100 per cent brands because a stick was not considered charcoal until it had increased in carbon content to such an extent that it could be readily fractured by a moderate blow with a hammer. The tars do not begin to come over until after there is some charcoal in the retort. The dissolved tar (tar soluble in the pyroligneous acid) comes over before the oily tar which settles out of the pyroligneous acid. The wood alcohol is the last valuable product to begin to be formed but it starts just prior to the appearance of the oily tar. This fact is of special interest in view of the experiments on temperature control.[2] It shows why the point when settled tar begins to come is of value in determining when to begin to practice control, that is, because the alcohol precedes the tar in order of formation. It also shows why it is not detrimental to the yields to push the distillation rapidly at the start, the reason being that only a small amount of the acid and none of the alcohol is formed during the first part of the distillation.

The practical application of the curve lies in the fact that it shows the losses in valuable products when the distillation is at any degree of completion. It may be noted that even with 10 per cent brands, which may be considered the maximum usually obtained in the commercial plant, the loss of alcohol is only 5.0 per cent and acetate 2.5 per cent. The charcoal loss is, of course, high, being about 12.5 per cent.

SUMMARY

Semi-commercial laboratory distillations were made with birch in which the distillation was stopped before completion. The brands obtained were redistilled. The results showed that the combined effect of the distillation in two steps gave practically the same yields of valuable products as when the distillation was completed in one step.

Considering the maximum yield of brands allowable in a commercial plant as 10 per cent of the original charge the data show that the loss of products is only 5.0 per cent wood alcohol and 2.5 per cent acetate of lime when the distillation is stopped at that point.

Analysis of the data is of interest from a scientific standpoint in showing the order in which the products are formed in the destructive distillation process. The acids are the first of the valuable products to be formed. The formic acid is formed more rapidly than acetic acid, the total yield of formic acid being obtained when about half of the wood remained as brands. The tar soluble in the pyroligneous acid is the next volatile product to be formed. This is followed by the oily tar which settles out of the pyroligneous acid. Wood alcohol is the last of the valuable products to begin to be formed but precedes the oily tar in order of formation. This fact is of special interest in view of experiments

[1] Gas is actually the first product formed.

[2] THIS JOURNAL, 7 (1915), 663.

in temperature control which showed that in order to obtain the maximum yield of wood alcohol it was very necessary to control the distillation just before the tar began to be formed.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

THE INFLUENCE OF MOISTURE ON THE YIELD OF PRODUCTS IN THE DESTRUCTIVE DISTILLATION OF HARDWOOD

By R. C. PALMER AND H. CLOUKEY

Received October 17, 1917

OBJECT OF WORK

In the destructive distillation of hardwood it has been considered for a long time the best practice to season the wood for at least 12 months before using it. The reason for this practice lies chiefly in the increase in operating expenses, due to an excessive dilution of the crude liquor. It is also the opinion of some operators that besides increasing the volume of liquor, green wood gives lower yields of products than dry, especially of acid. Other operators do not hold this view. In discussing the importance of using seasoned wood Klar[1] says "the yields of acetate of lime are inversely proportional to the water content of the wood carbonized—while the yield of alcohol is increased if changed at all."

There exists then no agreement among operators as to the influence of an excess of moisture on the yields. Many plants are now using wood with a higher moisture content than formerly because of changes in economic conditions of wood supply.

In making commercial experiments and demonstrations in controlling the distillation in order to secure the maximum yield of products, it became apparent that former experiments in controlling dry wood should be extended to determine the influence of moisture under controlled conditions.

In view of these conditions and the possible influence of moisture in temperature control, the experiments described in this paper were made. The tests also included a study of the effect of moisture under conditions comparable with uncontrolled as well as controlled plant conditions.

EXPERIMENTAL PROCEDURE

DISTILLATION—As it was thought that different species might be affected differently, the three standard distillation species, beech, yellow birch and hard maple, were studied separately. The material was ordinary cord wood from a commercial plant containing wood seasoned for about 18 months and wood seasoned from 4 to 6 months.

The tests were all made in a laboratory retort[2] holding about 50 lbs. of wood. In all previous work in the same retort it was the usual practice to start the distillation from a cold retort. By this method any excess moisture present was always distilled over before it could play any part in the destructive distillation reaction and no effect of moisture could be noted. In these tests the empty retort was first heated to what would correspond to the end temperature of a commercial distillation, at which time a specially constructed basket containing the wood was quickly introduced into the retort. In this way the distillations were comparable to continuous daily plant practice. Destructive distillation had always commenced in parts of the charge, while the water in another part continued to distil over.

Uncontrolled and controlled distillations were made for both green and seasoned wood of the three species. In former laboratory tests, in which the importance of control features was established, the procedure was based on the temperature-percentage distillate relation. In continuous plant practice it is not possible to determine the proportion of the total distillate at any stage of the distillation, so it was thought important to determine if the time-temperature relation would not serve as well. There seems to be no doubt but that it can, as the curves drawn for these relations were found in these tests to be quite parallel. In uncontrolled distillation the maximum fire was kept under the retort until the tar-point was well established and the fire was then checked so that the distillation was completed largely by means of the exothermic reaction. In the controlled runs, as soon as the first indications of tar were noted in the distillate, the fire was checked and the firing so regulated that after that point the rate of rise in temperature was appreciably lower than in the uncontrolled runs.

ANALYSES—The yields of settled tar and charcoal were determined by actual measurement. The yields of acetic and formic acids, dissolved tar and wood alcohol were determined by analysis of the clear pyroligneous acid.

For acid and dissolved tar determinations 100 cc. of pyroligneous acid were distilled until no further distillate came over and the temperature, measured in the residue, reached 140° C. The residual tar was then washed with 50 cc. of water and the distillate added to the first, the distillation being stopped when the temperature in the residue reached 150° C. The residue was dissolved tar.

A 25 cc. portion of the distillate was titrated with normal NaOH to give total acid, calculated as acetic. Another 25 cc. portion was diluted with 100 cc. water and placed on the steam bath with an excess of mercuric oxide and allowed to remain for about 2 hours, or until it was evident that there was no further reduction of the oxide. The flask was shaken occasionally. The whole was then distilled from phosphoric acid. Titration of the distillate with $N/10$ NaOH gave acetic acid. The difference between the total acid and acetic acid determinations was taken as the formic acid, the formic being oxidized by the mercuric oxide. Phenolphthalein was the indicator in both titrations.

Wood alcohol was determined by distilling from a 500 cc. sample of the pyroligneous acid. The distillate was made alkaline with strong NaOH and 65 per cent distilled from it. After again being sure that the distillate was alkaline a third distillation of 60 per cent was made. About 2 cc. of H_2SO_4 were added to

[1] "Technologie der Holzverkohlung," 1910 edition, p. 77.
[2] Forest Service *Bulletin* 129, and THIS JOURNAL, 7 (1915), 663.

this distillate and a fourth distillation of 60 per cent made. The final distillate was weighed and the specific gravity determined at 15.5° C. in a standardized pycnometer. The amount of alcohol was then determined by consulting the tables of Dittmar and Fawsett.[1]

No analyses were made of the settled tar so the yields of acid are proportionately lower than in plant practice, where the tar is washed for recovery of soluble products dissolved in it.

RESULTS

The results of distilling the wet and dry wood under controlled and uncontrolled conditions are given separately for the different species in Table I. The results for the mean of equal weights of beech, birch and maple are also given in the table. The data represent in every case the mean yield from at least two runs.

In Table II the same data are figured on a relative basis, taking the highest yield of each product as 100 per cent.

Moisture and control do not affect the tar and charcoal yields in the same way for the three species. Without control the wood containing more water gives more tar for beech but less tar for birch and maple, and when the distillations were controlled the wetter wood gave more tar for beech and birch but less for maple.

Control itself gave less tar for all species in the case of dry wood but more for beech and birch and less for maple in the case of the wood with a larger per cent of water. The charcoal yields are always increased by control but the effect of more water is different for the different species. For higher moisture beech gave lower yields of charcoal. Birch gave higher or the same charcoal yields and maple gave more when not controlled but less when controlled. The relative difference, due to different conditions, are shown more clearly in Table II.

[1] *Trans. Roy. Soc. Edin.*, **33** (quoted in Smithsonian Physical Tables).

ACETIC AND FORMIC ACIDS—The acetic and formic acid results are very important from a commercial viewpoint. The effects of moisture and control are different for different species.

The beech with higher moisture gave decidedly more total acid whether controlled or not, but when not controlled the increase in acid was largely formic acid, while when controlled the increase was nearly all acetic acid. When the drier beech was controlled the acid yields were appreciably decreased instead of increased.

In order to obtain the maximum yields of acetic acid from beech the experiments show quite conclusively that the wood should not be seasoned too long and the distillation should be controlled as carefully as possible.

Birch shows somewhat the same tendency as beech to give higher yields of acetic acid from the wetter wood but the differences are not nearly so great. The effect on formic acid is not especially marked. The control of dry birch gave good increases in acetic acid, in fact almost as much as the control of the wood with higher moisture content. The data do not show that there is much preference between controlled and uncontrolled distillations, if wet wood is being distilled. Considering all factors, however, the results would indicate that, as far as acetic acid is concerned, there is no advantage in seasoning birch too long.

In the case of maple also the wood with higher moisture is to be preferred for best acetic acid yields, provided the distillation is controlled, the results being almost as striking as with beech. If dry wood is distilled the uncontrolled distillations give the highest yields of acetic acid.

Considering the three species the best yields of acetic acid are evidently obtained from carefully controlled distillations of wood that has seasoned only about 6 months. These conditions gave nearly 15 per cent more acetic acid than either controlled or uncontrolled 18 months old wood.

TABLE I—THE YIELD OF PRODUCTS FROM BEECH, BIRCH AND MAPLE WITH DIFFERENT AMOUNTS OF MOISTURE AND UNDER DIFFERENT CONDITIONS OF CONTROL(a)

Condition	Beech: Moisture	Charcoal	Settled Tar	Dissolved Tar	Total Tar	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol	Maple: Moisture	Charcoal	Settled Tar	Dissolved Tar	Total Tar	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol
Dry—Not controlled...	24.90	39.45	5.21	4.91	10.15	5.52	4.62	0.69	1.74	21.32	38.66	5.80	6.98	12.78	5.43	4.92	0.38	1.77
Dry—Controlled.....	22.25	42.00	4.93	4.89	9.82	5.04	4.12	0.73	1.78	22.80	42.35	5.16	4.77	10.13	5.49	4.61	0.68	1.92
Wet—Not controlled...	31.80	38.72	5.45	5.03	10.48	6.23	4.98	1.03	1.80	32.80	39.20	6.12	5.05	11.17	5.37	4.54	0.66	1.88
Wet—Controlled.....	32.27	39.85	5.01	5.64	10.65	6.25	5.63	0.54	1.91	27.03	38.92	4.87	4.91	9.78	5.59	5.17	0.33	1.83
	Birch									Mean, Equal Portions Beech, Birch and Maple								
Dry—Not controlled...	20.82	38.88	5.96	5.64	11.60	5.02	4.28	0.59	1.62	22.31	38.98	5.66	5.84	11.50	5.32	4.54	0.55	1.71
Dry—Controlled.....	21.10	42.30	5.04	4.62	9.66	5.42	4.83	0.48	1.73	22.05	42.20	5.04	4.83	9.87	5.32	4.52	0.63	1.81
Wet—Not controlled...	30.17	40.25	5.93	4.26	10.19	5.62	4.97	0.52	1.58	31.59	39.39	5.83	4.78	10.61	5.74	4.83	0.74	1.75
Wet—Controlled.....	26.78	42.30	5.52	5.28	10.80	5.52	4.92	0.44	1.41	28.69	40.36	5.13	5.28	10.41	5.78	5.24	0.44	1.72

(a) The yields are all given in per cent weight of the oven-dry wood distilled.

TABLE II—THE RELATIVE YIELD OF PRODUCTS FROM BEECH, BIRCH AND MAPLE WITH DIFFERENT MOISTURE CONTENTS AND UNDER DIFFERENT CONTROL CONDITIONS(a)

Condition	Beech: Moisture	Charcoal	Settled Tar	Dissolved Tar	Total Tar	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol	Maple: Moisture	Charcoal	Settled Tar	Dissolved Tar	Total Tar	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol
Dry—Not controlled.....	74.8	94.0	95.7	87.1	95.4	88.4	82.1	67.0	91.1	65.0	91.3	94.8	100.0	100.0	97.2	95.2	54.6	92.2
Dry—Controlled.....	69.0	100.0	90.5	86.7	92.2	80.7	73.2	70.9	93.2	69.5	100.0	84.3	88.4	78.3	98.2	89.2	100.0	100.0
Wet—Not controlled.....	98.3	92.2	100.0	89.2	98.5	99.6	88.5	100.0	94.2	100.0	92.8	100.0	72.4	87.4	96.9	87.8	97.1	97.7
Wet—Controlled.....	100.0	94.9	92.0	100.0	100.0	100.0	100.0	52.4	100.0	82.4	91.9	79.6	70.3	76.5	100.0	100.0	48.5	95.4
	Birch									Mean, Equal Parts Beech, Birch and Maple								
Dry—Not controlled.....	69.0	92.0	100.0	100.0	100.0	89.3	86.1	100.0	93.7	70.7	92.4	97.1	100.0	100.0	92.1	86.7	74.4	94.5
Dry—Controlled.....	69.9	100.0	84.6	81.9	83.3	96.5	97.2	81.4	100.0	69.7	100.0	86.5	82.7	85.9	92.1	86.3	85.1	100.0
Wet—Not controlled.....	100.0	95.2	99.5	75.5	87.9	100.0	100.0	88.2	91.3	100.0	93.3	100.0	82.0	92.3	99.3	92.2	100.0	96.7
Wet—Controlled.....	88.8	100.0	92.6	93.6	93.2	98.2	99.0	74.6	81.6	90.8	95.7	88.0	90.4	90.5	100.0	100.0	59.4	95.0

(a) The yield from the condition giving the highest result is taken as 100 per cent.

It is of interest in this connection to give the results of a commercial temperature-control test lasting about three weeks. The plant was of about 50 cords per day capacity, distilling wood composed of about three-quarters maple and one-quarter birch. Approximately 1100 cords were distilled during the test. The wood had not been seasoned for more than 8 months and could be considered very comparable with the wet wood used in the laboratory tests described in this paper. The yield of acetate of lime in the commercial test was increased about 12 per cent over former uncontrolled practice. As the plant had been using wood of the same quality prior to the test, the results of these experiments in the laboratory, comparing wet uncontrolled with wet controlled runs for birch and maple, indicate that the increase in acetate was due largely to the maple. The increases obtained in the plant and in these tests check surprisingly well.

WOOD ALCOHOL—The influence of moisture on the wood alcohol is almost as pronounced as on the acids. The beech, with the higher moisture, gave decidedly the highest yield of wood alcohol when controlled and even the uncontrolled wet beech gave a little more alcohol than either the controlled or uncontrolled dry beech. The alcohol results, therefore, also indicate that beech should not be seasoned too long and that the distillation should be carefully controlled.

In the case of maple, both uncontrolled and controlled wet wood gave higher yields of alcohol than the dry uncontrolled runs, showing that moisture also favors the alcohol in this species. However, decidedly the highest yield was obtained from the dry controlled distillation, verifying former experiments. Considering both alcohol and acetate, the data would indicate that for best results from maple the wood should be only moderately seasoned and the distillation carefully controlled.

The alcohol results for birch showed that without doubt this species should be well seasoned for the highest yields, as the wetter wood gave much smaller amounts of alcohol. The dry controlled birch gave the highest yield. Since the acetate yield for the dry controlled birch was so nearly the same as from the wood with higher moisture, although slightly lower, it would seem, considering both products, that birch should be well seasoned and the distillation carefully controlled for the best returns. Birch, then, seems to be different from beech and maple as regards the influence of moisture on the more valuable products, such as alcohol, acetic acid and charcoal.

SUMMARY

I—Semi-commercial laboratory destructive distillations were made with beech, birch and maple. One lot was seasoned for about 18 months and another lot about 6 months. The results showed that moisture had a decidedly favorable influence on the yields of acetic acid when the distillations were controlled after the exothermic reaction had begun. The data indicate that beech and maple should be distilled only after moderate seasoning in order to secure the highest yields of acetic acid, provided the distillations are carefully controlled. The yields of acetic acid from birch which had been well seasoned were so nearly the same as from the wood which had been seasoned only about 6 months that there is no preference for this species, provided the distillations are controlled.

II—If the recovery of formic acid should become important in the distillation of hardwoods, the experiments showed that the highest yields were obtained from rapid (uncontrolled) distillations of wet wood, this being particularly true of beech.

III—A commercial temperature-control test using wood seasoned for only about 8 months gave practically the same increases in acetate as obtained in the laboratory tests.

IV—Former experiments showing the value of temperature control in increasing the yield of wood alcohol have been verified in these tests. Additional data on the influence of moisture shows that an excess tends to give still higher yields of alcohol in the case of beech and the same tendency is shown to a lesser degree for maple. With birch, however, the drier wood is preferred for the highest alcohol yields and although moisture favors the alcohol to a slight extent with maple as compared to uncontrolled dry distillation, the controlled dry maple runs gave decidedly the highest yields of alcohol for that species.

V—An excess of moisture in general gives lower tar and charcoal yields, but beech is the exception for tar and birch for charcoal.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

THE EFFECT OF CATALYZERS ON THE YIELD OF PRODUCTS IN THE DESTRUCTIVE DISTILLATION OF HARDWOODS

By R. C. PALMER[1]

Received October 17, 1917

PURPOSE OF WORK

The purpose of the work was to study the influence of various reagents or catalyzers on the formation of wood alcohol, acetic acid, etc. (1) during the primary reaction occurring in the destructive distillation of wood and (2) during any secondary reactions that take place between the original products.

SCOPE OF WORK

The experiments conducted so far have been preliminary and include a study of the effect of hydrolyzing acid catalyzers in an attempt to induce the maximum splitting off of acetyl or formyl groups from the cellulose or ligno-cellulose and the hydrolysis of these groups to acetic and formic acids or the decomposition of intermediate products, such as carbohydrates, into these products. Any influence on the formation of other products was, of course, noted. Phosphoric acid was selected as a catalyzer in these preliminary tests as being the most adaptable. It could be readily injected into the wood in solution and was non-volatile, being transformed into the meta-phosphoric acid at the maximum temperature of the destructive distillation of wood.

Maple and beech reduced to chips about 1 in. by

[1] Acknowledgment is made to Mr. H. Cloukey for making a number of the analyses.

1/2 in. by 2 in. in a pulpwood chipper were used. All tests were made in the autoclave, holding about 5 lbs. of wood, previously described in the report of tests on the effect of pressure on the yield of products, and the manner of making the tests was in general similar to that described in that paper.[1]

Preliminary experiments were also made on the distillation of wood in the presence of, or saturated with, wood tar, in a study of the possibility of splitting off methyl groups from the tar to form methyl alcohol.

DETAILS OF METHOD

The catalyzer was brought into intimate contact with the wood by placing the chips in enough of a water solution of the acid to completely immerse them and the solution brought to the boiling point to drive out the air in the wood. The chips were then cooled in the solution, causing a penetration of weak acid into the wood. The excess liquid was drained off and the chips weighed immediately after no more liquid dripped from them. The amount of catalyzer present was then calculated from the weight of solution absorbed, knowing previously the strength of the solution. Titrations were made before and after treating the chips with catalyzer solution in enough of the tests to show that no appreciable selective absorption took place. In the case of acid solution the chips were always apparently wet to the center. With the wood tar or creosote only a few of the largest chips were not completely penetrated by this method.

The chips, after treatment, were allowed to dry in some cases and in others were distilled immediately. Some runs were made putting the wood in a cold retort and others putting the wood in the retort previously heated to a temperature higher than the destructive distillation point.

The different control data were taken and analyses made as in previous work, including the (1) moisture content of the charge, (2) weight of distillate and charcoal, and (3) percentage of total acid, acetic acid, formic acid, settled and soluble tar, wood alcohol, and acetone, in the distillate.

RESULTS

The results in general are not very concordant, but several striking effects have been noted, indicating that when conditions are favorable the yields of primary products may be affected in a very marked degree by the presence of catalyzers. Not enough work has been done, however, to establish all the factors that influence the part the catalyzer plays in the decomposition reaction so that the results can be readily duplicated. The influence of various reagents that would poison the action of the catalyzer has not been worked out.

[1] THIS JOURNAL, 6 (1914), 890.

MAPLE—The results with maple chips, using phosphoric acid as a catalyzer, are given in Table I.

Run 1 was made without any catalyzer at atmospheric pressure for comparison with catalyzer runs and the yields are about the same as previous tests in the same apparatus.

The experiments with maple showed no striking increase in the valuable products, although several of the other products showed decided differences when the wood was distilled in the presence of the acid. In Runs 3 and 4 the lower yields of acid are undoubtedly due to the effect of pressure, as noted in previous work. The catalyzer apparently seemed to have had a detrimental rather than a beneficial effect on the acid yield in this series.

The yields of wood alcohol are quite variable. Bearing in mind that in previous work with this apparatus the alcohol yields were somewhat lower than commercial yields and also lower than laboratory yields in a larger retort,[1] several of the runs showed decidedly more alcohol than the standard in the autoclave but not higher than controlled laboratory runs in the larger retort. The highest yield in the series was 2.18 per cent (Run 2) as compared with 1.37 per cent from the standard, an increase of 60 per cent. Whether the manner of distillation was responsible for the higher yields or the catalyzer was playing an important part in the reaction cannot be determined, although the data would indicate the latter.

TABLE I—DISTILLATION OF MAPLE IN PRESENCE OF PHOSPHORIC ACID(a)

Run No.	Catalyzer Per cent	Max. Temp. Retort Degrees C.	Max. Temp. Bath Degrees C.	Pressure Lbs.	Pyro. Acid Less Moisture	Charcoal	Gas	Tar—Dissolved	Tar—Settled	Total Acid as Acetic	Acetic Acid	Formic Acid	Wood Alcohol	Moisture
1	0	312	470	0	35.05	39.15	22.66	5.36	3.14	5.81	4.56	0.79	1.37	41.35
2	7.59	332	465	0	41.27	44.90	13.85	1.85	Neg	5.05	4.52	0.40	2.18	45.35
3	7.92	323	470	60	40.57	46.20	13.40	1.17	Neg.	4.65	4.12	0 41	1.29	39.80
4	2.72	324	470	90	40.20	45.95	14 03	0 45	Neg.	4.55	3.98	0.43	1.46	36.00
5	23.75	320	470	60	40.80	44.05	15.15	0.72	Neg.	5.30	4.20	0.84	1.81	34.00

(a) Results are all in percentage of the dry charge.

The distillation of wood in the presence of an acid catalyzer has a marked effect on the tar, on the charcoal, and on the pyroligneous acid (including only the water formed by destructive distillation). The tar which usually settled out of the pyroligneous acid is apparently practically destroyed and the tar normally dissolved in the acid liquor is reduced at least 50 per cent in most of the runs distilled at atmospheric pressure. Previous work showed that pressure alone decreased the tar very much, so it was to be expected that distillations under pressure in the presence of the acid catalyzer would give even smaller yields of tar. Part of the tar can, no doubt, be accounted for by the higher yields of charcoal which averaged about 44.5 per cent compared to a normal of about 40 per cent, although since no appreciable amount of tar coke was noted in the retort any coking of the tar must have taken place in the charcoal or, in other words, the tar was decomposed practically in the wood at the moment of formation. Part of the tar can also probably be accounted for in the pyroligneous acid which was increased from 35 to 40.5 per cent, as during the analyses of the distillates, especially after neutralization with alkali, much larger amounts of creosote oil than usual were

[1] See apparatus described in tests on temperature control, THIS JOURNAL, 7 (1915), 663.

noted in the distillate. No qualitative or quantitative study has been made of this oil, but the yields and properties compared to normal creosote will be thoroughly investigated.

The increase in charcoal and oils in the acid liquor does not, however, account for all the tar, especially since the gas yield is lower than normal, so it is apparent that some other factors are entering into the reaction.

BEECH—The results with beech chips using phosphoric acid as the catalyzer are given in Table II. In this series a more comprehensive study of variables was attempted.

Run 6 was made without a catalyzer at atmospheric pressure. Unfortunately, no previous work has been done with beech in the autoclave with which the yields from this run, which was made as a standard, can be compared. The results are quite different from previous work with beech in the large retort, which gave 1.87 per cent alcohol and 5.87 per cent total acid compared with the autoclave run of 0.99 per cent alcohol, 7.03 per cent total acid and 5.13 per cent acetic acid. We will assume an alcohol yield of 1.37 per cent instead of 0.99 per cent standard, since this was the yield obtained from maple chips in the autoclave. This assumption can be reasonably made because beech and maple gave practically the same alcohol yields in the larger retort, and this yield is more plausible than the lower figure.

Runs 7, 8, 9 and 10 all showed decidedly more alcohol, the increases being 88, 80, 60 and 51 per cent, respectively, based on the assumed yield of 1.37 per cent. Apparently the alcohol yield increases with an increase of catalyzer up to 5 per cent catalyzer, the yield falling off slightly with higher percentages of catalyzer. This is shown in Table III.

The yields of alcohol from Runs 7, 8 and 9 are all appreciably higher than the highest yields obtained in the larger retort.

(b) Pressure Higher than Atmospheric—Runs 11 to 14, inclusive, were all made under constant pressure (110 lbs.) and moisture (about 60 per cent) conditions, but with variable amounts of catalyzer.

The yield of acids apparently bears no relation to the amount of catalyzer. In this series, however, the first marked effect of hydrolysis on the yield of acid is noted. Run 12 gave 16.05 per cent total acid and 13.82 per cent acetic acid, an increase of 128 per cent total acid and 169 per cent, or 2.7 times the acetic yield from Run 6, the standard. What conditions resulted in such a remarkable yield cannot be determined until further work is done. The yield of formic acid was also higher than normal but the proportional increase was less. This may be due to the fact that the maximum formation of formic acid takes place more readily than the formation of acetic acid, the yield of formic acid, therefore, representing more nearly the maximum possible yield. In the hydrolyzation of hardwood with sulfuric acid for the production of sugars, the proportion of formic to acetic acid is often much higher than by ordinary destructive distillation, indicating that the decomposition of the sugars or whatever is the source of the formic acid takes place more readily than the formation of acetic acid. The yields of total acid are not higher than normal in any of the other runs of this group. In fact, Runs 11 and 13 gave exceptionally low yields of acid.

TABLE II—DISTILLATION OF BEECH IN PRESENCE OF PHOSPHORIC ACID(*a*)

Run No.	Catalyzer Per cent	Max. Temp. Retort Degrees C.	Max. Temp. Bath Degrees C.	Pressure Lbs.	Pyro. Acid Less Moisture	Charcoal	Gas	Tar Dissolved	Tar Settled	Total Acid	Acetic Acid	Formic Acid	Wood Alcohol	Moisture
6.....	0	320	470	0	35.80	40.30	19.05	7.70	4.79	7.03	5.13	1.47	0.99	39.15
7(*b*)....	4.79	325	470	0	35.91	40.70	16.43	1.92	Neg.	6.76	5.20	1.20	2.58	138.90
8(*b*)....	4.96	321	470	0	39.38	44.85	15.77	2.11	Neg.	6.60	6.45	0.11	2.20	84.70
9(*b*)....	9.73	325	450	0	36.57	40.25	16.25	2.25	Neg.	6.96	6.70	0.19	2.47	135.90
10(*b*)....	2.63	333	465	60	34.73	44.55	26.62	1.25	Neg.	6.68	5.12	1.19	2.07	143.70
11.....	1.25	326	470	110	41.72	44.90	11.85	1.09	0.29	4.56	4.33	0.20	1.44	58.25
12.....	2.45	331	465	110	39.77	46.45	13.75	1.52	Neg.	16.06	13.85	1.72	2.00	59.30
13.....	4.85	327	465	110	41.26	44.20	14.54	0.70	0.20	3.58	2.43	0.88	1.33	58.50
14.....	20.78	326	465	110	37.81	45.20	16.79	0.90	Neg.	6.55	5.33	0.93	2.37	58.10

(*a*) Results are all in per cent of dry charge. (*b*) Charged from hot retort, carbon equals 5 per cent for Runs 7, 8 and 9.

(a) Atmospheric Pressure—Runs 7 and 8 were made under the same conditions except moisture content, and in Runs 7 and 9 the only variable was the amount of catalyzer. In all of this group the total acid yields were slightly less than the standard, but the acetic acid yields were 25 and 30 per cent higher, respectively, for Runs 8 and 9. Run 7, however, gave practically the same acetic yield as the standard. Other work has shown that the presence of an excess of water in beechwood tends to give more formic acid, which may account for the fact that Run 7 with the higher moisture content gave more formic acid. The data also indicate that as the amount of phosphoric catalyzer is increased, as in Run 9 compared with Run 7, the tendency is to form less formic acid, the moisture content being the same in both cases. Run 10 practically belongs to this group, except that it was run at 60 lbs. pressure, all other conditions being the same, and it may be noted that this run with the higher moisture content showed the same tendency to give a high formic acid yield, as in Run 7, the yields of acetic and formic acids being practically the same for both of these runs.

TABLE III

Run No.	Catalyzer Per cent of dry wood	Yield of alcohol Per cent of dry wood
6	0	0.99 (assumed 1.37)
10	2.63	2.07
7	4.79	2.58
9	9.73	2.47

The alcohol yields for this group are all higher than the actual normal, but only Run 12, which gave the high acid yields, and Run 14, with 20.87 per cent of catalyzer, gave appreciably more than the assumed normal of 1.37 per cent alcohol. Run 12 gave 46 per cent more and Run 14 about 73 per cent more alcohol than the assumed normal.

The same tendency as noted in the case of maple to give higher yields of charcoal and pyroligneous acid,

lower yields of soluble tar and negligible yields of settled tar, using H_3PO_4 as catalyzer, was also noted on all of these runs with beech, although the effect on the charcoal and pyroligneous acid was not so marked as with maple, especially when the distillations were made from a hot retort. Larger amounts of soluble creosote oil than normal were also noted during the analyses of the pyroligneous acid.

In the distillations from a hot retort the deposition of a very finely divided carbon in the outlet pipe was noted in several runs, amounting to as much as 5 per cent of the dry weight of the charge. This material was probably the result of decompositions of tar. No microscopic or chemical examination was made of the material, but this is now being done.

THE DISTILLATION OF WOOD AND TAR MIXTURES—A series of runs were made distilling beech chips which had previously been saturated with crude beechwood creosote. The results are given in Table IV. The runs were all made from a hot retort. In Runs 15, 16, 17 and 18 the conditions were practically constant, except for pressure.

The yield of total acid varied considerably in these runs but was not higher than normal in any case. The yield of alcohol, however, increased with pressure, the increase following a definite curve. The yield at 90 lbs. pressure for equal parts of wood and creosote figured in percentage of the dry weight of the wood was 153 per cent or $2^1/_2$ times as much as the yield obtained at atmospheric pressure with equal parts of wood and tar. Taking the yield from wood alone under these conditions as 1.37 per cent alcohol, as obtained in Run 15, the yield from tar alone was 2.1 per cent. Analyses of wood tar[1] have given 11.08 per cent methoxy group for crude creosote (195–255° C.). The results indicate then that the distillation at 90 lbs. pressure will split off about 20 per cent of these groups as methyl alcohol. Higher pressures would probably give better yields, but the use of higher pressures is restricted because of the loss of tar as coke. Since 70 per cent of the increase in alcohol is obtained at 30 lbs. pressure the lower pressures are more desirable because of the higher recovery of oil. The original tar contained $77^1/_2$ per cent oil and $22^1/_2$ per cent pitch, so the recovery of oil was 75 per cent for the run at 30 lbs. pressure. As it was not possible after distillation to differentiate between the tar formed by the distillation of the wood and the tar recovered from that added to the charge it was necessary to make the assumptions given in the table, knowing in general the effect of pressure alone on the tar formed from the wood.

In distilling the wood and creosote under pressure difficulty was experienced in maintaining the pressure to the end of the distillation and it was always necessary to relieve the pressure when about two-thirds of the total distillate had been recovered, but a large volume of the distillate always came over during the blowing-off of the pressure. Coking always took place when the pressure was relieved, not before, and although the decreasing of the pressure should have lowered the temperature, the temperature in the retort did not fall until enough time had passed after the pressure was gone for coking to take place, showing the exothermic character of the coking reaction.

The fact that methoxy groups can be split off from the tar by distillation under pressure was indicated by a change in the physical properties of the oil. Fractional distillation of the tar before and after the runs showed that the tar from which methyl groups had been apparently split off contained high boiling fractions whose specific gravity decreased with increase in boiling point, a most unusual property for wood tars. These fractions are being examined for acid phenols, which are likely to be present after splitting off the methyl groups from the phenol ethers.

Acetone determinations made in these studies showed that in no case was more than 0.5 to 1 per cent of the alcohol acetone and in Run 20, which gave the highest yield of alcohol, only 0.12 per cent of the alcohol was acetone. It should also be mentioned that in all of the tests with acid catalyzers the acetone yield was seldom over 1 per cent of the alcohol and generally less than 0.5 per cent of the alcohol.

WOOD TAR AND PHOSPHORIC ACID—The effect of the acid catalyzer on the tar formed in the normal distillation of wood has been noted above, the settled tar, which is the source of wood creosote, being practically destroyed. The effect of a combination of creosote and an acid catalyzer at once suggested itself as an additional means of splitting off methyl alcohol, and Run 19, using tar and phosphoric, was made to study that effect. The chips were first treated with acid and then allowed to dry out to about 10 per cent moisture and were then treated with creosote. The

TABLE IV—DISTILLATION OF BEECH IN PRESENCE OF WOOD CREOSOTE AND MIXTURES OF CREOSOTE AND ACIDS

Run No.	Per cent Catalyzer Tar	Per cent Catalyzer Acid	Maximum Temperature Retort Degrees C.	Maximum Temperature Bath Degrees C.	Pressure Lbs.	Pyro. Acid Less Moisture	Wood Charcoal Estimated	Wood Gas	Per cent Tar Recovered as Oil(b)	Per Cent Tar as Coke(c)	Total Acid	Wood Alcohol From Equal Parts Wood and Tar Based on Wood	Wood Alcohol Actual Per cent Dry Wood	Wood Alcohol Estimated from Tar Only	Moisture
15...	103.0	None	327	475	0	25.80	44	24.20	72.70	7.07	6.72	1.37	1.37	0	7.60
16...	106.5	None	313	440	30	31.30	44	20.70	58.10	37.95	5.35	2.83	2.87	1.46	7.80
17...	120.2	None	321	440	60	32.10	44	21.90	44.10	39.70	5.56	3.12	3.40	1.75	7.80
18...	112.2	None	334	470	90	31.09	44	24.36	39.65	51.00	6.50	3.47	3.66	2.10	11.26
19...	99.2	2.55 H_3PO_4	321	470	60	32.23	44	21.77	62.95	49.20	6.87	1.03	1.03	....	10.12

(a) Results are all in per cent of dry charge. (b) Estimated from assumption that tar formed by distillation of wood = 15 per cent at 0 lb.; 8 per cent at 30 lbs.; 5 per cent at 60 lbs.; 3.5 per cent at 90 lbs. for Runs 15, 16, 17 and 18, respectively, and 1.25 per cent for Run 19. (c) Estimated from assumption that wood charcoal = 44 per cent.

[1] Pieper, Humphrey and Acree, THIS JOURNAL, 9 (1917), 566.

results anticipated were not obtained as the alcohol yields were no greater than normal. It would seem then that the action of phosphoric acid on the tar is probably much more severe than splitting off of methoxy groups, and is more likely the immediate formation of hydrocarbon gases and coke. The work along this line is being extended, making tar-phosphoric acid distillations at lower temperatures to see if the destructive effect can be lessened.

Several distillations were made using sulfuric acid as a catalyzer along the lines suggested by German Patent 185,034, but instead of getting increased yields of acid and alcohol it was found that, especially under pressure, the acids were decreased and no alcohol at all was formed. Indications were obtained that the SO_2 formed by the reduction of the sulfuric acid acted very detrimentally in the destructive distillation reaction.

CONCLUSIONS

The general conclusions to be drawn from these preliminary tests are:

I—Under the proper conditions a very high yield of acetic acid may be obtained by the destructive distillation of wood, by using phosphoric acid as a catalyzer. Two and seven-tenths times as much acid as normal was obtained in one run.

II—The distillation of wood in the presence of phosphoric acid showed a pronounced tendency to give more wood alcohol. Increases varying from 40 to 90 per cent were obtained.

III—The distillation of mixtures of wood and tar under pressure showed that the methoxy groups in the tar can be readily split off, forming wood alcohol. Nearly 20 per cent of a possible theoretical was obtained at 90 pounds pressure. The work is being extended to include a study of many other catalyzers and variables.

The recovery of the metaphosphoric acid residual in the charcoal, which is readily soluble in cold or hot water, could in all probability be made practically quantitative by simple leaching. Just what recovery can be made is being studied.

The experiments described are only preliminary laboratory investigations, and no attempts will be made to commercialize the ideas developed until further work is done. With the quantitative recovery of phosphoric acid its use as a catalyzer would be entirely practicable and the application of these ideas would seem to open up the possibility for the destructive distillation of small forms of wood waste. The commercial practicability of the distillation of wood and tar mixtures would be in the same direction and depend on the recovery of more valuable constituents of the oil as well as a high yield of wood alcohol. Patent application has been made by the author for the protection of these ideas, the patents being dedicated to the public.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

SOME EXPERIMENTS ON THE PULPING OF EXTRACTED YELLOW PINE CHIPS BY THE SULFATE PROCESS

By Otto Kress and Clinton K. Textor

Received September 4, 1917

INTRODUCTION

Some time ago the Forest Products Laboratory was asked to determine whether longleaf pine chips, after the extraction of rosin and turpentine, would be suitable for the manufacture of kraft paper. This suggested itself inasmuch as commercial kraft is being made from longleaf pine and the removal of rosin should be an advantage provided there were no other factors entering. Extracted chips are only used as fuel under the boilers at the extraction plant and any excess over fuel requirements is a complete waste. If they can be converted into a by-product, the waste will be a source of income whereas its disposal is now an expense.

DESCRIPTION OF TEST MATERIAL

In preparation for extraction, the raw wood, hogged to the proper size, is placed in iron extractors, which, in this particular case, are not designed for pressure extraction, and steamed about 3 hrs. for recovery of crude turpentine. After this preliminary steaming treatment, the extractor is filled with hot gasoline, 58 to 60° Bé. and extracted for approximately 5 hrs. Two solvent drops are taken off and the chips are then washed with fresh solvent, this wash being used on the next extractor. The solvent solution containing the rosin and pine oil is evaporated first for recovery of solvent, then for pine oil, while the residue of rosin is run into barrels for shipment.

After the solution of gasoline and pine oil is all removed from the extractor and after draining for one hour to remove as much as possible of the above mixture, the extractor is steamed for 5 hrs. to recover solvent. The first part of the steaming occurs with wet steam, while the last half is with superheated steam.

The average yield per ton of wood extracted on a car weight basis is:

Rosin	250 pounds
Crude turpentine	8 gallons
Crude pine oil	2 gallons

The total amount of chips handled at the plant with which the Laboratory coöperated on these experiments is 400 tons per day, of which 300 tons are burned under the boilers, leaving 100 tons available per day.

The Laboratory received a shipment of 1,000 lbs. of "spent wood" chips, as they come from the extractor, and 500 lbs. of "fresh chips" which had not been extracted. We were informed that the original chips contained 12 to 13 per cent moisture, while the extracted chips contained 18 to 19 per cent moisture. These chips had been treated slightly differently from the ordinary run of chips, as in the usual practice saturated steam is admitted to the extractor for ten minutes preliminary to opening the digester. This treatment is given to avoid danger of fire.

PROCEDURE

PREPARATION OF THE WOOD—The chips from a superficial examination showed a large percentage of dust and

small slivers, which in any chemical pulping operation would consume cooking chemical and give practically no yield of pulp.

A 10-lb. sample of the extracted chips was screened through a series of screens, with progressively smaller openings and the amount passing through each screen weighed. The data from this test are shown in Table I. Unfortunately, such screening does not show the proper results as the chips are all of great length in comparison with their diameter. This means that only such slivers as struck the open mesh of the screen head-on passed through that particular screen. The proper screening of the chips is extremely important, as small slivers will give practically no yield of pulp, but will consume cooking chemicals during the pulping operation.

The ordinary chip screen as used at the Laboratory for screening pulp chips was far too coarse to properly screen this material and so a flat screen was made of wire having 12 meshes to the inch, with openings about 0.08 inch diameter. In many cases, slivers with small enough diameter to pass through the screen, would not be removed unless they happened to strike the screen opening head-on. By means of this flat 12-mesh screen, 24 per cent by weight of the material screened was removed. Cooks 247 to 250 gave very low yields (about 36 per cent), and this is probably due to the presence of considerable material that was not screened out preparatory to pulping. For later cooks, the chips were rescreened, various percentages being removed, as shown in Table II.

The cooks were made in a 63-gallon upright steel digester similar to the customary stationary digester as used in commercial practice for soda and kraft pulping with the exception that the bottom of the digester is steam jacketed. Only a small amount of steam was admitted to the jacket to counteract any excessive condensation. Further, the digester is fitted with a pump to circulate the cooking liquor during the digestion. The relief line from the digester leads to a cooling coil in a condenser for the purpose of separating and condensing all volatile products. The digester is manipulated in a way similar to those in commercial operation. After the cook was blown and washed, yield determinations were made. The pulp was then screened, using a 6-plate diaphragm screen with slots 0.009 inch wide. The pulp after thickening and beating was run into the form of paper or board over a 15-inch Pusey and Jones, Fourdrinier machine. The papers were run unsized and uncolored as all the pulps are run at the Laboratory for testing purposes in the form of waterleaf sheets. Further, having no cylinder machine at the time these tests were made, the boards were made by winding up the paper on the first press of the Fourdrinier machine, which, of course, gives poor lamination. The results of the tests are given in Table II.

TABLE I—SCREENING TESTS ON A 10-POUND SAMPLE (BONE-DRY WEIGHT) UNEXTRACTED CHIPS

Number of fraction	1	2	3	4	5	6	7	8	9
Through size screen	1/4"	3/16"	1/4"	No. 8(a)	No. 20	No. 40	No. 60	No. 80	No. 100
On size screen	3/8"	1/4"	No. 8	No. 20	No. 40	No. 60	No. 80	No. 100	Pan
Size of screen opening	0.437"	0.271"	0.099"						
Weight of fraction (moist), lbs.	0.5870	1.5700	4.9350	2.4255	0.9115	0.2095	0.0774	0.0555	0.1440
Percentage (bone-dry)	91.1	91.1	89.7	91.9					
Weight of fraction (bone-dry), pounds	0.535	1.43	4.43	2.325	0.930	0.191	0.0705	0.0505	0.131
Percentage (moist)	5.88	14.39	45.20	22.20	8.35	1.92	0.71	0.61	1.32
Percentage (bone-dry)	5.35	14.30	44.30	23.25	8.30	1.91	0.71	0.61	1.31

(a) Screens marked No. 8, No. 20, No. 40, No. 60, No. 80, No. 100 indicate the number of meshes to the inch

TABLE II—PULPING TESTS ON EXTRACTED CHIPS, USING THE KRAFT PROCESS

Nature of Chips	Cook No.	Per cent Original Wood Retained after Screening	Wood		Cooking Liquor		Duration of Cook			Max. Steam Pressure, Lbs. per Sq. In.	Yield Crude Pulp, Per cent[1]	Yield Screenings, Per cent[2]	Yield Screened Pulp, Per cent[1]	Calendered	Weight per Ream 24 × 26–500 Basis	Strength Factor Wts. per Lb. per Ream	Thickness 0.001"	Strength Ratio, Pts per 0.001"	Average Stretch, Per cent	Average Breaking Length, Meters	Average Folds, No.
			Moist Weight, Lbs.	Bone-Dry, Per cent	NaOH per Cwt. Chips, Lbs.	Na_2S per Cwt. Chips, Lbs.	Total Hrs.	Increase Period, Hrs.	Maximum Pressure Period, Hrs.												
Extracted	247	76	84.7	87.5	13.13	3.47	80	4.00	1.00	3.0	36.3	0.53	35.47	No	42.5	0.74	4.34	0.72	3.45	5175	726
														Yes	43.0	0.74	3.99	0.80	3.25	5060	622
Extracted	248	76	88.5	87.5	13.14	3.35	80	4.18	1.18	3.0	36.6	1.1	35.5	No	44.5	0.77	4.33	0.79	3.60	5012	614
														Yes	44.0	0.72	4.04	0.78	3.30	4970	525
Extracted	249	76	84.0	86.0	11.70	3.64	80	3.9	0.9	3.0	42.2	8.2	34.0	No	43.0	0.68	5.11	0.57	2.95	4340	352
														Yes	43.0	0.61	3.87	0.67	2.50	3995	273
Extracted	250	76	84.0	85.0	15.83	4.75	80	3.8	0.8	3.0	35.3	0.5	34.8	No	43.0	0.65	4.42	0.63	3.00	5440	414
														Yes	43.0	0.63	3.61	0.75	3.30	5020	359
Extracted	251	70	84.97	86.3	13.65	4.08	80	3.9	0.9	3.0	36.4	1.2	35.2	No	38.5	0.69	4.03	0.66	3.30	4995	447
														Yes	38.5	0.64	3.52	0.70	3.05	4810	377
Extracted	252	67.6	57.85	58.6	13.52	4.02	80	4.35	0.85	3.5	41.15	2.02	39.13	No	38.5	0.60	4.15	0.63	3.20	4670	338
														Yes	38.5	0.61	3.37	0.69	2.60	4250	260
Extracted	253	65.8	83.26	86.1	11.09	2.60	100	2.75	1.25	1.5	43.8	Not screened		This cook was not run as paper, but was made into board							
Fresh wood	254	63.7	86.45	88.65	11.50	2.78	80	4.4	0.9	3.5	33.2	2.02	31.2	No	38.5	0.62	4.17	0.57	2.85	4720	363
														Yes	38.5	0.60	3.49	0.66	2.80	4510	312
Fresh wood	255	70.8	88.10	88.50	11.48	2.79	80	4.8	0.8	4.0	41.4	13.5	27.9	No	41.0	0.38	5.44	0.29	1.80	3340	64
														Yes	40.5	0.38	4.57	0.34	2.10	2980	42
Fresh wood	256	68.4	130.3	80.4	8.46	2.23	100	2.4	0.9	1.5	51.15	Not screened		This cook was too raw and was not run over the machine							

[1] Bone-dry pulp in per cent of bone-dry wood cooked. [2] Bone-dry screenings in per cent of bone-dry wood cooked.

DISCUSSION

One of the most important problems in considering the feasibility of utilizing extracted yellow pine chips in the manufacture of paper pulp is the proper screening of the chips. This phase of the problem could not be satisfactorily studied for lack of proper screening apparatus and the shipment of wood was far too small to carry on any extensive experiments along these lines. As has already been mentioned, dust, shives, and slivers

of wood of small diameter are practically valueless for pulping purposes as they give no appreciable yield of pulp but consume cooking chemicals. The extraction plant handles 400 tons of chips per day, of which 300 tons are burned under the boilers for fuel purposes. This would make possible the rejection of 75 per cent of the wood for fuel purposes, while in our experiments 36.3 per cent of the original wood represented the maximum amount of screenings rejected. The cost of screening is small and this matter should receive further study. There is no question that if we had screened out 75 per cent of the fines and only pulped the comparatively coarse chips better and higher yields of pulp would have been obtained. Further, the extracted chips were apparently burnt by the steaming for removal of the oils and rosin, as could readily be seen by the clean fracture obtained in many cases on breaking the chip.

Rather surprising yields of oils were obtained by condensing the relief gases from the digester. The yield of oil on the extracted chips averaged about 2.3 gallons per ton of bone-dry chips. For cooks 254 to 256, made on the fresh wood, an average of about 6.7 gallons of oil were obtained per ton of bone-dry chips. The wood during transit and in storage at the Laboratory had probably lost some turpentine and other volatile oils, which will probably explain the discrepancy between these results and those obtained at the extraction plant.

Cooks 247 to 254 were made on the extracted chips varying the conditions of pulping as can be seen from a study of Table II. No special difficulties were experienced in pulping the extracted chips and the rather low yield of pulp we believe can be remedied to a large extent by the selection of only the larger chips through better screening.

The strength of the paper was low when compared with that which has been made at the laboratory from longleaf pine round wood. This weakness, we believe, was partly due to the small size of the chips in which the smaller slivers will readily overcook and to the apparent burning of the chips by the steaming treatment.

Cook 253 was run with the object of preparing a pulp suitable for the manufacture of a container board. Cooks 254, 255 and 256 were run on the fresh wood. In these cooks apparently insufficient alkali was used to saponify all the rosin and at the same time successfully pulp the wood. Cook 255 represents a raw cook, while cook 256 was so raw that it was not passed over the paper machine. Cooks 254 to 256 are of very limited interest, as they represent pulping tests made on chips of so high an oil and rosin content that commercially they would be extracted before pulping.

While the above experiments indicate that a commercial grade of kraft pulp might be made from longleaf yellow pine extracted chips, it is evident that the best results will be obtained if the chips are carefully selected by means of a proper screening system, by using the largest chip for extraction compatible with maximum recovery of the oils and rosin, and by avoiding as far as possible the burning of the chips in the preliminary steaming for removal of turpentine and rosin.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

THE PRODUCTION OF NITRIC ACID FROM NITROGEN OXIDES[1]

By Guy B. Taylor, Julian H. Capps and A. S. Coolidge

Received February 14, 1918

Practically all processes for the fixation of atmospheric nitrogen wherein the ultimate product desired is nitric acid involve recovery of nitrogen oxides. The arc and ammonia oxidation processes produce these gases largely diluted with air or nitrogen. Converting the nitrogen oxides into concentrated nitric acid requires an extensive equipment and is a considerable item in the cost of manufacture.

The usual industrial procedure is to pass the gases containing nitrogen peroxide (NO_2) with an excess of oxygen through a series of large packed towers and absorb the nitrogen oxides in water. The strength of the circulating acid varies in each tower, the first producing acid of 30 to 50 per cent concentration, depending on the concentration of NO_2 in the gas, while the last is almost entirely water. The diluter acids are moved up from tower to tower as their concentration increases so that the whole of the product is concentrated as far as practicable. This acid is further concentrated, when required, by means of distillation from sulfuric acid.

While the use of water as an absorbent produces nitric acid direct, it has certain disadvantages. The tower space required is very large and storage tanks, pumping lines and auxiliary equipment for handling the dilute acids must be made of special material to resist attack. The acid produced must nearly always be concentrated further. Also it is practically impossible to absorb all the nitrogen oxides by any system of towers of reasonable size and number. In some plants a tower circulating caustic soda or sodium carbonate solution is installed at the end of the system to recover the last traces of acid.

There have been a large number of patent claims for processes involving the working up of nitrogen oxides. Alkaline solutions are mentioned frequently both for the production of nitrates and nitrites. It has also been proposed to recover the nitrogen oxides in concentrated form from alkaline solutions with regeneration of the alkali. Proposals[2] for freezing out N_2O_4 do not seem commercially practicable. Patents[3] are held on a process for concentrating nitric acid by means of liquid nitrogen peroxide. An electrolytic process for concentrating dilute acid is proposed in a patent[4] held by the Salpetersäure Industrie Gesellschaft wherein NO evolved at the cathode is led into the anode space for re-oxidation. Classen[5]

[1] Published with the permission of the Director of the U. S. Bureau of Mines.

[2] W. Ramsay, British Patent 26,981 (1907); P. A. Guye, U. S. Patent 1,057,052 (1910).

[3] M. Moest, U. S. Patent 1,180,061 (1907); L. Friedrich, British Patents 319 and 403 (1911).

[4] British Patent 18,603 (1906).

[5] British Patent 18,065 (1915).

suggests the use of catalyzers, nickel or cobalt oxides and nitrates, for promoting the oxidation of NO to NO_2.

Among the more prominent methods proposed for the recovery of nitrogen oxides is that of absorption in rather concentrated (90 per cent) sulfuric acid with subsequent removal of the oxides of nitrogen by heat or denitrifying agents. The concentrated gas thus obtained is reabsorbed in the presence of air in water to form nitric acid.

In some experiments in this laboratory on absorbing nitrogen peroxide in sulfuric acid containing chromic acid, it was found that nitric acid was produced directly and if the absorbing liquid is maintained at 150° C., the acid issues from the system as a mist which, when precipitated, is 95–100 per cent HNO_3. Such a process has two drawbacks: the necessity for absorbing in a hot solution and the electrolytic recovery of chromic and sulfuric acids from chromium sulfate. A number of experiments were made in an attempt to produce a strong mixed acid by electrolysis of solutions of NO_2 in concentrated sulfuric acid. If the nitric oxide from the oxidizer in the presence of excess of air is cooled and allowed sufficient time to react wholly to NO_2, then its reaction with concentrated sulfuric acid may be written:

$$2NO_2 + H_2SO_4 = HNO_3 + HNOSO_4$$

Theoretically upon electrolysis this reaction may take place:

$$HNOSO_4 + 2H_2O = HNO_3 + H_2SO_4 + H_2 + 2 \text{ faradays}$$

This reaction is an ideal one since it also removes water by reaction and concentrates the acid. The power required is not great. In attempting to realize the reaction experimentally platinum electrodes were used and alundum thimbles as diaphragms. It was found that at low concentrations of nitrososulfuric acid, equivalent to 10 per cent HNO_3 in a mixed acid, a current efficiency of 50 per cent could be obtained for a short time. However, as the concentration of nitric acid in the solution increased, the efficiency dropped to a small value. Even when using 95 per cent sulfuric acid in the cathode chamber, nitric acid or nitrososulfuric acid diffused through the diaphragm and was reduced to NO and some free nitrogen. The nitrogen represents a loss of acid which might be prevented with efficient diaphragms. However, electrolysis of solutions containing the equivalent of nitric acid ordinarily used in nitrating acids did not work at all.

ABSORPTION BY WATER

The chemical reactions involved in the conversion of nitric oxide, which is produced by both the arc and ammonia oxidation processes, to nitric acid are essentially as follows:

$$2NO + O_2 \rightleftarrows 2NO_2 \quad (1)$$

$$2NO_2 + H_2O \rightleftarrows HNO_3 + HNO_2 \quad (2)$$

$$3HNO_2 \rightleftarrows HNO_3 + 2NO + H_2O \quad (3)$$

The NO arising from Equation 3 reacts with oxygen and the cycle is repeated. A full discussion of these reactions is given by F. Foerster and M. Koch.[1]

[1] *Z. angew. Chem.*, **21** (1908), 2161.

The reaction expressed by Equation 1 begins to proceed in the direction from left to right when the gases are cooled below 600°, but will not go nearly to completion even in a large excess of oxygen until 200° is reached as shown by calculation from the equilibrium formula. However, it has been shown by Foerster and Blich[1] that this reaction has a negative temperature coefficient so that the gases must be cooled as far as practicable before entering the absorption system. It has also been shown that this reaction occurs in distinctly measurable time.[2] Hence, it has been found necessary to allow the gases to pass into a large empty chamber or oxidation tower in order that the nitric oxide may react completely to nitrogen peroxide before the gases enter the absorption system.[3] An absorption system proposed by Moscicki[4] [British patent 17,355 (1911)] in which the gases are passed horizontally and at right angles to the acid flow inserts an empty oxidation space between successive units.

EXPERIMENTAL

The experiments described in this report were made with a small experimental plant used in experiments to determine the efficiency of metallic gauzes as catalyzers for ammonia oxidation. It may be stated at the outset that it was fully appreciated that the results obtained could not be strictly carried over to an industrial operation on a thousandfold larger scale, especially as to the ratio between tower space and capacity, but it was thought that the relative importance of acid concentration in the several towers, temperature, speed of passage of the gases and circulation of the absorption liquid, oxygen excess required, etc., could be obtained, and that many details might be worked out that would be of value in operating a larger system. Such details are generally regarded as legitimate industrial secrets and are almost never published. There is practically no information of a detailed nature available in this country dealing with gases as rich as those produced in ammonia oxidation on any sort of an efficient absorption system.

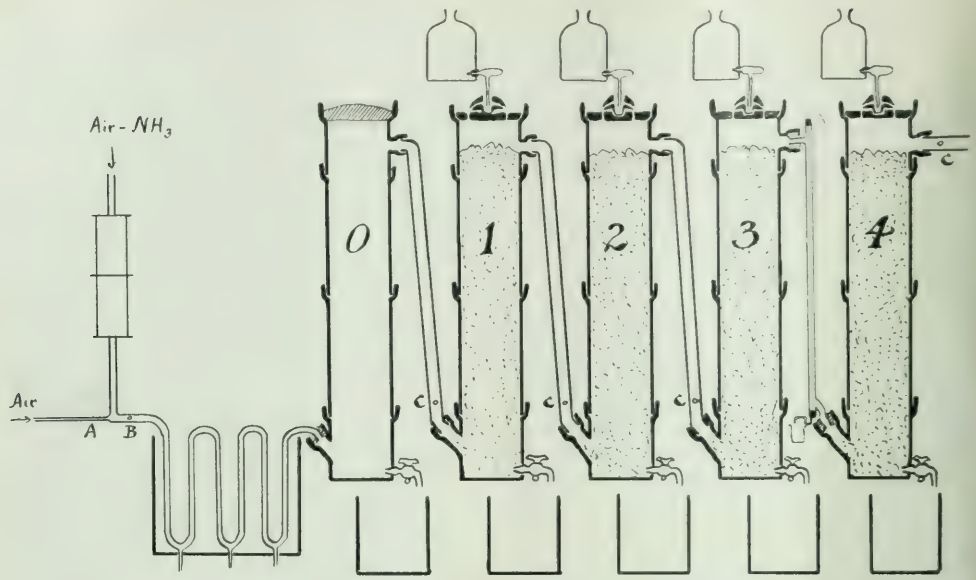
The apparatus consisted essentially of an ammonia saturator for securing a mixture of air and ammonia, an oxidizer utilizing a platinum gauze, 3 × 6 in., for producing nitric oxide and an absorption system consisting of a cooler and five stoneware towers. The absorption system is shown diagrammatically in the accompanying sketch. The gases from the oxidizer passed through an iron pipe into the Pyrex glass tubes of the cooler. These $^3/_4$-in. tubes were arranged in two sets of three U-tubes each, in parallel. The cooling water was continuously passed through the housing box which was 30 × 24 × 24 in. Each U-tube was provided with a drain for condensate and liquid sealed with a test-tube. From the condenser the gases passed to Oxidation Tower 0 and then in turn to

[1] *Z. angew. Chem.*, **23** (1910), 2017.

[2] W. Holweck, "Über die Reaktion zwischen Stickoxyd und Sauerstoff," *Ibid.*, **21** (1908), 2131.

[3] E. K. Scott, "Production of Nitrates from Air, with Special Reference to a New Electric Furnace," *J. Soc. Chem. Ind.*, **34** (1915), 113. An experimental absorption system with oxidation tower is described.

[4] E. K. Scott, "Manufacture of Synthetic Nitrates by Electric Power," *Ibid.*, **36** (1917), 774.



the bottom of the coke-packed Towers 1, 2, 3 and 4. These towers are of the following dimensions:

Height	6 ft.	
Diameter inside	10 in.	
Capacity	3.27 cu. ft.	
Tower packed with coke 5½ ft. at 50 per cent free space		= 1.50 cu. ft.
Reaction space above coke and in connecting pipe		= 0.40 cu. ft.
Reaction space provided by the Oxidation Tower 0, and pipe connecting to Tower 1		= 3.40 cu. ft.
Reaction space in each coke tower		= 1.90 cu. ft.
Total reaction space in the system (not counting space above coke in Tower 4)		= 10.60 cu. ft.
The coke was irregular in size, most pieces 1 to 2 in.	No accurate estimate could be made of the absorbing surface	

The desirability of having such an oxidizing tower as 0 for the oxidation of NO was demonstrated in small scale laboratory experiments. Nitric oxide from a small oxidizer containing an excess of oxygen was cooled to room temperature by means of a Liebig condenser. By means of suitable stopcocks the cooled gas could be passed through a 7-liter glass vessel into a small glass coke-filled tower or by-passed around the vessel. Forty per cent nitric acid was circulated rapidly through the tower and the efficiency of absorption determined by samples, as will be described later. In the following table, samples of the gas were taken with the reaction space in circuit and then immediately thereafter with the space cut out so that all other conditions were the same.

Reaction Space	Liters per Minute	Total Acid Removed before Tower Per cent	Total Acid Absorbed in Tower Per cent	Efficiency of Tower Per cent
In	0.7	26	49	61
Out	0.7	13	36	68
In	0.7	18	46	86
Out	0.7	13	81	89
In	1.0	20	46	88
Out	1.0	7	84	88
In	1.8	12	82	89
Out	1.8	5	43	46
In	1.8	10	83	88
Out	1.8	6	39	41

These results show clearly that at the higher velocity the reaction space increased the efficiency of the tower. The wet walls of the reaction space absorb acid and hence the gases enter the tower less concentrated than in cases where it was not used, but this fact does not affect the general conclusion that the oxidation space is useful.

The rest of the system needs little explanation. The acid was circulated by sucking up through glass lines into the feed bottles with a filter pump. Each bottle was provided with an automatic glass valve which closed under suction. The distributor at the top was a type manufactured by M. A. Knight in which acid overflows through 8 small holes arranged in circle.

METHOD OF OPERATION

Air was metered and passed through the ammonia saturator so as to make a mixture containing 8 to 11 per cent ammonia. Auxiliary air, also metered, was added at the point *A* just below the oxidizer. By controlling the relative volume of air and the composition of the ammonia-air mixture, any desired oxygen excess could be obtained in the absorption system.

The performance of each tower was determined by taking gas samples from the sample holes *C*. At *B* a sample was taken where the gas was still hot and before any condensation could have taken place, which represented the total acid entering the system. The samples were taken into evacuated glass bottles of 1 or 2 liters capacity. Each bottle was provided with a ground glass stopper carrying a capillary stopcock. After taking the sample, a measured volume of water containing hydrogen peroxide was introduced into each bottle to absorb the acid and sufficient to bring the resulting nitrogen-oxygen mix-

ture to atmospheric pressure. The volume of the bottle, minus that of the introduced reagent, gave the volume of gas, which, together with its analysis, furnished the necessary data required to calculate the volume of nitrogen present. The acid was titrated with $N/7$ NaOH. Since nitrogen does not react and is constant throughout the system, it is evident that it may be used as the reference point and the efficiencies calculated from a knowledge of grams of acid per liter of nitrogen. It was not found practicable to base any conclusions on measurements and analyses of the acids produced in each tower since the packing held up an indefinite quantity, and the runs were not long enough to reduce this source of error. The plant was operated 6 or 7 hrs. per day.

RUN 1—Preliminary run to make acid for future experiments. Acid was added to first tower and the rest allowed to build up. Samples were taken to determine relative effects of velocity of gas and oxygen concentration.
Cooler—water cooled.
Acid circulated through towers continuously 6 to 15 liters per hour.

RUN 2—Dec. 5, begun 2:00 P.M., closed 4:20 P.M.
Dec. 6, begun 9:45 A.M., closed 4:15 P.M.
Cooler—air cooled.
Rate acid circulation—towers flooded every 30 min. with 4 liters.
Strength of acid condensed in cooler—5 per cent HNO_3.
Strength of acid condensed in Tower 0—30 per cent HNO_3.

RUN 3—Dec. 7, begun 10:50 A.M., closed 4:10 P.M.
Dec. 8, begun 9:30 A.M., closed 4:00 P.M.
Dec. 10, begun 9:40 A.M., closed 4:10 P.M.
Dec. 11, begun 9:30 A.M., closed 4:00 P.M.
Cooler—air cooled.
Rate acid circulation—tower flooded every 30 min. with 4 liters.
Strength acid condensed in cooler—7 per cent HNO_3.
Strength acid condensed in Tower 0— 32.5 per cent HNO_3.

RUN 4—Dec. 14, begun 10 A.M., closed 3:25 P.M.
Cooler—water cooled.
Rate acid circulation—8 liters per hour continuous.
Strength acid condensed in cooler—5 per cent HNO_3.

RUN 5—Dec. 12, begun 10 A.M., closed 2:15 P.M.
Cooler—10 to 1:15 P.M., air cooled; 1:15 to 2:15, water-cooled.
Rate acid circulation—towers flooded every 30 min. with 4 liters.

RUN 6—Dec. 13, begun 10:30 A.M., closed 4:00 P.M.
Cooler—air cooled.
Rate acid circulation—tower flooded every 30 min. with 4 liters.

RUN 7—Dec. 17, begun 10 A.M., closed 3 P.M.
Cooler—air cooled.
Rate circulation—tower flooded every 30 min. with 4 liters.
7 per cent NaOH solution in Tower 4.

RUN 8—Dec. 19, begun 9:45 A.M., closed 1:45 P.M.
Same as Run 7, except 30 per cent NaOH solution in Tower 4.
80 to 90 per cent of acid absorbed by alkali is in form of nitrite.

The following tables contain the full data of all experiments. The date, time, and cubic feet per hour, and percentage of the total acid absorbed are given at the moment of taking the samples. In general, six samples were taken at once giving the total acid per liter of nitrogen entering the system, entering each tower, and leaving the last tower. The temperature of the gas entering each tower and the specific gravity of the acid in circulation at the time were recorded. The specific gravity was taken roughly with a hydrometer at the temperature of the acid running from the tower. In general, the acid from the first tower was 8 or 10° lower than the entering gas, in the other towers 2 or 3° lower.

DISCUSSION OF RESULTS

Run 3 having demonstrated that the strength of the acid could be built up in Tower 1 to about 50 per cent without materially increasing the acid loss from the system, it was considered sufficient in other cases to take samples with the acid concentrations in the several towers approximating what they would be toward the end of a run or the time when the acids would be moved up to the next tower.

The circulation of the acids through the towers was carried out in such a way as to be sure that the coke packing was always thoroughly wet. This was done in most cases by periodical flooding, *i. e.*, running in 4 liters of acid at the top in 10 min. at 30-min. intervals. After flooding in this manner it was found that the absorption capacity of the first tower did not change for an hour or more. In general, about 10 liters were placed in the jar for each tower at the beginning of a run. The volume of the circulating liquid increased as absorption took place in Towers 1 and 2. Tower 1 received part of the acid indicated as having been removed by Tower 0 by the gas analytical results, due to condensation in the connecting pipe. The volume of acid in circulation in 3 and 4 decreased, which will be explained later.

TEMPERATURE—Unfortunately, all our experiments were made under winter conditions and not much information was secured on the effect of temperature, which is probably the most important factor in determining the size of an absorption equipment necessary to handle a given quantity of gas. The small size of the plant did not permit of building up temperatures on short runs. All experience, however, goes to show that the absorption should be carried out at as low temperatures as practicable.

The effect of running the cooler air- and water-cooled is interesting. When water-cooled most of the water carried by the gas is condensed out with but little acid. The gases enter Tower 0 at room temperature, about 25°, where they warm up by the reaction going on between nitric oxide and oxygen. Practically no acid was obtained from Tower 0 under these conditions. When the cooler was air-cooled, most of the water carried by the gas was condensed in Tower 0 together with considerable acid. Artificial cooling of the gas in the reaction space (Tower 0) would be advantageous.

OXYGEN EXCESS—When the oxygen in the system was near the theoretical requirement, there was no marked increase in the acid loss. However, it is probably best not to let the concentration of oxygen in the exit gas fall below 5 per cent.

PRODUCTION AND EFFICIENCY—The first three towers (0, 1 and 2) absorb about 85 per cent of the acid input, the last two only about 10 per cent. At a gas velocity of about 2.5 cu. ft. per min. doubling the number of towers would probably not recover the other 5 per cent.

On a basis of 10 per cent ammonia in the air mixture fed to the oxidizer and 90 per cent efficiency of oxidation, 25 per cent auxiliary air must be added after oxidation to secure an oxygen concentration in the exit gas of 5 per cent. This excess may be secured in industrial operations from the operation of the acid lifts, but it would probably be advantageous to add

Date	Time	Tower 0: Cu. Ft. Air per Hour	Tower 1: HNO3 per Liter of Nitrogen, Gram	Tower 1: Acid Absorbed, Per cent	Tower 2: HNO3 per Liter of Nitrogen, Gram	Tower 2: Acid Absorbed, Per cent	Tower 2: Temp. Entering Gas, Deg. C.	Tower 2: Sp. Gr. Acid	Tower 3: HNO3 per Liter of Nitrogen, Gram	Tower 3: Acid Absorbed, Per cent	Tower 3: Temp. Entering Gas, Deg. C.	Tower 3: Sp. Gr. Acid	Tower 4: HNO3 per Liter of Nitrogen, Gram	Tower 4: Acid Absorbed, Per cent	Tower 4: Temp. Entering Gas, Deg. C.	Tower 4: Sp. Gr. Acid	Exit: HNO3 per Liter of Nitrogen, Gram	Exit: Per cent Oxygen	Exit: Per cent Acid Lost
Oct. 22	P.M.	176	0.2435	9.0	0.2210	65.8	35	1.225	0.0612	14.5	27	1.08	0.0261	4.2	23	1.03	0.0157	...	6.0	...
Oct. 24	A.M.	145	0.2125	7.5	0.1965	55.8	32	1.29	0.0780	24.0	22	1.11	0.0270	4.9	21	1.03	0.0166	3.0	21	1.01	0.0103	8.5	4.8
Oct. 25	A.M.	340	0.2540	6.0	0.2385	42.0	35	1.29	0.1320	30.0	24	1.11	0.0558	8.6	20	1.04	0.0342	5.3	20	1.02	0.0205	7.9	8.1
Oct. 25	P.M.	137	0.3160	7.0	0.2940	37.9	38	1.30	0.1742	34.1	27	1.135	0.0662	7.9	21	1.04	0.0434	3.4	19	1.02	0.0306	1.6	9.7
Oct. 26	2:30 P.M.	107	0.2845	10.4	0.2550	37.4	36	1.30	0.1485	37.2	27	1.155	0.0426	6.4	22	1.05	0.0245	3.6	21	1.025	0.0144	4.0	5.9
Oct. 26	4:00 P.M.	172	0.2295	7.0	0.2140	21.0	36	1.30	0.1650	49.5	28	1.165	0.0516	10.1	25	1.055	0.0284	4.7	25	1.025	0.0177	6.0	7.7
									Run No. 2														
Dec. 5	3:40 P.M.	137	0.2890	21.5	0.2270	52.0	40	1.24	0.0765	17.0	24	1.14	0.0275	3.5	23	1.05	0.0174	1.3	22	1.01	0.0137	2.9	4.7
Dec. 6	11:00 A.M.	147	0.2997	22.3	0.2322	41.4	41	1.26	0.1089	18.6	26	1.16	0.0531	3.1	25	1.06	0.0437	1.3	23	1.015	0.0398	0	13.3
Dec. 6	1:15 P.M.	143	0.2664	18.0	0.2196	43.5	42	1.275	0.1022	23.7	30	1.16	0.0390	6.2	24	1.065	0.0231	2.5	21	1.015	0.0164	4.2	6.1
Dec. 6	3:50 P.M.	145	0.2745	16.8	0.2286	35.2	43	1.285	0.1314	33.7	38	1.18	0.0394	5.3	24	1.07	0.0246	3.3	22	1.02	0.0156	5.0	5.7
									Run No. 3														
Dec. 7	11:50 A.M.	134	0.2205	25.7	0.1638	48.2	35	1.24	0.0576	17.5	24	1.13	0.0189	3.3	21	1.05	0.0117	1.6	17	1.005	0.0081	9.5	3.7
Dec. 7	1:50 P.M.	125	0.1935	18.6	0.1575	80.6	36	1.245	0.0597	18.9	23	1.14	0.0230	5.9	19	1.055	0.0117	2.3	17	1.01	0.0072	10.4	3.7
Dec. 7	3:45 P.M.	142	0.2628	19.6	0.2115	46.5	39	1.26	0.0891	21.7	25	1.145	0.0320	5.1	22	1.055	0.0186	2.7	19	1.01	0.0115	6.4	4.4
Dec. 8	10:40 A.M.	160	0.2007	18.4	0.1638	44.1	35	1.27	0.0751	24.4	22	1.15	0.0263	5.8	20	1.055	0.0147	3.6	18	1.01	0.0075	7.3	3.7
Dec. 8	12 M	138	0.2070	19.8	0.1661	41.4	39	1.27	0.0803	25.1	25	1.16	0.0283	6.4	23	1.06	0.0152	2.6	20	1.015	0.0097	9.0	4.7
Dec. 8	3:40 P.M.	152	0.2173	18.0	0.1782	31.6	43	1.285	0.1098	35.0	27	1.175	0.0335	6.0	25	1.07	0.0204	3.9	21	1.02	0.0119	8.0	5.5
Dec. 10	11:20 A.M.	150	0.2151	19.2	0.1737	34.2	39	1.295	0.1004	32.4	23	1.185	0.0306	6.7	22	1.07	0.0161	3.1	20	1.02	0.0095	7.8	4.4
Dec. 10	3:05 P.M.	128	0.2050	19.9	0.1642	29.9	38	1.30	0.1030	33.9	25	1.205	0.0333	8.4	22	1.075	0.0163	3.1	20	1.02	0.0099	8.5	4.8
Dec. 11	10:10 A.M.	131	0.3213	....	....	....	37	1.31	....	....	25	1.21	....	....	22	1.08	....	....	18	1.02	0.0171	2.0	5.3
Dec. 11	10:20 A.M.	140	0.2644	....	....	....	37	1.31	....	....	25	1.21	....	....	22	1.08	....	....	18	1.02	p.0095	3.5	3.6
Dec. 11	10:35 A.M.	151	0.3006	....	....	....	37	1.31	....	....	25	1.21	....	....	22	1.08	....	....	18	1.02	0.0096	5.8	3.2
Dec. 11	2:05 P.M.	114	0.3294	....	....	....	40	1.31	....	....	25	1.23	....	....	22	1.09	....	....	18	1.02	0.0166	1.8	5.0
Dec. 11	2:20 P.M.	121	0.3222	....	....	....	40	1.31	....	....	25	1.23	....	....	22	1.09	....	....	18	1.02	0.0177	2.0	5.5
Dec. 11	2:40 P.M.	124	0.3222	....	....	....	40	1.31	....	....	25	1.23	....	....	22	1.09	....	....	18	1.02	0.0201	1.8	6.2
Dec. 11	3:50 P.M.	152	0.2412	20.6	0.1915	17.8	41	1.32	0.1485	42.3	24	1.24	0.0465	10.8	20	1.09	0.0205	2.7	17	1.02	0.0140	6.3	5.8
									Run No. 4														
Dec. 14	11:15 A.M.	149	0.2808	5.8	0.2646	58.1	30	1.27	0.1012	22.6	25	1.165	0.0378	5.6	21	1.06	0.0220	1.9	20	1.00	0.0169	3.0	6.0
Dec. 14	2:10 P.M.	146	0.2637	6.5	0.2456	45.0	32	1.29	0.1272	33.6	26	1.17	0.0393	5.8	23	1.06	0.0239	3.3	19	1.00	0.0153	5.4	5.8
									Run No. 5														
Dec. 12	11 A.M.	265	0.2403	20.2	0.1917	34.5	40	1.285	0.1084	25.5	21	1.195	0.0477	8.2	17	1.075	0.0279	5.3	17	1.015	0.0150	7.5	6.3
Dec. 12	12:45 P.M.	265	0.2286	15.5	0.1935	23.3	48	1.280	0.1399	36.5	22	1.21	0.0562	10.3	18	1.075	0.0330	5.3	17	1.015	0.0209	7.4	9.1
Dec. 12	2:10 P.M.	265	0.2232	10.5	0.1998	30.7	36	1.295	0.1309	35.4	23	1.225	0.0522	10.2	17	1.085	0.0295	4.3	17	1.02	0.0198	7.7	8.9
									Run No. 6														
Dec. 13	11:45 A.M.	67	0.2582	23.7	0.1975	53.6	24	1.30	0.0587	17.8	19	1.195	0.0126	3.3	16	1.075	0.0042	0.4	16	1.02	0.0031	10.5	1.2
Dec. 13	2:00 P.M.	71	0.2700	23.0	0.2080	45.8	26	1.30	0.0842	22.3	22	1.20	0.0239	6.5	23	1.075	0.0066	2.4	18	1.02	0.0036	6.9	1.3
Dec. 13	3:40 P.M.	62	0.2970	20.4	0.2367	44.6	30	1.305	0.1040	24.4	22	1.20	0.0315	6.0	19	1.075	0.0135	2.4	18	1.02	0.0066	5.0	2.2
									Run No. 7														
Dec. 17	10:40 A.M.	144	0.2763	....	....	....	36	1.295	....	....	25	1.18	..	....	20	1.06	0.0134	...	18	NaOH	0.0055	5.0	2.0
Dec. 17	11:55 A.M.	142	0.2510	....	....	....	..	....	....	....	..	....	..	....	..	....	0.0182	...	..	NaOH	0.0068	6.4	2.7
Dec. 17	2:10 P.M.	116	0.3590	....	....	....	38	1.31	....	....	23	1.19	....	....	19	1.06	0.0298	...	18	NaOH	0.0139	1.2	3.9
Dec. 17	2:50 P.M.	134	0.3140	....	....	....	40	1.31	....	....	24	1.195	....	....	20	1.06	0.0340	...	17	NaOH	0.0141	2.0	4.5
									Run No. 8														
Dec. 19	10:20 A.M.	140	0.2592	....	....	....	36	1.315	....	....	21	1.21	....	....	26	1.07	0.0141	...	22	NaOH	0.0050	6.4	1.9
Dec. 19	11:45 A.M.	136	0.2443	....	....	....	38	1.315	....	....	26	1.22	..	....	23	1.07	0.0213	...	19	NaOH	0.0080	6.0	2.4
Dec. 19	1:35 P.M.	264	0.2313	....	....	....	42	1.315	....	....	27	1.24	....	....	23	1.08	0.0432	...	22	NaOH	0.0109	7.0	4.7

most of the air required before the gas enters the reaction space preceding the first absorption tower. Under the conditions of the tests our plant had capacities as follows, based on 0.285 g. HNO_3 per liter of nitrogen:

Cubic feet gas per minute.....	1.25	2.5	4.0
Efficiency of absorption—per cent...	98	95	91
HNO_3 recovered in 24 hours—lbs....	23	44.5	68

The last two towers were very inefficient. This was due largely to the great dilution of the nitrogen oxide when they reached this part of the system. Part of the loss is due to the formation of an acid mist which, of course, is unabsorbable. The decrease in volume of the circulating liquid in the last two towers cannot be accounted for by evaporation and is caused by this formation of mist.

EXPERIMENTS WITH A COTTRELL PRECIPITATOR—About a year ago, in making small scale experiments in the laboratory on the catalysis of ammonia oxidation, in which the acid make was determined by absorption in gas washing bottles, the occurrence of a mist throughout these bottles was noted, which caused certain losses from the absorption train even when alkali was used in the last bottles. At that time a fume precipitation apparatus was secured and a few successful experiments made. Press of other work caused these experiments to be discontinued. This equipment was installed in our experimental plant after making the experiments described above, by removing the connecting pipe between Towers 3 and 4 and substituting the $^3/_4$-in. glass tube shown in the figure.

The high-tension current required was obtained from a transformer such as is used in wireless telegraphy, capable of giving a maximum of 15,000 volts. The current was rectified with a kenotron furnished by the General Electric Company. A platinum wire was placed in the center of the glass tube and connected to the anode of the kenotron. A coil of copper wire was wrapped around the tube and connected with the inside wall with platinum wire. This coil and one terminal of the transformer were grounded. The voltage was regulated by a variable resistance in circuit with the primary of the transformer. This arrangement worked perfectly and stopped all mist even at considerable velocities of flow through the tube.

It was found that when all the mist issuing from Tower 3 was stopped no further mist was formed in Tower 4. Under conditions of operation obtaining in Run 3 where the total acid loss was about 5 per cent, it was found that during the first hour of opera-

tion, circulation acids at concentrations near end of a run, the acid obtained from the precipitator was about 2 per cent of the total acid input. The quantity of mist decreased steadily to about 0.5 per cent, where it remained constant. The quantity of mist varied widely under different conditions, all of which have not been determined. It has been observed in a full-sized plant that sometimes there was considerable mist issuing from the absorption system and at other times none at all. No correlation was established with different conditions of operation.

We found in our experimental plant that the mist was increased by increase of the gas velocity, reduction of the oxygen excess, and increase of the acid strength in Tower 3. For example, at a velocity of 150 cu. ft. per hour with a slight oxygen deficiency samples were taken of the exit gas with the precipitator turned on and ten minutes after turning it off. In the second case the acid in the exit increased from 0.0174 to 0.0248 g. per liter corresponding to an increase in the end loss of from 6.5 to 9.3 per cent. The acid recovered from the precipitator contained very little nitrous acid, being almost wholly nitric of 15 to 25 per cent strength. No evidence was secured of any increased absorption capacity of Tower 4 by the high potential discharge.

Of the three chemical reactions involved in absorbing nitrogen peroxide in water to form nitric acid, that represented by Equation 1 above requires appreciable time, and hence is the controlling one. In order to give this reaction sufficient time all the reaction space practicable should be provided. Atomized sprays are used in some cases for absorbing gases by liquids, and have been suggested as of possible application here. Removal of all packing material would increase the reaction space for the oxidation of NO, and efficient liquid absorption surface would be provided by the sprays. The Cottrell precipitator satisfactorily solves the problem of recovering any mist that would not settle out. Experiments along this line are projected.

ACKNOWLEDGMENT

The experiments described are part of the investigation being carried out by the Bureau of Mines on the oxidation of ammonia under the direction of the chief chemist, Dr. Charles L. Parsons.

BUREAU OF MINES
WASHINGTON, D. C.

INFLUENCE OF TIME OF HARVEST, DRYING AND FREEZING OF SPEARMINT UPON THE YIELD AND ODOROUS CONSTITUENTS OF THE OIL[1]

By FRANK RABAK

Received October 11, 1917

The cultivation of spearmint is conducted extensively for the production of the volatile oil, which is used largely for the flavoring of chewing gum. The efficacy of the oil for this purpose depends much upon its composition as regards the odorous constituents, the exact nature of which is not clearly understood.

The constituents which serve at least in part to produce the peculiar, yet much liked flavor of the oil and of the products flavored with the oil, are perhaps ester-like or alcoholic in character.

It is stated by Schimmel & Co.,[1] that Russian spearmint oil is strikingly different from American, German and Hungarian oils in that, in addition to carvone, which perhaps constitutes the major portion of these oils, an alcohol which has been identified as linalool has been found to be present in considerable quantities.

Elze,[2] in an examination of German spearmint oil, states that the carrier of the odorous principle of the oil is the acetic acid ester of dihydrocuminic alcohol.

More recently, Nelson,[3] working with an American spearmint oil, though unable to confirm the presence of dihydrocuminic acetate, reported the presence of the acetate of the alcohol dihydrocarveol. This ester is stated to possess the characteristic odor of spearmint.

Investigations of spearmint oil therefore, with a view to the identification of the constituents to which the characteristic odor is attributable, indicate that esters or alcoholic compounds play an important part as carriers of the aroma and flavor. Granting that the odor-bearing constituents are ester-like or alcoholic in character, a study of the plant was undertaken at Arlington Farm, Va., to obtain information regarding the effect of time of harvest, drying of the plant, and frost action upon the constituents as well as upon the yield and physical properties of the oils.

Experiments were conducted through a period of years in which the plants were harvested and distilled at three distinct stages of growth, *viz.*, budding, flowering and fruiting stages. The plants were distilled in both fresh and dried conditions and the oils subjected to examination and compared both as regards yield of oil and physical and chemical composition. At the same time, the leaves and flowering tops were separated from the fresh material at the different stages of growth and distilled in order to obtain information regarding the distribution of the oil in the plant and composition of the oil from the plant parts as compared with the whole fresh herb. An experiment was also conducted to determine the effect of frost action upon the yield and quality of the oil.

A comparison of the yields of oil from fresh and dry herb at different stages of growth during the seasons of 1908, 1909, 1910 and 1911, together with the dates of harvest and distillation are given in Table I.

No definite relationship exists in the yields of oil from the fresh herb at any stage of growth during the several seasons. The yields apparently vary with the season. Yields of oil during the seasons of 1908

[1] Published by permission of the Secretary of Agriculture.

[1] Schimmel & Co., Spearmint Oil. Semi-annual Report of Schimmel & Co., pp. 45–46, April 1898.

[2] "Ueber Krauseminzol," *Chem.-Ztg.*, **32** (1910), 1175.

[3] "A Chemical Investigation of American Spearmint Oil," U. S. Department of Agriculture, Bureau of Chemistry, *Circular* **92**, 1912.

TABLE I—YIELD OF SPEARMINT OIL FROM THE FRESH AND FROM THE DRY HERB AT DIFFERENT STAGES OF GROWTH DURING FOUR SUCCESSIVE YEARS
(All yields of oil calculated on basis of fresh herb)

	1908		1909		1910		1911		
MATERIAL	Date	Yield Per cent	Date	Yield Per cent	Date	Yield Per cent	Date	Yield Per cent	AVERAGE Per cent
Fresh Herb:									
Budding	July 24	0.30	July 7	0.11	July 14	0.11	July 7	0.23	0.187
Flowering	Aug. 3	0.22	July 15	0.15	Aug. 9	0.19	July 24	0.26	0.205
Fruiting	Sept. 9	0.19	July 26	0.24	Sept. 12	0.07	Aug. 8	0.21	0.147
Dry Herb:									
Budding	....	....	July 9	0.14	July 29	0.083	Aug. 3	0.15	0.123
Flowering	....	....	July 19	0.097	Aug. 25	0.11	Aug. 3	0.22	0.142
Fruiting	....	....	July 29	0.14	Sept. 23	0.035	Sept. 29	0.077	0.084

and 1911 were noticeably higher than during 1909 and 1910, from which it is apparent that seasonal conditions play an important part in affecting the yields of oil from the plants. The yield of oil from the fruiting plants is uniformly low as shown by the average, while the flowering stage produces the highest yields during most seasons.

The yields of oil from the dried plants during any of the stages of growth are lower in practically all cases than that of the fresh herb. As in case of the fresh herb, the flowering stage again shows highest average yield of oil while the fruiting stage shows the lowest yield. The yields of oil from the dried plants will, of course, be affected by the length of time allowed for drying, and weather conditions during the drying period. The average percentage of moisture in the plants during the three years, 1909, 1910 and 1911, was as follows: Budding stage, 71.6; flowering stage, 70.7; fruiting stage, 62.2 per cent.

In order to make a comparison of the yields of oil from the leaves and flowering tops of the plants at different stages of growth, the results were tabulated together with the yields from the whole fresh herb at the three stages of growth.

TABLE II—COMPARISON OF THE YIELDS OF SPEARMINT OIL FROM THE FRESH HERB, LEAVES AND TOPS AT DIFFERENT STAGES OF GROWTH DURING THREE SUCCESSIVE YEARS

	Yield of Oil, Per cent			
STAGE OF GROWTH	1909	1910	1911	AVERAGE
Whole Herb:				
Budding	0.11	0.11	0.23	0.150
Flowering	0.15	0.19	0.26	0.200
Fruiting	0.24	0.07	0.21	0.173
Leaves:				
Budding	0.21	0.08	0.24	0.176
Flowering	0.25	0.20	0.22	0.223
Fruiting	0.15	0.05	0.41	0.203
Tops:				
Budding	0.28	0.08	0.42	0.260
Flowering	0.31	0.14	0.48	0.310
Fruiting	0.27	0.05	0.41	0.243

An examination of Table II shows that the yield of oil from the whole herb is lower than either that from the leaves or flowering tops during any of the stages of growth, due doubtless to the presence of stems in the whole herb. The yield of oil from the flowering tops is uniformly higher than from the leaves. The tops during the fruiting stage show the

TABLE III—PHYSICAL PROPERTIES, ACID, ESTER AND ALCOHOL CONTENT OF SPEARMINT OIL DISTILLED FROM FRESH AND DRY HERBS IN VARIOUS STAGES OF GROWTH DURING SUCCESSIVE YEARS

			PHYSICAL PROPERTIES				ACID ESTER AND ALCOHOL CONTENT		
YEAR	MATERIAL	Color, Odor and Taste	Specific Gravity	Rotation 50 mm. Tube	Refraction	Solubility in 80 Per cent Alcohol	Free Acid as acetic ($C_2H_4O_2$) Per cent	Esters Calcd. as Acetate of Alcohol ($C_{10}H_{18}O$) Per cent	Alcohol Calcd. as ($C_{10}H_{18}O$) Per cent
1908	*Fresh Herb:*								
	Budding	Pale greenish yellow, pleasant characteristic odor, slightly bitter pungent taste	0.9255(*a*)	−25.1	1.4874(*b*)	1.3 clear in excess	0	3.8	9.1
	Flowering	Dark yellowish green, pleasant odor, slightly bitter and pungent taste	0.9288(*a*)	−24.5	1.4880(*b*)	1.25 clear in excess	0	4.6	8.54
	Fruiting	Light yellowish green, faint characteristic odor, very pungent taste	0.9290(*a*)	−21.7	1.4853(*b*)	0.75 clear in excess	0	8.7	13.4
1909	*Fresh Herb:*								
	Budding	Yellowish red, faint pleasant odor, bitter pungent taste	0.9316(*c*)	−16.3	1.4891(*c*)	1.2 turbid in 1.5 or more vols	0.32	8.6	12.0
	Flowering	Dark green, agreeable flowery odor, bitter aromatic pungent taste	0.9289(*c*)	−16.1	1.4864(*c*)	1 turbid in 2 or more vols	0.26	7.7	12.4
	Fruiting	Straw, pleasant mild odor, bitter pungent taste	0.9343(*c*)	−17.4	1.4873(*c*)	0.8 turbid in 1.5 or more vols	0.28	7.3	10.9
	Dry Herb:								
	Budding	Yellowish, unpleasant odor, bitter pungent taste	0.9279(*c*)	−17.0	1.4888(*c*)	0.8 turbid in 1.5 or more vols	0.04	7.0	11.7
	Flowering	Golden yellow, strong minty odor, bitter pungent taste	0.9331(*c*)	−17.5	1.4868(*c*)	0.8 clear in excess	0.86	10.8	12.7
	Fruiting	Dark straw, strong fatty aromatic odor, bitter, very pungent taste	0.9254(*c*)	−16.5	1.4846(*c*)	1 turbid in 1.5 or more vols.	0.21	9.1	15.6
1910	*Fresh Herb:*								
	Budding	Yellowish green, pleasant characteristic odor, pungent bitter aromatic taste	0.9312(*d*)	−22.8	1.4895(*d*)	0.6 clear in excess	0.14	7.6	16.0
	Flowering	Dark golden yellow, strong aromatic characterstic odor, very pungent bitter taste	0.9252(*d*)	−20.3	1.4825(*d*)	0.4 turbid in 2.2 or more vols	0.69	13.4	18.4
	Fruiting	Pale brown with green tint, fragrant flowery odor, bitter, slightly pungent taste	0.9303(*d*)		1.4800(*d*)	0.6 turbid in 6 or more vols	1.5	15.9	21.4
	Dry Herb:								
	Budding	Dark golden yellow, less characteristic herb like odor, fatty pungent bitter aromatic taste	0.9123(*d*)	−18.2	1.4725(*d*)	0.4 turbid in 10 or more vols	0.38	10.8	15.7
	Flowering	Pale brown, herb like strong aromatic odor, very pungent bitter taste			1.4788(*d*)		0.59	31.8	28.2
	Fruiting	Pale brown, herb like aromatic odor, strong aromatic very bitter and pungent taste	0.9159(*d*)		1.4745(*d*)	0.4 turbid in 6 or more vols	0.36	22.0	30.5

(*a*) At 22° C. (*b*) At 24° C. (*c*) At 21° C. (*d*) At 25° C.

highest average oil content. It is evident from these results that the greatest portion of oil in the spearmint plant is found in the flowering tops which comprise a large portion of the plant as compared with the leafy structure.

PHYSICAL AND CHEMICAL PROPERTIES OF OILS FROM FRESH AND DRY PLANTS

The physical and chemical properties of the oil from the fresh herb in 1908, the fresh and dry herb in 1909 and the fresh and dry herb in 1910 during the budding, flowering and fruiting stages were determined and tabulated in Table III. The physical properties determined were the color, odor, taste, specific gravity, rotation, refraction and solubility in 80 per cent alcohol. The chemical properties are represented by the free acid content as acetic acid, the ester content calculated as acetate of the alcohol $C_{10}H_{18}O$, and the alcohol content calculated as $C_{10}H_{18}O$.

As regards the color, odor and taste of the oils distilled from the fresh herb at the three stages of growth during the three seasons, some differences are noted. The odor of the oils from the fruiting herb in each case was decidedly more fragrant than that from the flowering or budding herb. No apparent relationship existed in the color of the various oils from the three stages of plant growth during the three seasons. The specific gravities and refraction of the oils from each stage of growth differ among themselves as well as from season to season. The rotations of the oils are comparable during any one season, but differ from season to season, while the solubilities vary likewise. The solubility of the oils from the flowering and fruiting stages of the fresh herb during the three years

TABLE IV—COMPARISON OF PHYSICAL PROPERTIES, ACID, ESTER AND ALCOHOL CONTENT OF SPEARMINT OILS DISTILLED FROM LEAVES, FLOWERING TOPS AND ENTIRE HERB AT VARIOUS STAGES OF GROWTH

			Physical Properties				Acid, Ester and Alcohol Content		
								Esters Calcd. as Acetate of Alcohol $C_{10}H_{18}O$ Per cent	Alcohol Calcd. as $C_{10}H_{18}O$ Per cent
Year	Material	Color, Odor and Taste	Specific Gravity	Rotation 50 mm. Tube	Refraction	Solubility in 80 Per cent Alcohol	Free Acid (as acetic) Per cent		
1909	*Budding Stage:*								
	Herb	Yellowish red color, faint pleasant odor, bitter pungent taste	0.9316(*a*)	—16.3	1.4891(*a*)	1.2 turbid in 1.5 or more vols.	0.32	8.6	12.0
	Leaves	Deep golden yellow, faint characteristic odor, acid bitter pungent aromatic taste	0.9776(*a*)	—12.3	1.4923(*a*)	0.6 turbid in 3.5 or more vols.	2.36	14.0	14.0
	Tops	Pinkish, pleasant characteristic odor, bitter pungent aromatic taste	0.9351(*a*)	—15.2	1.4906(*a*)	0.8 turbid in 1.5 or more vols.	0.14	5.9	9.9
	Flowering Stage:								
	Herb	Dark green, agreeable flowery odor, bitter aromatic pungent taste	0.9289(*a*)	—16.1	1.4864(*a*)	1 turbid in 2 or more vols.	0.26	7.7	12.4
	Leaves	Yellowish green, pleasant aromatic minty odor, bitter pungent aromatic taste	0.9383(*a*)	—15.9	1.4887(*a*)	1.2 turbid in 2 or more vols.	0.25	7.7	10.0
	Tops	Deep golden yellow, flowery aromatic minty odor, slightly acid, bitter pungent taste	0.9429(*a*)	—13.8	1.4898(*a*)	1 slightly turbid in 4 or more vols.	0.64	10.3	12.9
	Fruiting Stage:								
	Herb	Straw, pleasant mild odor, bitter pungent taste	0.9343(*a*)	—17.4	1.4873(*a*)	0.8 turbid in 1.5 or more vols.	0.28	7.3	10.9
	Leaves	Light straw, faint not pleasant odor, acid, bitter pungent taste	0.9634(*a*)	— 6.3	1.4902(*a*)	0.6 turbid in 2 or more vols.	1.70	11.9	6.1
	Tops	Light straw, faint characteristic odor, acid bitter pungent taste	0.9421(*a*)	—10.2	1.4887(*a*)	0.8 turbid in 1.5 or more vols.	0.62	8.75	7.7
1910	*Budding Stage:*								
	Herb	Yellowish green, pleasant characteristic odor, pungent bitter aromatic taste	0.9312(*b*)	—22.8	1.4895(*b*)	0.6 clear in excess	0.14	7.6	16.0
	Leaves	Dark yellowish green, faint characteristic odor, very bitter and pungent taste	0.9271(*b*)	—22.4	1.4899(*b*)	0.66 turbid in 1.5 or more vols.	0.10	14.3	14.9
	Tops	Light yellowish green, faint flowery pleasant odor, very bitter pungent taste	0.9260(*b*)	....	1.4908(*b*)	0.66 turbid in 1.5 or more vols.	0.20	12.4	17.0
	Flowering Stage:								
	Herb	Dark golden yellow, strong aromatic characteristic odor, very pungent, bitter taste	0.9252(*c*)	—20.3	1.4825(*c*)	0.4 turbid in 2.2 or more vols.	0.69	13.4	18.4
	Leaves	Pale golden yellow, pleasant faint characteristic odor, pungent bitter aromatic taste	0.9224(*c*)	—19.2	1.4830(*c*)	0.5 turbid in 1.5 or more vols.	1.70	17.1	9.7
	Tops	Dark golden yellow, faint agreeable fatty odor, slightly acid, bitter pungent taste	0.9219(*c*)	—19.8	1.4835(*c*)	0.7 turbid in 1.7 or more vols.	1.30	18.8	17.9
	Fruiting Stage:								
	Herb	Pale brown with green tint, fragrant flowery odor, bitter, slightly pungent taste	0.9303(*b*)	. .	1.4800(*c*)	0.6 turbid in 6 or more vols.	1.50	15.9	21.4
	Leaves	Pale brown with green tint, mild, fragrant, characteristic odor, very bitter pungent taste	. . .	. .	1.4868(*b*)	Faintly turbid in 8 or more vols	0.36	18.2	28.0
	Tops	Pale brown with green tint, very flowery characteristic odor, very bitter, strongly pungent, aromatic taste	....	.	1.4870(*b*)	Faintly turbid in 10 or more vols.	0.48	30.8	50.2

(*a*) At 21° C. (*b*) At 23° C. (*c*) At 24° C.

generally excels that of the budding herb, which would perhaps indicate a higher content of esters and alcohols, and a lower content of terpenic compounds in the oils during those stages of growth.

Discussing the physical properties of the oils from the dry herb, the most conspicuous difference as compared to the oils from the fresh herb was the odor which was distinctly more aromatic in most cases, although accompanied by a herb-like odor. The specific gravities, rotation and refraction averaged lower in case of the oils from dry plants than those from the fresh herb. The oils from the dry herb were, on the other hand, distinctly more soluble in 80 per cent alcohol than from the fresh herb.

The percentage of free acids as acetic acid varied much among the oils from both fresh and dry herb at the three stages of growth. The percentage of esters, however, in the oils from both fresh and dry plants was higher in most instances in the oils from the flowering and fruiting herbs. The oils from the dry plants showed noticeably higher ester content than the fresh herb oils. The percentage of esters varies during the several seasons from 3.0 to 10.8 per cent in the budding plant, 4.6 to 31.8 per cent in the flowering plant, and 7.3 to 22.0 in the fruiting plant. The percentage of free alcohols varies in about the same ratio as the ester content, increasing in both fresh and dry plants as the plant matures. The percentage of alcohol in the oil from the fresh herb varies from 9.1 to 16 per cent during the budding stage, from 8.54 to 18.4 per cent during the flowering stage, and from 10.9 to 21.4 per cent during the fruiting stage. The oils from the dry herb vary in alcohol content from 11.7 to 15.7 per cent in budding herb, from 12.7 to 28.2 per cent in flowering herb, and from 15.6 to 30.5 per cent in fruiting herb.

While the percentage of free acids in the oils from the dry herb shows no constant increase or decrease as compared with the oils from the fresh herb, the ester and alcohol content of the oils from the dry herb at the various stages of growth are considerably higher than in the oils from the fresh herb at the same stages of growth. The drying process has therefore tended to cause chemical changes favoring esterification and formation of alcohols.

In connection with the study of these oils, the oils from the leaves and tops of the plants were examined similarly and the results tabulated for comparison with the oil from the fresh herb.

Table IV shows that in physical properties, the oils from the leaves and tops do not differ greatly from the oil from the whole fresh herb. The color of the oils is distinctly variable. The odor of the oils from the flowering tops seemed to excel that from the leaves in fragrance and agreeableness in practically every case. The specific gravity and refraction of the oils from the leaves and tops are variable. The rotation in all cases is lower than in that of the oil from the whole fresh herb, while the solubility in 80 per cent alcohol of the oils from leaves and tops also differs from that of the oils from the fresh herb during the three stages of growth. These differences in physical properties apparently indicate a difference in general composition of the oils from leaves and tops as compared with that from the whole fresh herb in its three stages of growth.

In acid value of the oils from leaves and tops much variation exists during the two seasons and also during the several stages of growth when compared with one another, and also when compared with the oils from the whole fresh herb at the three stages of growth. In every case, the oils from the leaves and tops are richer in esters than the fresh herb. As a general rule these oils also proved to be richer in alcohols than the fresh herb. The leaf oils in nearly every instance contain somewhat lower percentages of alcohols than the oils from the flowering tops. No apparent relationship seems to exist between the acid content and the ester and alcohol content of the oils, although it appears that the formation of esters and alcohols is more pronounced in the flowering tops than in the leaves. A general increase is noted in most cases in the ester and alcohol content of the oils from leaves and tops as the plants mature, the fruiting stage producing oils in 1910 with a much higher content of these constituents than the flowering or budding stages.

EFFECT OF FROST ACTION—In connection with the above experiments it was thought desirable to study the effect of frost upon the resulting volatile oil. On account of the lateness of heavy frosts it was necessary to utilize a second growth of spearmint. This second crop had not even advanced to the budding stage, the plants consisting mainly of leaves and stems. The plants were distilled on November 18, after a heavy frost, the action of which was very noticeable. The oil obtained from the frozen plant was compared with an oil obtained from unfrozen plants distilled at about the same stage of maturity. The yield of oil, physical properties, and chemical composition of the oils from frozen and unfrozen plants are compared in Table V.

TABLE V—COMPARISON OF YIELD, PHYSICAL PROPERTIES, ACID, ESTER AND ALCOHOL CONTENT OF SPEARMINT OILS FROM FROZEN AND UNFROZEN PLANTS

ITEMS OF COMPARISON	FROZEN PLANTS	UNFROZEN PLANTS
Physical Properties:		
Yield (per cent)	0.11	0.13
Color	Deep golden yellow	Yellowish green
Odor	Mild characteristic, very pleasant	Characteristic, very minty
Taste	Bitter, slightly pungent, aromatic	Bitter, very pungent aromatic
Specific gravity	0.9180 at 24° C.	0.9252 at 23° C.
Rotation in 50 mm tube degrees	—4.7	—27.5
Refraction	1.4771 at 25° C.	1.4822 at 23° C
Solubility in 80 per cent alcohol (volume)	0.5 clear in excess	0.6 turbid in 2 or more volumes
Chemical Composition:		
Free acids calcd. as acetic acid (per cent)	0.79	0.85
Esters calcd. as acetate of alcohol $C_{10}H_{18}O$ (per cent)	25.90	8.75
Alcohols calcd. as $C_{10}H_{18}O$ (per cent)	19.26	12.22

The yield of oil from the frozen plants was only slightly lower than from the unfrozen material. The color of the oil from the frozen plants was lighter and the odor and taste very decidedly milder and more agreeable than that from the unfrozen plant.

The specific gravity and refraction were much lower in the oil from the frozen plant. A most remarkable difference between the oils is noted in the rotation, the rotation of the oil from the frozen plants being but one-sixth that of the unfrozen plants. The oil from the latter doubtless contained much higher content of laevogyrate compounds, possibly carvone. The oil from the frozen plants was much more readily soluble in 80 per cent alcohol, dissolving in one-half volume of alcohol, showing no turbidity when alcohol was added in excess, indicating a possible lower content of terpenes and a higher content of alcohol-soluble compounds.

The ester and alcohol constituents of the oil from the frozen plants differed greatly from the unfrozen material. The much higher ester content is especially significant, indicating increased activity in the esterification process in the frozen plants. The higher alcohol content also points to the existence of favorable conditions, due to frost action, affecting the formation of alcohols in the oil.

CONCLUSIONS

The yield of oil in the spearmint plant is affected by seasonal conditions, being distinctly higher in some seasons than in others. The maximum content of oil appears to be present during the flowering period, the tops containing the highest percentage of oil. Drying of the plants or plant parts results in a lower yield of oil and causes changes producing increased ester and alcohol content. Esterification and alcohol formation tend to increase as the plant matures. Freezing of the plant produces a marked increase in the formation of the odor-bearing esters and alcohols.

BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

CARBONATION STUDIES
II—THE CARBONATION OF DISTILLED WATER

By HARRISON E. PATTEN AND GERALD H. MAINS

Received September 25, 1917

Water is the principal solvent in carbonated beverages such as wines, pops, malt liquors, etc., consequently a knowledge of its solvent and holding power for carbon dioxide gas is of basic importance. Data are extant for the solubility of carbon dioxide in water up to moderate pressures.[1] But very little work, if any, has been done at higher pressures, especially upon the rate of evolution of carbon dioxide from its aqueous solutions, the so-called "holding power" of the solution. The data here presented were secured on distilled water in order to give fundamental characteristics which were needed in connection with our further studies on carbonation.

METHOD AND APPARATUS

770 cc. of distilled water from our regular laboratory supply were placed in a quart champagne bottle,[2] and iced until the liquid was at the freezing temperature. An impregnating apparatus, previously described[1] and consisting essentially of a rotating stirrer fitting into the bottle, with means for admitting gas while stirring, and of measuring the pressure of the gas, was connected with a cylinder of carbon dioxide, and the water impregnated under the conditions of pressure and stirring given below. The finished product was then examined as to its holding power for the gas.

Portions of the gas withdrawn from the bottle were measured and analyzed in the apparatus shown in Fig. I. This consists of a relatively large gas burette, *G*, to hold the large quantity of gas which rushes out of the carbonated water on opening the valve of the stirring head; and a graduated gas burette, *B*, serving to measure portions of the gas from *G*, before and after

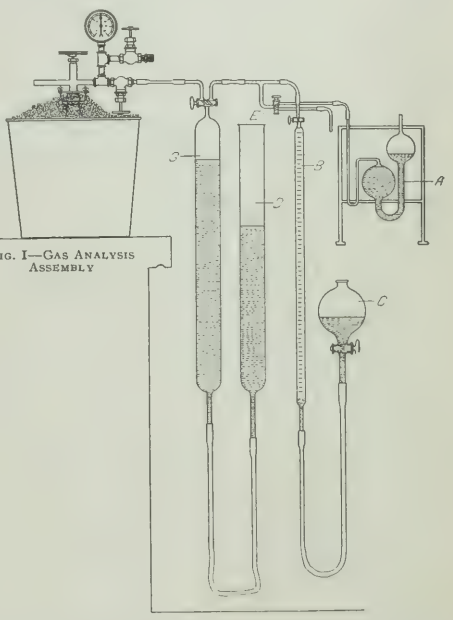


FIG. I—GAS ANALYSIS ASSEMBLY

absorption in sodium hydroxide solution in bulb *A*. Levelling tubes *C* and *D* enable one to transfer gas at will through the proper connections as shown in Fig. I. The two-way stopcock *E* and exit tube permit gas to be ejected from the system, after measurement and analysis. The apparatus is filled with a saturated brine solution which does not absorb enough carbon dioxide during the short interval of contact of gas and solution to affect the measurements of gas volume.

Recovery of pressure in the bottle after the gas cushion has been allowed to come to atmospheric pressure[2] is indicated on the pressure gauge when the valve is again closed. The rate of pressure recovery

[1] Findlay and Creighton, *J. Chem. Soc.*, **97** (1910), 536; Findlay and Shen, *Ibid.*, **99** (1911), 1313; **101** (1912), 1459; Findlay and Williams, *Ibid.*, **103** (1913), 636; Findlay and King, *Ibid.*, **103** (1913), 1170.

[2] This quantity of liquid used in a quart bottle gives a suitable gas cushion, 18 to 25 cc. above the liquid, and approximates trade conditions of bottling.

[1] "Carbonation Studies—I. A Mechanical Stirrer for Impregnating Liquids with Gases," THIS JOURNAL, **9** (1917), 787.

[2] Accomplished by opening the stirring head valve for an instant and allowing gas to escape into tube *G*, Fig. I.

TABLE I—PRESSURE RECOVERY AND ANALYTICAL DATA. DISTILLED WATER. CARBONATION NO. 1. SLOW SPEED STIRRING

	Opening: First		Second		Third		Fourth		Fifth		Sixth		Seventh		Eighth		Ninth	
	Temperature of Bottle:	0°	0°		0°		0°		0°		0°		0°		0°		0°	
	Opening Pressure:	65 Lbs.	30.5 lbs.		31.1 lbs.		30.0 lbs.		30.1 lbs.		27.0 lbs.		29.6 lbs.		27.5 lbs.		27.2 lbs.	
	Period(a) M. S.	Pr.(b) Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.	Period M. S.	Pr. Lbs.
	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0
	0 5	1.0	0 1	5.0	0 1	2.0	0 1	4	0 1	3.0	0 2	3.0	0 1	5.0	0 1	5.0	0 1	2.0
	1 10	2.0	0 10	8.0	0 2	3.0	0 4	6	0 2	5.0	0 2	4.0	0 3	7.0	0 2	6.0	0 3	5.0
	2 08	3.0	0 19	10.0	0 5	4.0	0 5	7	0 3	6.0	0 5	6.0	0 5	8.0	0 4	7.0	0 5	7.0
	3 20	5.0	0 24	11.0	0 7	5.0	0 8	8	0 5	7.0	0 7	7.0	0 8	9.0	0 6	8.0	0 9	8.0
	3 45	6.0	0 34	12.0	0 9	6.0	0 10	9	0 7	8.0	0 11	8.0	0 13	11.0	0 10	9.0	0 11	9.0
	4 13	7.0	0 43	13.0	0 10	7.0	0 12	10	0 12	9.0	0 13	9.0	0 19	12.0	0 13	10.0	0 13	10.0
	4 35	8.0	0 55	14.0	0 14	8.0	0 15	11	0 14	10.0	0 15	10.0	0 28	13.0	0 16	11.0	0 17	11.0
	4 55	9.0	1 15	15.0	0 17	9.0	0 21	12	0 17	11.0	0 21	11.0	0 37	14.0	0 23	12.0	0 24	12.5
	5 45	11.0	1 32	16.0	0 24	10.0	0 28	13	0 24	12.0	0 26	12.0	0 48	15.0	0 29	13.0	0 30	13.0
	6 20	12.0	2 10	17.0	0 29	11.0	0 38	14	0 32	13.0	0 36	13.0	1 25	17.0	0 39	14.0	0 39	14.0
	7 50	14.0	2 50	18.0	0 42	12.0	1 03	16	0 44	14.0	0 48	14.0	1 55	18.0	0 50	15.0	0 53	15.0
	8 45	15.0	4 00	19.0	0 52	13.0	1 18	17	0 55	15.0	1 05	15.0	2 38	19.0	1 07	16.0	1 09	16.0
	10 00	16.0	5 35	20.0	1 09	14.0	1 45	18	1 11	16.0	1 23	16.0	3 30	20.0	1 29	17.0	1 27	17.0
	11 30	17.0	7 45	21.0	2 15	16.5	2 15	19	2 19	18.5	3 08	19.0	8 55	22.5	2 05	18.0	2 02	18.0
	19 20	18.5	12 30	23.0	3 05	18.0	3 07	20	3 24	20.0	5 48	21.0	15 25	24.0	3 07	19.0	2 47	19.0
	26 30	19.0	16 25	24.0	4 05	19.0	4 20	21	8 39	23.0	9 58	23.0	31 ..	25.5	6 32	21.0	3 57	20.0
	33 05	20.0	23 10	25.0	5 30	20.0	5 35	22	19 49	25.0	13 33	24.0	43 ..	26.2	8 52	22.0	8 37	22.0
	86 ..	21.0	34 00	26.0	7 15	21.0	7 45	23	30 ..	26.0	23 38	25.0	58 ..	27.0	17 02	24.0	17 42	24.0
	1140 ..	30.5	46 ..	27.0	9 15	22.0	15 05	25	45 ..	27.0	50 ..	26.5	73 ..	27.5	37 ..	25.2	30 ..	25.3
			76 ..	28.5	12 05	23.0	32 15	27.0			64 ..	27.0			61 ..	26.1	1140 ..	27.5
			129 ..	29.8	15 05	24.0	41 ..	27.5			1020 ..	29.0			92 ..	27.2		
			253 ..	31.1	22 45	25.0	68 ..	29.0										
					35 30	26.0	138 ..	29.8										
					50 ..	27.0	175 ..	30.1										
					1140 ..	30.0												
	Cc GAS:																	
	Withdrawn(c)	166.0	57.0		55.4		58.2		55.1		33.2		56.2		49.5		43.2	
	Residual	5.8	1.5		2.6		1.1		0.6		0.5		1.3		0.9		0.5	
	Per cent CO_2	96.5	97.4		95.3		98.1		98.9		98.5		97.7		98.2		98.8	

RATE OF PRESSURE RECOVERY

(a) Period of Pressure Recovery is given in Minutes and Seconds, abbreviated M. and S.
(b) All gauge readings in this and the other tables are in lbs. per sq. in. where zero on the gauge equals 14.7 lbs. per sq. in. (atmospheric pressure).
(c) All gas volumes given are for standard conditions (0° C. and 760 mm pressure) calculated from measurements at room temperature and pressure, allowance being made for the vapor pressure of the saturated sodium chloride solution over which the gas was collected, as taken from the table in the footnote on page 281.

was secured by using a stop-watch started as soon as the valve was closed, and taking simultaneous readings of time and pressure as long as the pressure continued to rise. After a sufficient number of pressure recovery curves to give the characteristic rates for the bottle had been taken, the remainder of the gas was withdrawn in convenient portions into the analysis apparatus, measured and analyzed. When practically all of the gas that would come off at ice temperature and atmospheric pressure was removed, the bottle was raised to room temperature. Further portions of gas were withdrawn, and the bottle was then placed in a steam bath and the remainder of the gas removed by boiling.

EXPERIMENTAL DATA AND DISCUSSION

CARBONATION NO. 1—SLOW SPEED STIRRING.

The conditions maintained during carbonation were as follows:

Volume of distilled water used	770 cc
Volume of gas space "gas cushion"[1] over free surface of water in bottle	18 cc
Speed of stirrer	400 revolutions per minute
Temperature of liquid	0° C. (melting ice)
Carbonating pressure[1]	65 lbs. per sq. in.

[1] All gas pressures are given in pounds per square inch above atmospheric (14.7 lbs. per sq. in.) as read by a standardized pressure gauge.

TIME SCHEDULE—Stirred under 65 lbs pressure for 10 min., shut off carbon dioxide supply and stopped stirrer, and then opened the exit valve for an instant, thus "blowing off" the foreign gas accumulated in the gas cushion. Turned on gas, stirred at 65 lbs. pressure for 23 min., and again removed surface gas from bottle. Stirred again under the same pressure for 2 hrs. 5 min., and placed bottle in cold storage over night. Carbonation was resumed at 65 lbs. pressure, and continued for 7 hrs. 10 min. The bottle was then placed in cold storage over two nights and a day. It then showed a pressure of 20 lbs., indicating that equilibrium corresponding to the carbonating pressure had not been reached. Carbonation was continued for 3 hrs. 50 min. When the stirrer was stopped, and the gas supply shut off, the pressure in the bottle stood at 65 lbs. Total time of stirring—13 hrs. 40 min. (round). Total period of carbonation—71 hrs.

The tests on the bottle of carbonated water were commenced immediately after the completion of the carbonation described above. The data for 17 recovery curves, together with the volume and composition of the gas evolved, are assembled in Table I, whose headings are self-explanatory.

Typical rate of pressure recovery curves, plotted from the data in Table I, using time intervals in minutes as abscissas and pressure in pounds per square inch above atmospheric as ordinates are shown in Fig. II.

PRESSURE RECOVERY CURVES—The curves plotted for Carbonation No. 1 in Fig. II were selected from the data with a view to securing uniformity in the length of time during which the pressure was allowed to rise, before the opening, and thus eliminating one of the variable factors. This factor of length of time between openings has a marked effect on the ensuing rate of pressure recovery curve as will be shown in subsequent data. In Carbonation No. 1, this effect is obscured by other factors, *e. g.*, the withdrawal of an excessive portion of gas at the first opening.

In view of the impression which prevails in the trade, that an artificially carbonated liquid loses its gas with extreme rapidity as compared with a liquid naturally carbonated (bottle fermented), the regularity of the pressure recovery curves (which of course register rate of gas evolution) is striking. One would rather expect a sudden rise of the curve and then a rather sharp cessation of pressure increase. With the exception of Curve 1, all of the curves given for Carbonation No. 1 show this regularity, being in general of logarithmic type.

Curve 1 shows a retardation in evolution of carbon dioxide in the initial portion of the curve, due to the

TABLE I (*Concluded*)

TENTH 0° 27.5 Lbs.		ELEVENTH 0° 27.2 Lbs.		TWELFTH 0° 26.5 Lbs.		THIRTEENTH 0° 26.0 Lbs.		FOURTEENTH 0° 25.6 Lbs.		FIFTEENTH 0° 24.5 Lbs.		SIXTEENTH 0° 25.8 Lbs.		SEVENTEENTH 0° 26.1 Lbs.		0°	23°	100° C.
PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	PERIOD M. S.	PR. Lbs.	....	....	...
0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	.	...	...
0 1	4.0	0 1	5.0	0 1	3.0	0 1	3.0	0 1	2.0	0 1	2.0	0 2	4.0	0 1	2.0	...	...	...
0 3	6.0	0 2	6.0	0 2	4.0	0 2	5.0	0 2	4.0	0 4	4.0	0 5	6.0	0 3	4.0	...	...	...
0 6	7.0	0 4	7.0	0 4	5.0	0 5	7.0	0 4	5.0	0 6	5.0	0 7	7.0	0 4	5.0	...	...	...
0 8	8.0	0 7	8.0	0 6	6.0	0 11	8.0	0 7	6.0	0 7	6.0	0 13	8.0	0 5	6.0	...	...	...
0 12	9.0	0 11	9.0	0 9	7.0	0 15	9.0	0 9	7.0	0 11	7.0	0 23	9.0	0 7	7.0	...	...	...
0 16	10.0	0 14	10.0	0 12	8.0	0 21	10.0	0 13	8.0	0 16	8.0	0 33	10.0	0 10	8.0	...	...	...
0 20	11.0	0 20	11.0	0 16	9.0	0 27	11.0	0 17	9.0	0 21	9.0	0 49	12.0	0 13	9.0	...	...	...
0 27	12.0	0 28	12.0	0 22	10.0	0 38	12.0	0 24	10.0	0 28	10.0	1 04	13.0	0 18	10.0	...	...	...
0 39	13.0	0 39	13.0	0 30	11.0	0 52	13.0	0 31	11.0	0 36	11.0	1 22	14.0	0 25	11.0	...	...	...
0 49	14.0	0 53	14.0	0 39	12.0	1 07	14.0	0 40	12.0	0 51	12.0	1 59	15.0	0 36	12.0	...	...	...
1 06	15.0	1 11	15.0	0 51	13.0	1 37	15.0	0 55	13.0	1 07	13.0	2 44	16.0	0 50	13.0	...	...	...
1 26	16.0	1 41	16.0	1 08	14.0	2 12	16.0	1 14	14.0	1 29	14.0	3 59	17.0	1 05	14.0	...	...	...
1 56	17.0	2 19	17.0	1 33	15.0	3 14	17.0	1 41	15.0	2 04	15.0	5 29	18.0	1 32	15.0	...	...	...
2 36	18.0	4 14	19.0	2 08	16.0	4 34	18.0	2 21	16.0	2 54	16.0	8 24	19.0	2 05	16.0	...	...	...
3 41	19.0	10 39	21.5	2 56	17.0	6 54	19.0	3 11	17.0	4 00	17.0	10 40	20.0	2 50	17.0	...	...	...
5 03	20.0	14 49	22.0	3 56	18.0	15 29	21.5	4 21	18.0	5 34	18.0	15 40	21.0	4 10	18.0	...	...	...
13 36	23.0	18 49	23.0	5 06	19.0	19 34	22.0	6 41	19.0	8 04	19.0	25 40	22.0	6 50	19.0	...	...	...
25 16	24.5	26 19	24.0	7 46	20.0	32 ..	23.0	9 31	20.0	11 54	20.0	47 ..	23.0	9 25	20.0	...	...	...
31 16	25.0	42 ..	24.5	12 16	21.0	49 ..	24.0	15 21	21.0	20 14	21.0	96 ..	24.0	25 10	22.0	....	...	...
54 ..	26.0	151 ..	26.5	16 46	22.0	90 ..	25.3	23 21	22.0	36 ..	22.2	126 ..	24.5			....	...	...
82 ..	26.8			23 06	23.0	164 ..	25.6	58 ..	23.5	2400 ..	25.8	202 ..	25.5			....	...	...
147 ..	27.2			40 ..	24.0			94 ..	24.5			250 ..	26.1			....	...	...
				1140 ..	26.0													
55.7		45.8		41.0		51.3		45.7		44.3		53.0		49.7		1615.5	766.5	983.7
1.2		0.8		0.7		1.2		0.4		0.5		1.5		0.8		15.5	3.8	2.0
97.8		98.3		98.3		97.7		99.1		98.9		97.2		98.4		99.0	99.5	99.8

GAS WITHDRAWN: At 0° C. ..... 2575.8 cc.
23° C. ..... 766.5 cc.
100° C. ..... 983.7 cc.

Total Gas in Bottle ..... 4326.0 cc.

Total Residual Gas from NaOH Absorption ... 43.2 cc.
Foreign Gases Present ..... 1.0 per cent
Gas Cushion ..... 18 cc.
Volume of Liquid ..... 770 cc.

removal of an excessive amount of gas in the first opening and a consequent depletion of the gas content of the upper layers of the liquid; but the subsequent trend of this curve likewise becomes logarithmic. In succeeding openings of the bottle the valve was closed the instant that the gauge indicator stopped falling, so that only the gas was withdrawn that had been in excess of atmospheric pressure in the gas cushion and any retardation of the recovery curve, due to excessive gas removal, was eliminated.

As portions of gas are withdrawn from the bottle the amount of gas in the liquid, which is the driving force behind the pressure recovery, is gradually decreased. Hence the normal recovery curves, taken after like periods of standing, will naturally take the same form and fall slightly below each other according to their order of taking. Curve 1, due to the excessive gas withdrawal, falls much below its normal position, and as the upper layers have not yet regained their full share of gas, this effect persists in Curve 2 to a lesser extent, bringing it below its normal position. The curves beyond No. 4 are for practically normal conditions.

ACCORDANCE WITH HENRY'S LAW—To one who has not followed the carbonation industry, some of the data presented and some of the considerations discussed would appear almost axiomatic; but in looking over the field, it appears necessary to include these. For example, the solubility of these gases can be very closely calculated for various temperatures and pressures from existing data according to Henry's law. In the practical operation of carbonating machinery, however, it would appear that saturation in respect to carbon dioxide or other gas does not attain to the value that would be expected.[1]

One of the contributory causes to this incomplete saturation is the presence of foreign gases which lower the partial pressure of the carbon dioxide gas. This means that the effective pressure of the carbonation is the partial pressure of carbon dioxide, and not the total pressure of gases in the gas cushion as shown by the gauge.

The total volume of gas forced into the system was 4326 cc. calculated to 0° C. and 760 mm. pressure, allowing for the vapor tension[2] of the brine solution over which the gas was collected. Using the solubility of carbon dioxide in water at 0° C. and 760 mm. as 1.713 volumes[2] carbon dioxide per unit volume of water, at the indicated carbonating pressure, 65 lbs. per sq. in., there would be according to Henry's law 7150 cc. of gas dissolved in the 770 cc. of water in the bottle.

It might then be inferred that at this high pressure Henry's law does not hold; but in this case we are not dealing with equilibrium conditions. The initial pressure, 65 lbs., simply represents the carbonation pressure from the source of carbon dioxide gas plus the partial pressures of any foreign gases[3] left in the gas cushion.

The partial pressure[4] of carbon dioxide in the gas

[1] Henry's law is not expected, of course, to hold absolutely rigid with any gas such as carbon dioxide, which combines with the solvent or which undergoes polymerization when in solution.

[1] From the data obtained by Emden, and given in Landolt-Bornstein, "Physikalisch-Chemische Tabellen," 4th Ed., **1912**, p. 410, Table 119, the vapor tension of a solution of NaCl saturated at 20° C. was calculated for various temperatures by graphical extrapolation. These calculated data are given here for convenient reference in the following table:

VAPOR TENSION OF SODIUM CHLORIDE SOLUTION
(36 g. NaCl per 100 g. H_2O = saturation point at 20° C.)

Temp.	Pressure mm. of Hg	Temp.	Pressure mm. of Hg	Temp.	Pressure mm. of Hg
15° C.	9.6	22° C.	15.0	29° C.	22.1
16	10.2	23	15.9	30	23.3
17	10.9	24	16.8	31	24.7
18	11.6	25	17.7	32	26.2
19	12.4	26	18.7	33	27.8
20	13.2	27	19.8	34	29.4
21	14.1	28	20.9	35	31.0

[2] Van Nostrand's "Chemical Annual," Olsen, 3rd Ed., **1913**, p. 736, Table XXV. Data by Bohr and Bock

[3] The foreign gases present come from three sources: air originally dissolved in the water used, air in gas cushion above the liquid, and the small amount of nitrogen in the carbon dioxide gas used. See paragraph on gas analysis and composition for the quantities of foreign gas present.

[4] The value of the partial pressure of CO_2 in the gas cushion is found as follows. Since the opening pressure in the gas cushion was 65 lbs. above atmospheric, or 5.42 atmospheres, and the volume of foreign gas withdrawn

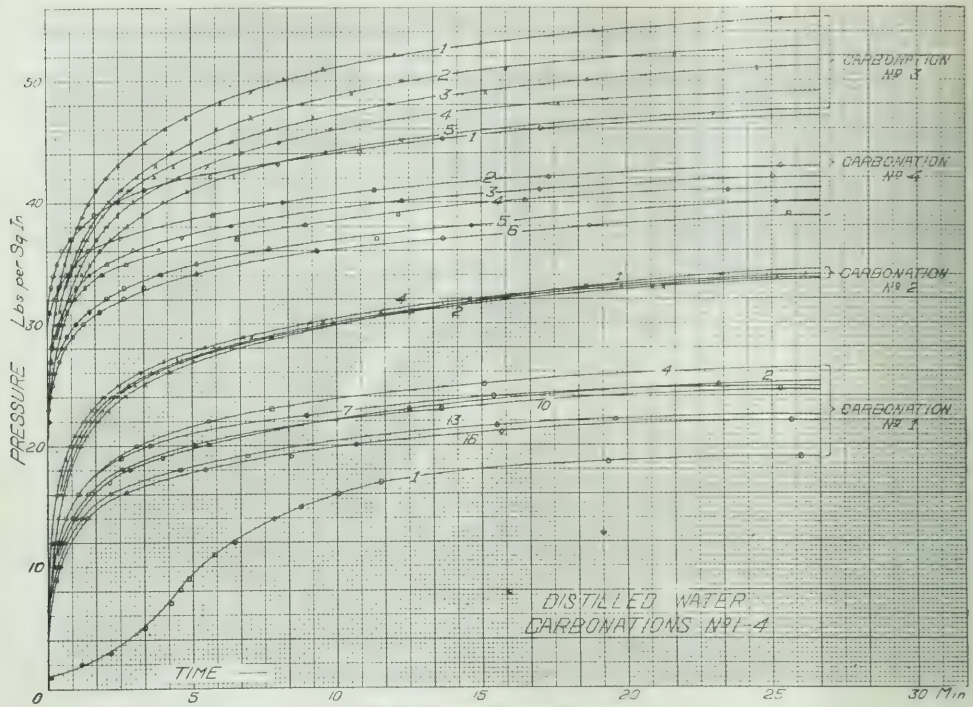


FIG. II—PRESSURE RECOVERY CURVES

cushion of the bottle at this stage is 5.03 atmospheres or 59.2 lbs. above atmospheric pressure, and the volume of CO_2 in the liquid, if complete saturation had been reached, would be 6635 cc. Actually there were 4190 cc. of carbon dioxide in the liquid. This simply shows that saturation was not complete, and that even after this extremely long period of stirring complete equilibrium between the gas dissolved in the liquid and the gas in the gas cushion under the carbonating pressure was not reached.

When, however, the recovered pressure, 30.5 lbs., 19 hrs. after the first opening of the bottle (Table I) is reached, a comparison of the total carbon dioxide contained in the liquid at that point, 4070 cc.,[1] with the theoretical volume calculated from solubility data and Henry's law, 3890 cc., shows a slight degree of supersaturation. Our observation has been that complete equilibrium in the bottle between the gas in the liquid and in the gas cushion is not quite reached at the end of 19 hrs., but is approximately so after a 40-hr. period, as will be shown by subsequent data. These results, then, show that at high pressures of CO_2 we have a close agreement with Henry's law.

Applying now these considerations to the case of carbonated beverages as put out in the trade, it will be seen how and why a poorly carbonated product (with large percentage of foreign gas present or insufficient period of carbonation) may have a high initial pressure in the gas cushion, without having a correspondingly great quantity of gas held in the liquid. The result of this is that, when the pressure drops to atmospheric upon opening of the bottle, the liquid may remain almost non-effervescent.

COMPOSITION OF THE GAS—The total residual gas after absorption over sodium hydroxide was 43.2 cc. or 1.0 per cent of the total gas.[1] Analysis shows that a large portion of the residual foreign gas in the gas cushion is withdrawn at the first opening. Thus of the total residual gas in the bottle 5.8 cc., or approximately 13 per cent, was withdrawn at the first opening. In the next two openings also comparatively large

at the first opening by reducing the pressure to atmospheric was 5.8 cc., there must have been $(5.8 \times 5.42) \div 4.42 = 7.1$ cc. of foreign gas in the gas cushion before opening. With the volume of gas cushion 18 cc. the partial pressure of foreign gas is $7.1 \div 18 = 0.39$ atmospheres. The partial pressure of carbon dioxide in the gas cushion is then $5.42 - 0.39 = 5.03$ atmospheres or 59.2 lbs. above atmospheric.

[1] The total gas in the bottle at this point is 4160 cc. $(4326 \text{ cc} - 166 \text{ cc}$ withdrawn at the first opening). Of this volume, a portion $(18 \times 30.5 + 14.7/14.7 = 55.3$ cc.) is in the gas cushion above the liquid, and the remainder, 4105 cc. (reading to the nearest unit), is dissolved in the liquid. The foreign gas withdrawn at the second opening is 1.5 cc.; foreign gas in gas cushion before withdrawal $= (1.5 \times 3.07) + 2.07 = 2.2$ cc. This volume subtracted from the total volume of foreign gas in the bottle, 37.4 cc., leaves 35.2 cc. foreign gas in the liquid. The actual volume of CO_2 in the liquid then at the time of 2nd opening was $4105 - 35 = 4070$ cc. The partial pressure of foreign gas was $2.2/18 = 0.12$ atmospheres or 1.8 lbs. The partial pressure of carbon dioxide then equals $30.5 - 1.8 = 28.7$ lbs. above atmospheric. The calculated volume of CO_2 in the liquid corresponding to this pressure according to Henry's law is $(28.7 + 14.7) \div 14.7 \times 0.770 \times 1.713 = 3890$ cc.

[1] The carbon dioxide gas used in these carbonations showed an average analysis of 99.7 per cent CO_2. The foreign gas contained no oxygen or carbon monoxide, and consisted of nitrogen with perhaps a trace of the rare gases

TABLE IIA—CARBONATING CONDITIONS: CARBONATION NO. 2

Distilled Water Used	Temperature of Water during Carbonation	Speed of Stirrer	Carbonating Pressure	Gas Cushion
770 cc.	0° C.	400 r. p. m.	70 lbs. per sq. in.	25 cc.

Period of Stirring: Started at	Stopped at	Interval Hrs.	Interval Min.	Pressure at End of Stirring Lbs. per sq. in.	Subsequent Treatment	Period of Rise Sec.	Pressure Recovered Lbs. per sq. in.
3 : 43	3 : 53	0	10	70	Opened valve, letting off gas to zero pressure. Closed valve, noting pressure recovery in each case.	240	0
3 : 57	4 : 20	0	23	56		10	6
4 : 24	4 : 30	0	6	41	Let bottle stand over night. Pressure dropped to zero.		
11 : 35	4 : 31	4	56	70	Let bottle stand over night. Pressure dropped to 34.5 lbs.		
11 : 05	12 : 40	1	35	70	Gas supply shut off.		
12 : 40	1 : 40	1	0	48.5	Gas supply turned on.		
1 : 40	4 : 25	2	45	70	Let bottle stand over Sunday, pressure fell to 60 lbs. Connected to analysis apparatus and began test (*See* Table IIB).		
Total Stirring.....		10	55		TOTAL PERIOD OF CARBONATION —48 hrs. 40 min. (round).		

TABLE IIB—PRESSURE RECOVERY AND ANALYTICAL DATA: CARBONATION NO. 2. SLOW SPEED STIRRING

Rate of Pressure Recovery	First Opening 0° 60.0 lbs. Period Min. Sec.	Pressure Lbs.	Second Opening 0° 43.5 lbs. Period Min. Sec.	Pressure Lbs.	Third Opening 0° 43.5 lbs. Period Min. Sec.	Pressure Lbs.	Fourth Opening 0° 39.0 lbs. Period Min. Sec.	Pressure Lbs.	0°	24°	100° C.
	0 0	0.0	0 0	0.0	0 0	0.0	0 0	0.0	....	...	....
	0 2	3.0	0 1	5.0	0 1	4.0	0 3	8.0	....	...	....
	0 5	6.0	0 8	10.0	0 3	8.0	0 6	10.0	....	...	....
	0 11	10.0	0 10	11.0	0 5	10.0	0 9	12.0	....	...	....
	0 15	12.0	0 19	14.0	0 12	14.0	0 14	14.0	....	...	....
	0 23	14.0	0 28	16.0	0 18	16.0	0 20	16.0	....	...	....
	0 31	16.0	0 42	18.0	0 28	18.0	0 30	18.0	....	...	....
	0 45	18.0	1 05	20.0	0 37	19.0	0 44	20.0	....	...	....
	1 01	20.0	1 23	21.0	0 48	20.0	0 56	21.0	....	...	....
	1 15	21.0	1 43	22.0	1 02	21.0	1 11	22.0	....	...	....
	1 31	22.0	2 10	23.0	1 23	22.0	1 32	23.0	....	...	....
	1 56	23.0	2 41	24.0	1 44	23.0	1 52	24.0	....	...	....
	2 22	24.0	3 25	25.0	2 12	24.0	2 28	25.0	....	...	....
	3 02	25.0	4 11	26.0	2 53	25.0	3 10	26.0	....	...	....
	3 51	26.0	5 08	27.0	3 38	26.0	4 03	27.0	....	...	....
	4 43	27.0	6 22	28.0	4 40	27.0	5 25	28.0	....	...	....
	5 59	28.0	7 42	29.0	5 55	28.0	6 45	29.0	....	...	....
	7 12	29.0	9 50	30.0	7 10	29.0	8 05	30.0	....	...	....
	9 03	30.0	12 30	31.0	9 30	30.0	12 25	31.0	....	...	....
	11 33	31.0	15 50	32.0	12 35	31.0	15 35	32.0	....	...	....
	14 35	32.0	21 15	33.0	15 53	32.0	27 00	34.0	....	...	....
	18 34	33.0	27 45	34.0	20 50	33.0	35 ..	35.0	....	...	....
	24 05	34.0	35 ..	35.0	26 10	34.0	45 ..	36.0	....	...	....
	37 ..	35.5	46 ..	36.0	32 40	35.0	60 ..	37.0	....	...	....
	43 ..	36.0	65 ..	37.0	44 ..	36.0	1000 ..	40.3	....	...	....
	59 ..	37.0	91 ..	38.0	61 ..	37.0			....	...	....
	70 ..	38.0	107 ..	38.5	100 ..	38.0			....	...	....
	96 ..	39.0	2900 ..	43.5	160 ..	39.0			....	...	....
	125 ..	40.0							....	...	....
	1140 ..	43.5							....	...	....
Cc. Gas: Withdrawn		63.6		89.0		91.1		72.0	2825.4	947.4	1041.0
Residual		6.0		6.0		5.1		1.6	17.7	9.0	1.8
Per cent CO_2		83.6		93.3		94.4		97.8	99.4	99.1	99.8

GAS WITHDRAWN: At 0° C.....3141.1 cc.
24° C..... 947.4 cc.
100° C..... 1041.0 cc.

Total Gas in Bottle.....5129.5 cc.

Total Residual Gas from NaOH Absorption... 51.6 cc.
Foreign Gases Present..... 1.0 per cent
Gas Cushion..... 25 cc.
Volume of Liquid..... 770 cc.

portions of residual gas were found. After this period, the volumes of residual gas in the portions withdrawn at the various openings were much smaller and fairly constant, except that upon standing for long periods (over night) more of the foreign gas collected in the gas cushion, giving a lower per cent of carbon dioxide in the gas withdrawn at the succeeding opening.

EFFECT OF GAS CUSHION—The volume of the gas cushion was determined, as necessary to the determination of the partial pressures of the gases in it, and since the rate of rise of pressure obviously is influenced somewhat by the size of the space that the gas liberated at the surface of the liquid has to fill.

CARBONATION NO. 2. SLOW SPEED STIRRING

A second bottle of distilled water was carbonated with the stirrer rotating at the same rate and the data of the first carbonation were practically duplicated.

The conditions of carbonation are given in Table IIA. In Table IIB is presented the rate of pressure recovery data for Carbonation No. 2, and the corresponding curves are plotted in Fig. II.

DISCUSSION OF DATA—The carbonating pressure from the cylinder was a little higher in this case than in the first carbonation (70 lbs. compared with 65 lbs.) and consequently a somewhat greater volume of gas was forced into the liquid in a slightly shorter time than in the first carbonation. The data, however, coincide with those of Carbonation No. 1 in general. It is again shown that at this slow speed stirring (400 r. p. m.) a very long period of stirring (11 to 13 hrs.) is necessary to obtain a fair degree of carbonation, and even after this long period the saturation point is not reached. To illustrate, the partial pressure of carbon dioxide gas at the first opening is 4.56 atmospheres[1] or 52.3 lbs. above atmospheric pressure, and the corresponding volume of carbon dioxide that should be dissolved in the liquid according to Henry's law, is 6015 cc. The actual volume of CO_2 in the liquid at this point is only 4965 cc.

At the third opening, after the bottle had stood for over 40 hrs. and equilibrium between the carbon dioxide in the gas cushion and in the liquid had practically been reached, we find a very close agreement with Henry's law and solubility data. The actual volume of carbon dioxide in the liquid at this point is 4850 cc. The partial pressure of carbon dioxide is 3.69 atmospheres or 39.6 lbs. per sq. in. above atmospheric pressure, and the corresponding volume of gas in the liquid should be: $770 \times 1.713 \times 3.69 = 4865$ cc.

[1] The partial pressure of CO_2 is determined in a manner similar to that in Carbonation No. 1, *i. e.*, calculating the volume of foreign gas in the gas cushion from the volume of foreign gas withdrawn at the first opening, from that the partial pressure of foreign gas, and subtracting the latter from the total initial pressure to obtain the partial pressure of CO_2. The volume of CO_2 actually in the liquid is the total gas volume minus the volume of gas in gas cushion, minus the volume of foreign gas in the liquid.

The agreement is as close as could possibly be obtained within the limits of accuracy afforded by the methods used.

RATE OF PRESSURE RECOVERY—By glancing at the pressure recovery curves shown in Carbonation No. 2, Fig. II, it will be seen that the general form is of the same logarithmic type as for the curves in Carbonation No. 1. The curves lie very close together, overrunning one another, much as did the first four curves in Carbonation No. 1. If a continued set of curves had been taken in this case down to a low pressure recovery, the curves would have gradually fallen below those preceding in a similar manner to the curves in Carbonation No. 1.

There are three important factors that affect the rate of pressure recovery from the same solution at various stages. One which has been mentioned before is the quantity of gas removed at the opening. The removal of an excessively large amount of gas (by not closing gauge as soon as indicator ceases to fall) strips the gas from the top layers of solution, and retards the rate of pressure recovery.

A second factor is the formation of bubbles on the container surface. When gas escapes from the liquid in a container, small bubbles form on the sides of the container serving as nuclei for the liberation of gas from solution. The pressure recovery curve taken after the bottle has been standing over night shows a slowing down due to the resolution of the bubbles that had formed on the inner surface of the bottle. As soon as the bottle is opened we again have the bubbles formed, and if a second recovery curve is taken on the same day the rate will be speeded up. The shorter the period between openings the more will this speeding up be in evidence.

A third factor affecting the rate of pressure recovery is the relation between the concentrations of gas in the various layers of liquid and in the gas cushion at the time of opening the bottle. When the bottle is opened and the gas in excess of atmospheric pressure is withdrawn from the gas cushion, the gas in the upper layers of liquid rushes into the gas cushion while that in the lower layers passes more gradually into both gas cushion and stripped upper layers, until finally when equilibrium is reached the concentration throughout the liquid layers is practically uniform. However, when the bottle is opened before equilibrium has been reached, the upper liquid layers are not at their full concentration, and hence the rate of pressure recovery is slowed down. The amount of this slowing down will depend on the interval between the successive openings: the shorter the interval the greater the tendency to slow down the pressure recovery rate, due to this effect.

We have, then, two counterbalancing factors, formation of bubbles and relative gas concentrations in the different liquid layers, both of which are dependent upon the period between successive openings. The shorter the period the more will the rate curve tend to be speeded up, due to bubble formation, but at the same time the more will it tend to slow down, due to low concentration of gas in the upper layers. The exact length of the period, the nature of the solution, the total pressure in the bottle, the roughness of the inner bottle surface (serving to accentuate bubble formation) all go to determine which of these counterbalancing factors will predominate. Often then the curve will rise excessively during the first few minutes owing to the presence of bubbles, and then recross the preceding curve and fall below it, due to the low concentration of the upper layers of solution at the time of opening. The action of these factors may be seen in the curves in Carbonation No. 2, Fig. II, but are brought out more distinctly in Carbonations Nos. 3 and 4.

COMPOSITION OF THE GAS—While the amount of foreign gas in the bottle was slightly greater than in Carbonation No. 1, the percentage of foreign gas based on the total gas content was identical in the two cases, being 1.0 per cent. Of the total foreign gas present (51.6 cc.) 10.4 cc., or about 20 per cent, was withdrawn at the first opening. It will be noticed here again that the foreign gas does not come out of the liquid as rapidly as the carbon dioxide does, so that the volume of foreign gas in the portions withdrawn is smaller than normal, except where the bottle has been allowed to stand over night before opening.

EFFECT OF GAS CUSHION—The volume of gas cushion, 25 cc., is 7 cc. greater than that in Carbonation No. 1. The smaller gas cushion would tend to favor a somewhat more rapid rise of pressure due to liberated gas, but this is partly compensated, in case of the larger gas cushion, by the increased area of the free surface of liquid in the bottle, produced by the flaring of the neck. This increased area permits the more rapid evolution of gas. It was shown by measurement and graphical calculations that, at the point on a standard champagne bottle where the neck begins to flare, the increase in volume of the gas cushion bears a linear relation to the increase in free surface of the liquid in the bottle. Bottles of such size as to furnish a 25 cc. gas cushion were also used in Carbonations Nos. 3 and 4.

CARBONATION NO. 3. HIGH SPEED STIRRING

The remarkable slowness with which the carbon dioxide was absorbed in Carbonation No. 1, suggested that increased rate of stirring be tried. Consequently the speed of the stirrer was increased from 400 revolutions per minute to 2500.

The conditions of carbonation for this bottle are given in Table IIIA.

The rate of pressure recovery data are presented in Table IIIB, under appropriate headings, and the rate curves plotted therefrom are shown in Carbonation No. 3, Fig. II.

One is immediately struck by the tremendous increase in efficiency of carbonation produced by a simple increase in speed of stirring. The total gas forced into the system was 6263 cc. stirring at 2500 r. p. m. compared with 5130 cc. at 400 r. p. m. (Carbonation No. 2), the carbonation pressure, volume of liquid, volume of gas cushion, and number of blow-offs being the same. The period of stirring was only 6 minutes with the high speed stirring compared with approximately 11 hours for Carbonation No. 2. This means that by increasing the rate of stirring about six times

TABLE IIIA—CARBONATING CONDITIONS: CARBONATION NO. 3

Distilled Water Used	Temperature of Water during Carbonation	Speed of Stirrer	Carbonating Pressure	Gas Cushion
770 cc.	0° C.	2500 r. p. m.	70 lbs. per sq. in.	25 cc.

Period of Stirring: Started at	Stopped at	Interval Min.	Pressure at End of Stirring Lbs. per sq. in.	Subsequent Treatment	Period of Rise Sec.	Pressure Recovered Lbs. per sq. in.
2 : 40	2 : 41	1	43	Opened valve, letting off gas to zero pressure. Closed valve, noting pressure recovery in each case.	10	15
2 : 42	2 : 44	2	62		10	42
2 : 46	2 : 49	3	70	Connected bottle to analysis apparatus and began test (*See* Table IIIB).		
Total Stirring		6		Total Period of Carbonation—9 minutes.		

TABLE IIIB—PRESSURE RECOVERY AND ANALYTICAL DATA: CARBONATION NO. 3. HIGH SPEED STIRRING

Rate of Pressure Recovery	First Opening		Second Opening		Third Opening		Fourth Opening		Fifth Opening				
Temperature of Bottle	0°		0°		0°		0°		0°		0°	26°	100° C.
Opening Pressure	70.0 lbs.		60.0 lbs.		56.7 lbs.		54.0 lbs.		53.0 lbs.				
	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.			
	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	....	...	...
	0	1	10.0	0	1	5.0	0	1	5.0	0	1	15.0	0	1	10.0	....	...	...
	0	2	15.0	0	2	10.0	0	2	10.0	0	2	20.0	0	2	15.0	....	...	...
	0	3	20.0	0	6	25.0	0	3	15.0	0	5	25.0	0	3	20.0	....	...	...
	0	5	25.0	0	14	28.0	0	4	20.0	0	9	27.0	0	5	22.0	....	...	...
	0	15	30.0	0	22	30.0	0	7	25.0	0	13	28.0	0	8	24.0	....	...	...
	0	19	31.0	0	28	31.0	0	14	28.0	0	16	29.0	0	11	25.0	....	...	...
	0	22	32.0	0	33	32.0	0	23	30.0	0	22	30.0	0	13	26.0	....	...	...
	0	25	33.0	0	40	33.0	0	29	31.0	0	30	31.0	0	17	27.0	....	...	...
	0	31	34.0	0	47	34.0	0	34	32.0	0	38	32.0	0	22	28.0	....	...	...
	0	37	35.0	0	52	35.0	0	41	33.0	0	47	33.0	0	27	29.0	....	...	...
	0	45	36.0	1	03	36.0	0	50	34.0	0	58	34.0	0	34	30.0	....	...	...
	0	55	37.0	1	19	37.0	0	58	35.0	1	10	35.0	0	43	31.0	....	...	...
	1	03	38.0	1	34	38.0	1	10	36.0	1	26	36.0	0	52	32.0	....	...	...
	1	14	39.0	1	54	39.0	1	27	37.0	1	46	37.0	1	03	33.0	....	...	...
	1	25	40.0	2	10	40.0	1	44	38.0	2	08	38.0	1	18	34.0	....	...	...
	1	42	41.0	2	37	41.0	2	04	39.0	2	30	39.0	1	32	35.0	....	...	...
	2	03	42.0	3	10	42.0	2	27	40.0	3	01	40.0	1	49	36.0	....	...	...
	2	31	43.0	3	47	43.0	2	53	41.0	3	25	41.0	2	18	37.0	....	...	...
	2	55	44.0	4	20	44.0	3	43	42.0	4	36	42.0	2	50	38.0	....	...	...
	3	25	45.0	5	01	45.0	4	25	43.0	5	37	43.0	3	19	39.0	....	...	...
	4	02	46.0	5	52	46.0	5	23	44.0	6	44	44.0	4	04	40.0	....	...	...
	4	50	47.0	7	05	47.0	6	25	45.0	8	01	45.0	4	54	41.0	....	...	...
	6	00	48.0	8	52	48.0	7	43	46.0	9	49	46.0	6	30	42.0	....	...	...
	7	05	49.0	10	35	49.0	9	14	47.0	17	40	48.0	7	50	43.0	....	...	...
	8	15	50.0	12	15	50.0	11	51	48.0	35	..	50.0	9	40	44.0	....	...	...
	9	35	51.0	15	52	51.0	15	09	49.0	54	..	51.0	12	15	45.0	....	...	...
	12	05	52.0	21	40	52.0	18	35	50.0	110	..	52.0	23	..	47.5	....	...	...
	15	00	53.0	27	40	53.0	24	30	51.0	200	..	53.0	33	..	48.0	....	...	...
	18	50	54.0	40	..	54.0	36	..	52.0				44	..	49.0	....	...	...
	25	20	55.0	68	..	55.0	1170	..	54.0				62	..	50.0	....	...	...
	32	50	56.0	125	..	56.7							117	..	50.5	....	...	...
	66	..	58.0													....	...	...
	1260	..	60.0													....	...	...
Cc. Gas:																		
Withdrawn	133.0		114.7		111.2		121.0		103.0							3965.6	856.4	858.6
Residual	10.9		5.9		2.7		3.9		1.2							13.3	5.6	0.2
Per cent CO_2	91.2		94.9		97.6		96.8		98.8							99.7	99.3	99.9

Gas Withdrawn: At 0° C. ..... 4548.5 cc.
26° C. ..... 856.4 cc.
100° C. ..... 858.2 cc.

Total Gas in Bottle ..... 6263.1 cc.

Total Residual Gas from NaOH Absorption... 44.4 cc.
Foreign Gases Present..... 0.7 per cent
Gas Cushion..... 25 cc.
Volume of Liquid..... 770 cc.

we have increased the speed of carbonation over 100 times.

We have a nearer approach to saturation of the liquid at the end of this short period of high speed stirring than with the extremely long period using slow speed. The actual volume of carbon dioxide in the liquid before the bottle is opened is 6090 cc., whereas the volume corresponding to the partial pressure of CO_2 over the liquid (5.25 atmospheres) calculated from solubility data and Henry's law is 6925 cc. After withdrawing portions of gas, and letting the bottle stand while the gas comes out of the liquid until equilibrium is practically established, we have, as in the two previous carbonations, a fairly close agreement with Henry's law.

PRESSURE RECOVERY CURVES—In considering the rate of pressure recovery curves for Carbonation No. 3, it will be noted that Curve 1, taken shortly after carbonating, is somewhat high since the bubbles on the container surface have not had time to be suppressed. Curve 2, taken after standing over night, gives the normal[1] pressure recovery. Curve 3, taken on the same day as No. 2, starts up fairly rapidly because of bubble formation, but falls quite a bit below it due to the subnormal concentration of the gas in the upper layers. After standing over night Curve 4 again gives a normal pressure recovery, the difference between the two normal curves, Nos. 2 and 4, being due to the lowering of the total gas content of the liquid by the volume of gas removed from the bottle between the two openings. Curve 5 again shows a depression due to low concentration of gas in the upper layers of liquid. The regular logarithmic form of pressure recovery curve is obtained here as in the other carbonations.

[1] We will consider as normal the pressure recovery from the quiescent state of the liquid, after equilibrium is practically reached.

COMPOSITION OF THE GAS—The residual volume from absorption over sodium hydroxide was 44.4 cc. or 0.7 per cent of the total gas. As in the previous carbonations a large portion of this foreign gas, 10.9 cc., nearly 25 per cent, was withdrawn at the first opening. Over 50 per cent of the foreign gas was withdrawn by the fourth opening, whereas less than 8 per cent of the total gas was withdrawn during the same time.

CARBONATION NO. 4

A second bottle of distilled water was carbonated at the same high rate of stirring, and in addition the effect of residual foreign gas in the gas cushion was

TABLE IVA—CARBONATING CONDITIONS: CARBONATION NO. 4

Distilled Water Used	Temperature of Water during Carbonation	Speed of Stirrer	Carbonating Pressure	Gas Cushion
770 cc.	0° C.	2500 r. p. m.	70 lbs. per sq. in.	25 cc.

Period of Stirring: Started at	Stopped at	Interval Min.	Pressure at End of Stirring Lbs. per sq. in.	Subsequent Treatment	Period of Rise Sec.	Pressure Recovered Lbs. per sq. in.
3:09	3:10	1	47		10	8
3:11	3:12	1	51		10	30
3:13	3:14	1	56	Opened valve, letting off gas to zero pressure. Closed valve, noting pressure recovery in each case	10	40
3:15	3:16	1	61		10	47
3:17	3:18	1	63		10	50
3:20	3:21	1	64		10	54
3:23	3:24	1	66	Connected bottle to analysis apparatus and began test (see Table IVB)		
Total Stirring		7		Total Period of Carbonation 15 min.		

TABLE IVB—PRESSURE RECOVERY AND ANALYTICAL DATA CARBONATION NO. 4 HIGH SPEED STIRRING

	First Opening			Second Opening			Third Opening			Fourth Opening			Fifth Opening			Sixth Opening					
Temperature of Bottle Opening	0°			0°			0°			0°			0°			0°			0°	20°	100° C.
Pressure	66.0 lbs.			48.5 lbs.			48.0 lbs.			46.0 lbs.			47.5 lbs.			44.5 lbs.					
Rate of Pressure Recovery: Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.	Period Min.	Sec.	Pressure Lbs.			
0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	....	....	....
0	7	31.0	0	3	27.0	0	1	18.0	0	1	10.0	0	1	10.0	0	3	10.0	....	....	....
0	10	32.0	0	5	30.0	0	2	22.0	0	2	20.0	0	2	18.0	0	4	21.0	....	....	....
0	13	33.0	0	11	31.0	0	5	23.0	0	5	25.0	0	5	23.0	0	6	23.0	....	....	....
0	16	34.0	0	18	32.0	0	8	27.0	0	8	26.0	0	9	24.0	0	7	24.0	....	....	....
0	20	35.0	0	25	33.0	0	10	28.0	0	10	27.0	0	11	25.0	0	13	25.0	....	....	....
0	30	36.0	0	39	34.0	0	14	29.0	0	12	28.0	0	14	26.0	0	17	26.0	....	....	....
0	49	37.0	0	59	35.0	0	21	30.0	0	19	29.0	0	20	27.0	0	26	27.0	....	....	....
1	11	38.0	1	29	36.0	0	33	31.0	0	26	30.0	0	29	28.0	0	37	28.0	....	....	....
1	40	39.0	2	36	37.0	0	47	32.0	0	42	31.0	0	41	29.0	0	50	29.0	....	....	....
2	25	40.0	3	45	38.0	1	02	33.0	0	58	32.0	1	02	30.0	1	13	30.0	....	....	....
3	36	41.0	5	45	39.0	1	30	34.0	1	20	33.0	1	32	31.0	1	50	31.0	....	....	....
5	40	42.0	8	10	40.0	2	05	35.0	1	58	34.0	2	05	32.0	2	30	32.0	....	....	....
8	00	43.0	11	20	41.0	2	58	36.0	2	44	35.0	2	48	33.0	3	20	33.0	....	....	....
10	50	44.0	17	20	42.0	4	43	37.0	3	53	36.0	3	55	34.0	5	10	34.0	....	....	....
13	40	45.0	25	20	43.0	6	25	38.0	6	35	37.0	5	10	35.0	7	20	36.0	....	....	....
17	00	46.0	34	00	44.0	9	05	39.0	8	55	38.0	7	40	36.0	13	40	37.0	....	....	....
41	..	48.0	44	..	45.0	12	15	40.0	12	10	39.0	11	25	37.0	18	40	38.0	....	....	....
1320	..	48.5	70	..	46.0	17	00	41.0	16	30	40.0	14	40	38.0	25	30	39.0	....	....	....
			120	..	47.5	25	00	42.0	23	30	41.0	18	50	39.0	35	20	40.0	....	....	....
			165	..	48.0	41	..	43.0	37	..	42.0	25	10	40.0	57	..	41.0	....	....	....
						58	..	44.0	56	..	43.0	34	45	41.0	86	..	42.0	....	....	....
						75	..	45.0	76	..	44.0	52	..	42.0				....	....	....
						100	..	46.0	1260	..	47.5	81	..	43.0				....	....	....
												113	..	44.0				....	....	....
												167	..	44.5				....	....	....
Cc. Gas: Withdrawn	120.8			134.1			100.6			102.7			108.9			97.9			3761.4	657.7	1177.9
Residual	3.9			3.0			0.5			0.4			0.9			0.4			7.7	1.1	1.1
Per cent CO_2	96.8			97.8			99.5			99.6			99.2			99.6			99.8	99.8	99.9

Gas Withdrawn: At 0° C. ..... 4426.4 cc.
20° C. ..... 657.7 cc.
100° C. ..... 1177.9 cc.
Total Gas in Bottle ..... 6262.0 cc.

Total Residual Gas from NaOH Absorption... 19.0 cc.
Foreign Gases Present ..... 0.3 per cent.
Gas Cushion ..... 25 cc.
Volume of Liquid ..... 770 cc.

19.0 cc. total residual gas from NaOH absorption
0.3 per cent—foreign gases present

more nearly eliminated by "blowing off" the surface gas several times. The conditions of carbonating are given in Table IVA.

Table IVB presents the data on rate of pressure recovery, and on the analysis of the gas. The rate of pressure recovery curves are plotted in Carbonation No. 4, Fig. II.

In Carbonation No. 4 the same volume of gas, 6262 cc., was forced into the system as in Carbonation No. 3. No. 4 was stirred for seven minutes and No. 3 for six minutes, but to offset this the carbonating pressure in No. 3 was slightly greater. Also No. 4 had the surface gas "blown off" six times as compared with twice in No. 3 and as this blowing off removes quite a little gas from the system, it would naturally take slightly longer to bring No. 4 to efficient carbonation. The degree of saturation in Carbonation No. 4 was almost exactly the same as in Carbonation No. 3, and somewhat higher than in the carbonations with slow speed stirring. The actual total carbon dioxide in the liquid was 6110 cc.,[1] whereas the calculated volume from the observed partial pressure (5.30 atmospheres or 63.3 lbs. per sq. in. above atmospheric) was 6990 cc. Comparison of the observed and calculated volumes of gas in the liquid at later openings upon the attaining of equilibrium after the bottle had stood over night, showed a close agreement with Henry's law and solubility data.

RATE OF PRESSURE RECOVERY—In considering the rate of pressure recovery curves for Carbonation No. 4, it will be noticed that Curve 1, taken immediately following the first opening of the bottle, shows a very rapid rise due to presence of bubbles on the inner surface of the container. Where the bottle stands over night, pressure recovery Curve 2 shows a slowing down due to re-solution of the bubbles. The curve taken at this stage, when there is approximate equilibrium between the gas in the various layers of liquid and in the gas cushion, is in reality the normal form of curve. Curves 3 and 4, taken the same day as No. 2, are speeded up due to lack of time for re-solution of the bubbles, formed at the opening of the bottle, and lie fairly close to No. 2. Here the time elapsing between curves is such that the speeding-up effect due to the bubbles predominates over the slowing-down effect caused by low concentration of gas in the upper layers. Curve 5, taken after standing over night, is another normal curve. No. 6, taken on the same day, again shows the speeding-up characteristic.

[1] The method of determining the actual volume of CO_2 in the liquid and the partial pressure of CO_2 in the gas cushion is detailed in footnote 4, col. 2, page 281, and footnote 1, col. 1, page 282.

COMPOSITION OF THE GAS—The repeated "blow-offs" during carbonation (six in number) have the effect of giving a very pure carbon dioxide in the system. After the first two openings of the bottle (Table IVB), the gas portions withdrawn contained 99.5 per cent of carbon dioxide, and the major portion of the gas showed from 99.8 to 99.9 per cent carbon dioxide. The total residual volume, or foreign gas, was only 19.0 cc., 0.3 per cent of the total, and about one-third as much as in the other carbonations with only two blow-offs.

RELATION OF INITIAL PRESSURE TO GAS CONTENT—From the data and discussion that have preceded it can readily be seen why the initial pressure (the pressure of the gas cushion indicated on a gauge connected to a bottle of carbonated liquid before opening the bottle and removing any of the gas) of a bottle of carbonated liquid is no indication of the gas content of that liquid. If the bottle is taken directly from the carbonating machine and kept iced until the initial pressure is read, that initial pressure will simply be the pressure of carbon dioxide under which the liquid was carbonated and the bottle was sealed, plus the partial pressure due to any residual foreign gas in the gas cushion.

However, if the excess gas in the gas cushion is drawn off and the bottle kept closed and iced until the pressure recorded on the gauge has reached a maximum (point of equilibrium between gas in liquid and in gas cushion), the partial pressure of the carbon dioxide[1] in the gas cushion at that time will be a true indication of the amount of carbon dioxide in the liquid. Fig. III shows graphically how far the initial partial pressures of CO_2 in the four experimental carbonations depart from the saturation curve between gas content and corresponding partial pressure of carbon dioxide. This departure of the initial pressure from the saturation curve is greater in the slow speed stirring tests, Nos. 1 and 2, where the liquid was not brought to as high a degree of saturation as in the high speed carbonations, Nos. 3 and 4.

If the excess gas in the gas cushion of the bottle is withdrawn, and the bottle is not kept at 0° C. but is allowed to warm up, an excess of gas passes into the gas cushion, all of which will not go back into solution when the bottle is again brought to ice temperature. Hence the partial pressure of carbon dioxide at that point will bear no direct relationship to the gas content of the liquid. The reason that the gas after once coming out from the liquid does not readily reenter is due to poor surface contact between the layers of gas and liquid not in equilibrium. Even with a stirrer rotating at 400 r. p. m., as has been shown in the data, equilibrium is not complete after 11 or 12 hrs. of stirring. Such a condition of warming up and recooling with consequent increase in the volume and pressure of gas in the gas cushion is the natural result of the ordinary commercial methods of handling artificial beverages.

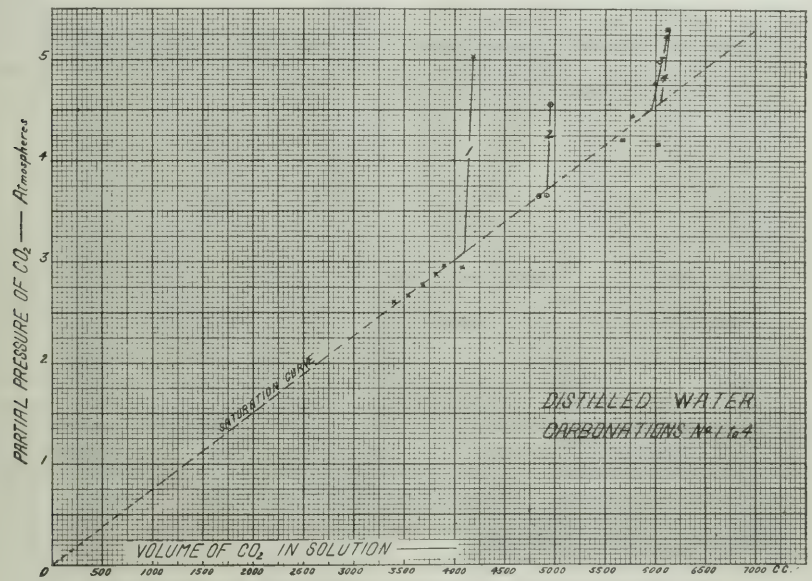


FIG. III—DEPARTURE OF INITIAL PARTIAL PRESSURES OF CO_2 FROM THE SATURATION CURVE

SUMMARY

I—A method of study has been developed for systems under high pressure, which can be applied to the statics and dynamics of gas–liquid and of gas–liquid–solid systems.

II—Regular rate of pressure recovery curves nearly

[1] The method of determining the partial pressure of CO_2 is to record the total pressure, withdraw the excess gas in the gas cushion, measure the volume of foreign gas withdrawn, from that calculate the volume of foreign gas in the gas cushion before withdrawal, then from the volume of the gas cushion and volume of foreign gas calculate the partial pressure of foreign gas, subtract this from the total pressure to give the partial pressure of CO_2.

reproducible and evidently logarithmic in form have been obtained.

III—A high degree of impregnation of water with carbon dioxide gas has been obtained using a rotary stirrer while maintaining the liquid under a steady pressure of gas.

IV—The effect of an increase in speed of stirring is to tremendously shorten the time of carbonation, and at the same time increase the degree of impregnation.

V—In an efficiently carbonated water the gas content, after the first opening of the bottle, closely approximates Henry's law.

VI—The degree of impregnation of a liquid with a gas is not directly indicated by the "initial pressure," that is, the pressure of the gas over the free surface of the liquid before the first opening of the bottle.

VII—The length of time that the carbonated water is allowed to stand before opening bears a marked relation to the maintenance of the supersaturated condition after the pressure in the gas cushion is released. This effect is evidently due to the gradual solution of fine gas bubbles retained on the inner surface of the container.

VIII—By "blowing off" of the foreign gases in the gas cushion, a higher degree of carbonation can be secured. This principle has been used by the practical men in the trade.

IX—A high degree of carbonation may be obtained using distilled water alone, as a solvent, and if this product is allowed to stand for a period before opening, the carbon dioxide gas is retained remarkably well.

Bureau of Chemistry
U. S. Department of Agriculture
Washington, D. C.

EXAMINATION OF AMERICAN-MADE ACETYLSALICYLIC ACID

By Paul Nicholas Leech

Received December 29, 1917

At the request of the Council on Pharmacy and Chemistry, the A. M. A. Chemical Laboratory has undertaken examinations of American-made synthetic drugs. The most extensively used synthetic is acetylsalicylic acid and hence an investigation of this product was deemed expedient.

For seventeen years acetylsalicylic acid was protected by a United States Patent (the proprietors were not given a patent in other countries) and sold under the name "Aspirin." In February 1917 the patent expired, and since then a number of firms have engaged in the manufacture of acetylsalicylic acid, selling it either as such or as aspirin, modified, of course, by a distinctive firm designation. During this period the former manufacturers (The Bayer Co., New York, in past years called Farbenfabriken of Elberfeld Co., New York) have been extensively advertising, both to physicians and the public, the alleged superior qualities of their product. The chemical examination, therefore, was concerned chiefly with tests of purity, and the comparison of the American brands with the formerly patented product.

In European countries, acetylsalicylic acid[1] is described in the various pharmacopoeias as a condensation product of acetic anhydride or acetyl chloride with salicylic acid (*o*-hydroxybenzoic acid). Generally the test of identification is hydrolysis of acetylsalicylic acid and qualitative tests for acetic acid and salicylic acid. For purposes of purity the requirements are essentially that the specimen should have a certain melting point, should show absence of salicylic acid by means of ferric chloride (the manipulations for the tests are variously described) and leave no appreciable ash. The two tests of purity most generally employed, however, are the melting point and the reaction with ferric chloride.

MELTING POINT

The melting point of acetylsalicylic acid has been given at various temperatures from 118° to 137° C.;[2] the *British Pharmacopoeia* describes the melting point at 133° to 135° C.; the *German Pharmacopoeia* "about 135° C.;" the *French Pharmacopoeia* at 135° C.; *New and Nonofficial Remedies*, 1917, 134–136° C. The Bayer Company, in the patent trial at Chicago a number of years ago, gave among the "four infallible tests" a melting point of "about 135° C." Several men have carefully determined the melting point in recent years. Emery and Wright[3] in 1912 found that "Aspirin, Bayer" melted at 130.5–131° C. In France, François[4] has determined the melting point of pure acetylsalicylic acid, which, according to his method, is 132° C. When various samples of acetylsalicylic acid were examined in this laboratory, it was found that the melting point of none was as high as that described in *New and Nonofficial Remedies* or the British, French, or German pharmacopoeias when taken according to the general method of the *U. S. Pharmacopoeia*, Vol. 9, p. 596. On critical observation, it may be seen that the melting point of acetylsalicylic acid is preceded and accompanied by decomposition. If the sample in the melting tube is heated from the original room temperature of the bath to 120° C., the temperature of melting will be lower than if the bath is first heated to 120° C. and the melting-point tube then placed in the bath.[5] Thus the melting point of acetylsalicylic acid, like so many organic compounds which decompose and do not melt sharply, is unsatisfactory and cannot be taken as an "infallible test" of purity, especially when determined by different operators who do not give their method in detail. After making a large number of melting-point determinations of acetylsalicylic acid, alone and in parallel with other operators, it was decided to use the

[1] Unfortunately, the non-descriptive name "aspirin" has been used extensively in European literature and has even gotten into European pharmacopoeias, instead of the scientific name "acetylsalicylic acid."

[2] For reference to older literature see Beilstein II, 1496, 889.

[3] "The Melting Temperature of Aspirin and Salicylic Acid Mixtures," *Proc. Assn. Off. Ag. Chem.*, **1912**; Bureau of Chemistry, Department of Agriculture, *Bull.* **162**.

[4] "Assay of Aspirin," *J. Pharm. Chim.* **15** (1917), No 7, 213.

[5] Similar observations were made by Emery and Wright, who state: "An accurate determination of the melting temperature in this way (the rate of heating was such as to give a rise in temperature of about 1° per minute) is rendered difficult by the fact that 'aspirin' decomposes on heating, as evidenced in the depression of the melting temperature of the pure substance of about 1° for every five minutes' heating just below its melting temperature."

method described in the *U. S. Pharmacopoeia* modified by first heating the bath to 120° C. before attaching the melting-point tube to the thermometer.

The melting point of purified acetylsalicylic acid was found to be 131.5–132.5° C. (corr.).[1] With the exception of one specimen, which was obviously impure, the various specimens examined melted between 128° and 133° C. as may be seen in the accompanying table. It would appear that this range of melting points would be more acceptable and reliable than the melting points described in various standards.

PRESENCE OR ABSENCE OF FREE SALICYLIC ACID

It is generally conceded that the presence of salicylic acid in amounts more than traces is deleterious. Furthermore, the amount of salicylic acid is a good index of the purity of the acetylsalicylic acid, because the test is so delicate that, under favorable conditions, mere traces may be determined and, as a rule, the better the product, the less the amount of free salicylic acid.

The tests appearing in various pharmacopoeias for salicylic acid as an impurity in acetylsalicylic acid do not give concordant results, different workers interpreting the results differently, nor are they detailed in such a manner as to yield maximum delicacy.

After experimentation, it was decided to establish a "limit" test of approximately 0.1 per cent free salicylic acid, when carried out according to the following method:

0.1 g. of the substance was placed in a dry colorimeter tube and 1 cc. of alcohol,[2] previously distilled over NaOH, was added. After the acetylsalicylic acid had dissolved, 48 cc. of water and 1 cc. of fresh 0.1 per cent ferric chloride ($FeCl_3.6H_2O$) solution were added. At the same time a control was run by treating 1 cc. of a "standard" salicylate solution the same as above.[3] If within two minutes the color given by the acetylsalicylic acid is not more intense than the color given by the "standard," the presence of not more than 0.1 per cent free salicylic acid[4] is proved.

The solutions used were prepared as follows:

Redistilled alcohol was treated with a small amount of sodium hydroxide for 24 hours, then again distilled.

The color standard was made by dissolving 0.116 g. of dried sodium salicylate in water, adding 1 minim of glacial acetic acid, and making up to 1000 cc. Each cc. represents 0.1 mg. of salicylic acid.[5]

The ferric chloride solution was made by diluting 1 cc. ferric chloride ($FeCl_3.6H_2O$) test solution *U. S. P.* with 99 cc. of water. The diluted solution must be freshly prepared each day.

With one exception, all of the commercial specimens examined responded satisfactorily to the above test showing less than 1 part salicylic acid in 1000 parts acetylsalicylic acid. The individual results are given in the accompanying table.

MELTING POINT AND SALICYLIC ACID DETERMINATIONS

BRAND	Melting Point Corrected	Free Salicylic Acid Colorimetrically
Acetylsalicylic acid, P. W. R.[1]	130.0–131.0°	Colored, but showing less than 0.1 per cent
Acetylsalicylic acid, Millikin[2]	130.0–131.0°	No color
Acetylsalicylic acid, Millikin[2] 5-grain capsules	129.0–130.0°	No color
Acetylsalicylic acid, Millikin[1] 5-grain capsules[3]	128.0–129.0(*a*)	Colored, but showing less than 0.1 per cent(*a*)
	125.5–126.5°(*b*)	Considerably more than 0.1 per cent(*b*)
Acetylsalicylic acid, Squibb[2]	131.0–132.0°	No color
Acetylsalicylic acid (Aspirin),[1] Monsanto	131.0–132.0°	No color
Acetylsalicylic acid, M. C. W.[1]	130.5–131.5°	Colored, but showing less than 0.1 per cent
Acetylsalicylic acid, M. C. W.[1]	131.5–132.5°	Colored, but showing less than 0.1 per cent
Acetylsalicylic acid, M. C. W.[1]	131.0–132.0°	Colored, but showing less than 0.1 per cent
Aspirin, Bayer[1] (before patent expired)	131.5–132.5°	No color
Aspirin, Bayer[1,4] (after patent expired)	128.5–129.5°	Colored, but showing less than 0.1 per cent
Aspirin, Bayer[1,4] (after patent expired)	129.5–130.5°	Colored, but showing less than 0.1 per cent
Aspirin, Lehn and Fink[2]	130.5–131.5°	0.1 per cent
Aspirin, Lehn and Fink[2]	130.5–131.5°	Colored, but showing less than 0.1 per cent
Aspirin, Lehn and Fink[1]	131.0–132.0°	Colored, but showing less than 0.1 per cent

[1] Obtained on the open market.
[2] Obtained from manufacturer.
[3] One-third of the capsules (*a*) contained a white powder; two-thirds of the capsules (*b*) contained a pink powder having strong odor of acetic acid and not complying with the tests.
[4] Not described in "New Nonofficial Remedies, 1917," the other products are.

OTHER TESTS

New and Nonofficial Remedies, 1917, requires that acetylsalicylic acid shall form a clear solution with warm sodium carbonate solution; that sulfates, chlorides and heavy metals shall be absent; that 0.5 g. shall leave no weighable ash. All the brands reported in this paper complied with these requirements.

So far there has been no satisfactory quantitative estimation of acetylsalicylic acid. True, various methods have been proposed, but they are objectionable. It was thought that hydrolysis of acetylsalicylic acid and then titrating the solution by comparing the color formed by ferric chloride with that of a standard control might yield interesting results, providing that the conditions were alike. For this purpose 1 g. of acetylsalicylic acid was dissolved in 10 cc. of alcohol and diluted to 1000 cc. The solution was then heated at 98–100° C. for 2 hours, allowing the alcohol to evaporate, then allowed to stand at room temperature (22° C.) for 22 hours. After adding water sufficient to make 1000 cc., it was compared colorimetrically for salicylic acid strength. The amount of hydrolysis varied so with different samples under the same conditions, that it was realized that an approximate assay by this method was unreliable. If the assay were made under more exact conditions, quantitative comparisons might be possible. In one experiment, after 60 days the hydrolysis of the acetylsalicylic acid was 61 per cent, which is in rough agreement with the work of Tsaklatos and Horsh.[1]

DISCUSSION

Apart from the proposed revision of the standards for the melting point and limit of salicylic acid in acetylsalicylic acid, the examination shows that there is no appreciable difference between the various brands

[1] **Isolated crystals attached to the walls of the melting-point tube, apart from the bulk of acetylsalicylic acid, melted at a lower temperature.**

[2] **An excess of alcohol destroys or lessens the color when only a very minute amount of salicylic acid is present.**

[3] **The control should be made each time as standing in the air changes its tinctorial power.**

[4] **The presence of pure acetylsalicylic acid does not seem to affect the iron (Fe+++) salicylic acid coloration. The small amount of acetic acid was added to the sodium salicylate control solution (1) to simulate an acidity approximating the acidity of the acetylsalicylic acid, and (2) since acetylsalicylic acid gives by hydrolysis both acetic acid and salicylic acid, it was thought advisable to add acetic acid to the standard. If there is any free acetic acid in a sample of acetylsalicylic acid containing salicylic acid (which I believe is generally the case when salicylic acid is present) then it would modify the color given by the same amount of salicylic acid alone. For this reason it was thought to be more comparable to have the standard contain a slight amount of acetic acid.**

[5] **This standard is somewhat similar to the one proposed by T. W. Thoburn and Paul J. Hanzlik, *J. Biol. Chem.*, 23, 175.**

[1] *Apoth Ztg.*, **1915**, p. 247; *Bull. soc. chim.*, **17** (1915), 401. "Studies of the decomposition of aspirin determined by titrametric methods and by conductivity measurements indicate that the reaction is exceedingly complex," T. and H. *Chem. Abs.*, **10**, 591.

of acetylsalicylic acid examined, all of them with one exception (acetylsalicylic acid, Millikin, 5-grain capsules, purchased on the open market) complying with the tests described in this paper. *The Journal of the American Medical Association*, in past years, has protested repeatedly against the monopoly given to the Bayer Company for their "Aspirin," contending that acetylsalicylic acid (aspirin) was not new, and that "Aspirin, Bayer" was simply a good brand of acetylsalicylic acid which could be bought in foreign countries at much lower prices than here. Although the patent in the United States has expired, "Aspirin, Bayer" is still being retailed at higher prices than other products which are now enjoying the privilege of American manufacture.

Mr. Paul Bakewell,[1] in an opinion answering the warning circular of the Bayer Co. in reference to the use of the word "aspirin" by firms other than Bayer, argues very ably that acetylsalicylic acid, before the patent was granted, meant the impure substance which was not used therapeutically, while "aspirin" was designated as the improved product (a new article of manufacture, the particular acetylsalicylic acid made under the Hoffman patent) and "is the substance now known in pharmacy as aspirin" (statement made by an officer of the Farbenfabriken of Elberfeld Co. in U. S. Circuit Court, 1909). The products reported in this paper are (with the one exception) the same as described in the Hoffman patent, and, in the sense of Mr. Bakewell's argument, are "aspirin." However, it would seem better if the name acetylsalicylic acid, instead of aspirin, were used, especially by physicians in their prescriptions because (1) it is a generic, scientific name; (2) "Aspirin, Bayer" is sold at higher prices than other products, whereas chemically equivalent products sold under the descriptive name may be purchased at a lower price. Finally, the manufacture of acetylsalicylic acid in this country is another example of the fact that American chemists can produce the drug synthetics, and at the same time make products as good as, if not better than, those of German origin.

I express my appreciation to Dr. W. A. Puckner for his kind interest.

CHEMICAL LABORATORY
AMERICAN MEDICAL ASSOCIATION
CHICAGO, ILLINOIS

THE DETERMINATION OF ARSENIC IN INSECTICIDES[2] BY POTASSIUM IODATE

By GEORGE S. JAMIESON

Received January 8, 1918

The methods employed for the determination of arsenic in insecticides are based upon the well-known iodimetric processes. Arsenious compounds are titrated with iodine in the presence of an excess of sodium bicarbonate. Arsenic compounds in a strongly acidified solution are treated with potassium iodide and the iodine which is liberated by the reaction is titrated with sodium thiosulfate in the usual manner. It is not proposed to discuss in detail the various modifications of these methods that have been suggested and investigated in connection with the analysis of arsenical insecticides. The reader is referred to the exhaustive reports published in the *Journal of the Association of Official Agricultural Chemists*, 1915, 1916 and 1917. The method adopted as official by the A. O. A. C. for the determination of total arsenic is based upon the distillation of the arsenic as arsenious chloride by means of cuprous chloride and concentrated hydrochloric acid. The distillate obtained is diluted to a definite volume and aliquot portions are titrated with iodine in the presence of sodium bicarbonate.[3]

The object of this paper is to show that the iodate titration as applied to the determination of arsenic has many advantages over the iodimetric methods.

The iodate method, which is based upon titrating arsenious compounds with a standard solution of potassium iodate in the presence of 11 to 20 per cent of hydrochloric acid, until the iodine liberated during the first part of the reaction has disappeared from the chloroform indicator, was first described by L. W. Andrews.[4] More recently the writer[5] has shown that arsenic can be accurately determined by this method, and confirmed the results obtained by Andrews. It may be well to enumerate again the advantages of the iodate titration over the iodimetric for those who are not familiar with the literature on this subject. One great advantage is that the iodate solution is prepared ready for use by simply weighing the calculated amount of pure dry normal potassium iodate,[6] dissolving it in water, and diluting to the proper volume. No further standardization of this solution is required at any time so long as the evaporation of the water is prevented (a solution kept for seven years showed no measurable change). This is in marked contrast to the work and time required to prepare the iodine solution as well as the sodium arsenite or sodium thiosulfate solutions used for its standardization and the restandardization necessary at frequent intervals. Another marked advantage in favor of the iodate titration is the exceedingly sharp and definite end-point obtained with the chloroform indicator. Furthermore cupric and ferric compounds as well as most kinds of organic matter have no influence upon the accuracy of the method. In the direct titration of insecticides, cuprous and antimonious compounds react with potassium iodate as is the case with the iodine titration, but fortunately these compounds occur only in very small amounts.

In connection with the determination of total arsenic in which the distillation process is employed in order to obtain all the arsenic in the trivalent condition, the iodate titration has the advantage over the iodine method not only in regard to the time required but also in that no sodium hydroxide or sodium bicarbonate is used. The first potassium iodate solution employed in the present investigation contained 3.567 g. of

[1] "In the Matter of Aspirin. Answer to the warning circular of the Bayer Co. of June 1, 1917," by Mr Paul Bakewell, Monsanto Chemical Works.

[2] Published by permission of the Secretary of Agriculture.

[3] Roark and McDonnell, THIS JOURNAL, **8** (1916), 327.

[4] *J. Am. Chem. Soc.*, **25** (1903), 756.

[5] THIS JOURNAL, **3** (1911), 250; *Am. J. Sci.*, **44** (1917), 150.

[6] *Ibid.*, **44** (1917), 151.

KIO_3 in 1000 cc. It had the value 1 cc. = 0.003300 g. of As_2O_3. When this solution was exhausted, a more convenient one was prepared. It contained 3.244 g. of KIO_3 in 1000 cc. and had the value 1 cc. = 0.003000 g. of As_2O_3. For the preparation of these solutions, Kahlbaum's pure normal potassium iodate which had been dried at 140° C. was used. The reaction between the potassium iodate and arsenious compounds is represented by the following equation:

$$As_2O_3 + KIO_3 + 2HCl = As_2O_5 + ICl + KCl + H_2O$$ [1]

For the determination of arsenious oxide in Paris green or other arsenite from 0.15 to 0.4 g. of the sample, depending upon the amount of arsenic present, was weighed directly into a 250 cc. or 500 cc. glass-stoppered bottle. 30 cc. of hydrochloric acid, sp. gr. 1.19, 20 cc. of water, and 6 cc. of chloroform were added. The titration was made by adding the potassium iodate solution, rapidly at first, while shaking the bottle so as to give the contents a gyratory motion. When the iodine which is liberated during the first part of the titration has largely disappeared from the solution, the stopper is inserted and the contents of the bottle are given a thorough shaking. From this point, the titration is continued cautiously, shaking the stoppered bottle after each addition of iodate solution, until the iodine color of the chloroform has disappeared which marks the end-point. It is customary to allow the titrated solution to stand 5 min., then if, after shaking again, any color is observed in the chloroform, it is expelled with the smallest possible amount of iodate solution. It is very important to shake the solution more thoroughly the nearer the end-point is approached, otherwise the solution may be over-titrated. Furthermore, it has been found that the larger the volume of the solution being titrated, the more shaking is required to bring the chloroform carrying the iodine in contact with the potassium iodate. The entire determination, after a little practice with the iodate titration, can usually be completed in about 15 min. It should be observed that as Andrews[2] has shown, the strength of the hydrochloric acid in which the titration is made, is of much importance. The acidity of the solution at the end of the titration should not be less than 11 per cent of actual hydrochloric acid so as to prevent the hydrolysis of the iodine monochloride. On the other hand, the acidity should not be over 20 per cent, otherwise the reaction proceeds very slowly. It is a simple matter to keep the acid within the required limits. In order to facilitate calculations, and also if it is desired to weigh larger amounts of the insecticide, a gram or factor weight may be employed. In such cases it would be recommended that the sample be dissolved in 200 cc. of hydrochloric acid, sp. gr. 1.19, and made to 500 cc. volume; then to each 100 cc. aliquot, 10 cc. of hydrochloric acid should be added to maintain the proper acidity. Using a potassium iodate solution of which 1 cc. = 0.003300 g. As_2O_3, the following results were obtained:

[1] *Am. J. Sci.*, **44** (1917), 151.
[2] *Loc. cit.*

Insecticide	Gram Taken	Cc. of KIO_3 Used	Percentage As_2O_3 Found: Iodate Method	Hedge's Modified Method
Paris Green No. 12542	0.1287	22.2	56.92	57.05
Paris Green No. 12542	0.1166	20.1	56.88	56.93
Paris Green No. 12542	0.1207	20.8	56.87	...
Paris Green No. 12542	0.1325	22.85	56.90	...
Paris Green No. 12489	0.1794	33.92(*c*)	56.72	56.75
Paris Green No. 12489	0.1533	28.95(*c*)	56.65	...
Paris Green No. 12489	0.1124	21.23(*c*)	56.67	...
Paris Green(*a*)	0.1649	31.22(*c*)	56.80	56.85
Paris Green(*a*)	0.1851	35.05(*c*)	56.81	...
Zinc Arsenite(*a*)	0.2088	26.25	41.68	41.79
Zinc Arsenite(*a*)	0.2998	41.65(*c*)	41.68	41.87
Bordeaux Zinc Arsenite(*b*)	0.1984	20.60	34.21	34.22
Bordeaux Zinc Arsenite(*b*)	0.1788	18.50	34.14	...
Bordeaux Zinc Arsenite(*b*)	0.2000	20.72	34.19	...
Bordeaux Paris Green(*a*)	0.3179	30.60	31.76	31.70
Bordeaux Paris Green(*a*)	0.2279	21.90	31.71	31.61
Bordeaux Paris Green(*a*)	0.1912	18.4	31.74	...

(*a*) A. O. A. C. 1915 Referee Sample.
(*b*) A. O. A. C. 1916 Referee Sample.
(*c*) KIO_3 Sol. with 1 cc. = 0.003000 g. As_2O_3.

The results obtained by the iodate method agree closely with those of the modified Hedge procedure. It was found preferable in the Hedge method to neutralize the larger part of the hydrochloric acid used to dissolve the insecticide with 25 per cent sodium hydroxide instead of neutralizing all the acid with sodium bicarbonate, as recommended, because this is liable to cause some loss of arsenic on account of the violent evolution of carbon dioxide.

In order to apply the iodate titration to the determination of total arsenic in any arsenical insecticide or fungicide, the official distillation process of the A. O. A. C. mentioned above was employed and the distillation apparatus was arranged as follows: An 8 oz. distilling bulb, provided with a long-stem 50 cc. dropping funnel, was connected to a 24 in. Liebig condenser. The outlet of the condenser was connected to a 500 cc. Erlenmeyer flask with a bent glass tube which extended through a 3-hole rubber stopper for about 4 in. The middle hole carried a safety tube 18 in. long which extended within half an inch of the bottom of the flask. The third hole carried a bent tube which extended through a 2-hole stopper to within half an inch of the bottom of the second 500 cc. flask. Another bent tube just passing through the second hole of this stopper was arranged so that it dipped into the 50 cc. of water placed in a 250 cc. Erlenmeyer flask which served as a trap. During the distillation the first two Erlenmeyer flasks were surrounded by cracked ice in a pan. The distillation flask rested in a circular hole cut through a heavy sheet of asbestos board. A wire gauze was placed under the asbestos board. Before starting the distillation 50 cc. of water were placed in the first receiver, 100 cc. in the second receiver, and 50 cc. in the third. The sample taken for analysis was weighed directly into the dried distilling bulb and 5 g. of cuprous chloride were added. This was followed by 100 cc. of hydrochloric acid, sp. gr. 1.19, which washed any material sticking to the neck into the bulb. Care must be taken that none of the sample or cuprous chloride enters the outlet tube of the distilling bulb. When the volume in the distillation bulb is reduced to about 40 cc., 50 cc. more of the acid are added through the dropping funnel and the distillation is continued until the volume is again reduced to about 40 cc. Then 25 cc. more of the acid are added. The distillation is finished

when the contents of the bulb are reduced to not more than 20 cc. This procedure ensured the distillation of all the arsenic. After the distillation was completed, the condenser and connecting tubes were thoroughly rinsed into the receivers. The contents of the first two Erlenmeyer flasks were transferred to a 500 cc. graduated flask. These flasks were rinsed several times, using the entire contents of the third flask which served as a trap. Then each flask was rinsed again with a small quantity of water. All of the rinsings were added to the graduated flask. Before diluting to the mark, the solution in the 500 cc. flask was warmed to 20° C. An aliquot of 100 cc. was placed in the titration bottle along with 6 cc. of chloroform and titrated with the potassium iodate solution as described above. If more than 25 or 26 cc. of the iodate solution were required, 10 to 15 cc. of concentrated hydrochloric acid were added before finishing the titration in order to maintain the proper acidity. For comparison, aliquots were titrated with standard iodine solution according to the official method of the A. O. A. C.

Using a potassium iodate solution of which 1 cc. = 0.003000 g. As_2O_3, the following results were obtained: On account of the physical property of the powdered insecticides which made them adhere to glass, making their transference difficult, it was found preferable to weigh portions of the samples by difference from specimen tubes rather than attempt to weigh, for example, an exact 0.5 g. The results of the test analyses by the iodate method given above show excellent agreement with those obtained by the official method. This accurate method is not only quicker, but is simpler than the iodine titration. The very definite and remarkably sharp end-point, the great stability of the potassium iodate solution, and the readiness with which it can be prepared all recommend its use in place of the iodimetric procedure.

Insecticide	Gram Taken	Cc. of KIO$_3$ Used for 100 cc. Aliquot	Total Arsenic as As_2O_3 Per cent Iodate Method	Official Method
Paris Green No. 12542	0.4382	18.20	57.06	57.15
Paris Green No. 12489	0.4366	23.68	56.62	56.64
Paris Green No. 12489	0.4548	24.66	56.86	56.57
Paris Green(*a*)	0.4888	23.83	56.88	56.92
Paris Green(*a*)	0.6042	22.85	56.86	56.80
Bordeaux Paris Green(*a*)	0.5865	12.55	32.09	32.06
Bordeaux Paris Green(*a*)	0.6820	A 13.95 B 13.95	32.09 32.09	32.12 . . .
Lead Arsenate-Arsenite(*b*)	0.3032	7.20	26.65	. . .
Lead Arsenate-Arsenite(*b*)	0.4945	8.80	26.70	26.71
Zinc Arsenite(*b*)	0.5486	15.40	42.10	42.21
Bordeaux Zinc Arsenite(*b*)	0.6406	14.00	34.39	34.37
Bordeaux Zinc Arsenite(*b*)	0.6193	14.18	34.34	34.38

(*a*) A. O. A. C. 1915 Referee Sample.
(*b*) A. O. A. C. 1916 Referee Sample.

BUREAU OF CHEMISTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LABORATORY AND PLANT

NOTES ON SODIUM CYANIDE

By W. J. SHARWOOD

Received January 15, 1917

The contradictory evidence given by certain "experts" in a recent sensational murder trial indicates an imperfect realization, even by some chemists, of the fact that commercial *potassium* cyanide can scarcely be said to exist at the present time, its place having been usurped by the sodium compound. Sodium cyanide is now widely used as a solvent of the precious metals in ore treatment, in electroplating, and also as a source of hydrocyanic acid for fumigation, especially in western orchards where gaseous hydrocyanic acid is applied as an insecticide to individual trees which are covered with tents during the process.

The sodium cyanide of commerce is one of the purest technical salts now available, containing 96 to 98 per cent NaCN, with less impurity than is found in most samples of potassium cyanide sold as chemically pure. I wish to suggest here that chemists might with advantage make a point of recognizing the use of sodium cyanide, and call it by that name in their laboratories. As with so many other alkali-metal salts, we can now use the sodium instead of the potassium compound as a reagent, except in the very few cases where the potassium ion is essential to the reaction, or where there is some marked difference in solubility. Sodium cyanide not only contains less carbonate and sulfide, but is cheaper, reacts identically with the salts of silver, copper, zinc, etc., except in concentrated solutions, and is more permanent in solution than ordinary potassium cyanide, showing less decomposition and no discoloration on keeping. It has an additional advantage in not being deliquescent.

It seems desirable for the medical and pharmaceutical professions to revise their standards for cyanides—presumably this has been done in preparing the new Pharmacopoeia. The alkaline cyanide now sold must be much more poisonous than the old material, which was no doubt the basis of most of the familiar statements as to its lethal effects. It has long been stated that 5 grains of cyanide have repeatedly proved fatal—at which rate a pound would suffice to kill some 1400 people. This statement no doubt refers to cyanide of the old type, containing probably 30 to 35 per cent of potassium cyanide or, say, 12 to 14 per cent of cyanogen. Modern sodium cyanide—commercial as well as "C. P."—contains 50 to 52 per cent cyanogen, or practically four times as much as the material formerly sold, and is presumably four times as lethal in its action, so that a pound would suffice for over 5000 fatal doses.

Nearly thirty years ago, when potassium cyanide was suggested as a practical solvent for extracting gold from ore, various objections, mainly based on limited experience, were raised: It would not dissolve gold in practical quantities; its solution was extremely unstable; it was highly dangerous on account of its poisonous qualities; the world's sources of supply were altogether insufficient. All these objections have proved groundless. Both gold and silver are successfully and economically extracted; the dilute solution "keeps" admirably when handled on a large scale;

the only recorded deaths attributable to its use have been due to gross carelessness; the supply has been enormously augmented with increased demand and the quality improved, while the price per unit of cyanogen has been reduced to a fraction of the former cost.

At that time, in addition to its use for electroplating, potassium cyanide was employed widely, but in comparatively small quantities, in western gold mills for the purpose of removing stains from the amalgamated copper plates and facilitating the amalgamation of the gold. Samples of the commercial salt which I have tested usually contained from 10 to about 35 per cent of potassium cyanide, with a large proportion of potassium carbonate; it was a highly deliquescent mixture, sold in tin cans holding from 1 to 20 lbs.

This material was derived from hoofs, horns, and the like, by first preparing and crystallizing potassium ferrocyanide, which was then heated, alone or with addition of potassium carbonate or carbon, the reduced iron, etc., being allowed to settle through the fused mass. Sodium was present only in small quantities, and the deliquescence was due to the potassium carbonate remaining or resulting from the decomposition of the cyanide. Sometimes sodium carbonate was used in fusing the ferrocyanide.

With increasing demand other sources of nitrogen were drawn on. Ferrocyanide was obtained from coke and gas works; thiocyanates from the same source were desulfurized. Ferrocyanide was made to give a larger yield by reducing it with metallic sodium, or with a lead-sodium alloy, yielding a mixed cyanide, $NaCN + 2KCN$. Beet-sugar waste (schlempe) was made to yield a certain amount of cyanide. Synthetic methods have also been introduced; ammonia and metallic sodium forming sodamide ($NaNH_2$) which, on heating with carbon, finally yields nearly pure sodium cyanide, etc.

Formerly it was possible to purchase fairly pure potassium cyanide for special purposes, prepared by passing hydrocyanic acid into an alcoholic solution of potash; but pure sodium cyanide was very difficult to get. Some years ago I obtained some sodium cyanide of German manufacture, labeled "C. P." and "very highest purity," but when trying to prepare pure sodium zinc cyanide the first crystals to separate proved to be those of the potassium compound, the sample of guaranteed sodium cyanide containing nearly 1 per cent of potash and a considerable amount of carbonate. Commercial fused sodium cyanide of domestic origin, now obtainable for something like 28 cents per pound[1] in lots of 100 lbs. or more, contains a mere trace of potash, and only 2 to 4 per cent of all impurities combined.

Originally, as just mentioned, commercial cyanide contained potassium as the positive radical with various impurities, such as carbonate, but little or no sodium or other base was usually to be found. It was tested by titrating the cyanogen with standard silver nitrate, Liebig's method, and analysts were accustomed, quite correctly, to report it in terms of KCN; 40 parts of CN found being reported as 100 of KCN.

[1] Since 1916, when this was written, war conditions have increased the price of cyanide materially.

It may be recalled that pure KCN contains, by calculation, 39.97 per cent of CN; pure NaCN contains a much higher proportion, 53.07 per cent CN. For most purposes these are taken as 40 per cent and 53 per cent, respectively.

As the potassium in commercial cyanide was gradually replaced by the lighter atom of sodium, other things remaining the same, the percentage of cyanogen was correspondingly increased. This allowed manufacturers to make a salt containing a large proportion of impurity, which would still titrate 38 or 39 per cent *cyanogen* and would be reported on the old basis as 97 or 98 per cent KCN. Pure *sodium cyanide*, by the same system, would have been reported as 5300/40 or 132.8 per cent KCN. In fact, sodium cyanide was sometimes deliberately diluted with inert material (carbonate, etc.) to supply the demand for 98 per cent KCN. At first there was a prejudice against the use of sodium cyanide in gold extraction, some early experiences indicating that it was less efficient, but laboratory tests indicate that equivalent amounts of the cyanides of potassium, sodium, and calcium are equal in effect, and sodium cyanide is now almost exclusively used in the industry. In fact, with the present shortage of potassium, owing to war and other conditions, it would be impossible to supply the potassium compound in anything like the required quantity.

Until recently, however, cyanide has continued to be sold and used on the basis of its KCN equivalent, even if no trace of potassium was present; thus commercial NaCN was commonly sold as "128 per cent KCN," and most works using cyanide also continued to make up their solutions on the basis of KCN. For the past year cyanide has for the first time been generally sold on the more rational basis of its cyanogen, or its actual NaCN, content; thus the highest grade is now offered as either "sodium cyanide 96 to 98 per cent" or "cyanogen 51 to 52 per cent," while the old, so-called "98 per cent KCN" used to carry about 39 per cent cyanogen. Four pounds of this sodium cyanide are therefore chemically equivalent, and actually equal in effect as a solvent, etc., to about 5 lbs. of the old "potassium cyanide," and there is a corresponding saving of about one-fifth in freight and storage. There is no reason why all users of cyanide should not accept the rational method of reporting the concentration of their solutions in terms of the sodium cyanide which they actually are using, and discard the absurd fiction of calling it—or translating it into—potassium cyanide, which causes unnecessary trouble in making up solutions, etc.

At various times commercial cyanide has been cast in thin slabs, and in large bricks weighing up to 50 lbs. or even more. Some produced in the wet way has been sold in granular form, and some briquetted. The most recent and convenient system is to cast it mechanically into uniform egg-shaped cakes weighing an ounce each, so that for many purposes, such as fumigation, no further weighing is necessary. It was formerly shipped in boxes with an air-tight lining of sheet zinc, of 112 or 224 lbs. each; tin-plate is

now used for lining and 200 lbs. is the usual net weight.

ANALYSIS

For titrating *potassium* cyanide it has been the universal custom to make up a solution containing 1.303 per cent silver nitrate, so that 1 cc. was equivalent to 10 mg. KCN. This was roughly 0.0767 *N*. For titrating commercial sodium cyanide it is possible, by a convenient coincidence, to use *N*/10 or *N*/20 silver solution without necessitating any calculation. One cc. of *N*/10 silver solution is equivalent (by Liebig's titration, or using the preferable modification with potassium iodide indicator) to 5.202 mg. of CN, or to exactly 9.802 mg. of NaCN. Now 98 is almost the exact percentage of actual NaCN in the high-grade commercial material now in use. Therefore we can titrate solutions with *N*/10 silver nitrate and call 1 cc. equivalent to 10 mg. of the actual 98 per cent salt which has to be weighed out in making up the solutions. For technical purposes it is perhaps preferable to use *N*/20 solution (1 cc. = 5 mg. commercial NaCN) as the end-point with iodide indicator is very delicate and the burette readings then also indicate "pounds per ton of solution" directly. For instance, taking a 10 cc. sample: suppose 2 cc. of *N*/20 silver nitrate are consumed; this indicates 10 mg. or 0.10 per cent of commercial sodium cyanide in solution, or 2 lbs. per ton of solution—the "ton" or "fluid ton" used in hydro-metallurgy being about 32 cu. ft., or the volume of 2000 lbs. of water.

When determining sodium and potassium in a mixed cyanide, chlorides and carbonates being the usual impurities, it is often possible to work by directly evaporating with hydrochloric acid, gently igniting and weighing the mixed chlorides remaining, and titrating chlorine in part of the residue. The following formula, based on 1914 Atomic Weights, gives the results in the most direct manner possible:

If A = grams mixed chlorides, and

B = total grams chlorine in mixed chlorides;

then K in grams = 2.4286 A — 4.004 B, and

Na in grams = 3.004 B — 1.4286 A = A — B — K.

Not infrequently the class of cyanide can be determined simply by titrating cyanogen and alkalinity in a *freshly prepared* solution, using methyl orange as indicator.

The determinations in the following table may be taken as typical.

It may not be out of place to call attention to the importance, when testing cyanides for the presence of alkaline sulfide, of preparing the solution at the moment of making the test, or, what is better, of dissolving the solid cyanide in the reagent to be applied. If the cyanide is dissolved in water and allowed to stand even a few minutes, the sulfide content may be seriously diminished, and traces of sulfide may be easily overlooked. Three simple methods are available: Shaking with fine lead carbonate suspended in water; dissolving the solid cyanide in a solution of silver nitrate containing slightly less than 1 mol. $AgNO_3$ for 2 equiv. CN; or dissolving the solid cyanide in a little mercuric chloride solution; each of these reagents yielding a black precipitate or dark coloration. The sulfide may be quantitatively determined by the silver or mercury method.

	Sulfide	N C	CN calcd. as KCN	Cc. normal acid neutralized by one gram of sample: Phenol-phthalein	Methyl Orange	Mc. Orange calcd. from N or C
		Per cent	Per cent	Cc.	Cc.	Cc.
1 "Straight" Potassium Cyanide	Strong test	38.2	95.5	13.0	14.9	14.7
2 Mixed Salt, high in potassium	Fairly strong test in each	39.0	97.5	13.5	15.5	15.0
3 Similar to No. 2		39.3	98.25	14.0	16.0	15.1
4 Sodium Cyanide, diluted with carbonate	Strong test	38.4	96.0	..	19.3	14.75
5 Similar to No. 4	Strong test	40.4	101.0	..	19.5	15.5
6 Sodium Cyanide (commercial)	Trace	51.5	128.75	18.0	20.4	19.8
7 Pure KCN (*calcd.*)	...	39.95	100.00	..	15.34	15.34
8 Pure NaCN (*calcd.*)	...	53.07	132.8	..	20.37	20.37
9 NaCN (73.5%) diluted with Na_2CO_3 (*calcd.*)	...	39.0	97.5	..	20.0	15.0
10 NaCN (73.5%) diluted with NaCl (*calcd.*)	...	39.0	97.5	..	15.0	15.0

Incidentally, while sodium cyanide is not deliquescent, it is decidedly more soluble in water than potassium cyanide. The following determinations were made with the commercial salt, using a sample titrating about 98 per cent NaCN.

Sp. Gr. 18-20° C.	Actual NaCN per 100 Cc. Grams	Commercial NaCN (98%) per 100 Cc. Grams	Actual NaCN Per cent
1.205	44.75	45.65	37.9(*a*)
1.122	25.65	26.16	22.86
1.087	18.3	18.67	16.84
1.0475	9.65	9.84	9.22

(*a*) Nearly saturated.

A fair approximation to the concentration of a not too dilute solution of such material may be obtained from the formula:

(Specific Gravity — 1) × 200 = Grams NaCN per 100 cc.

STABILITY OF SOLUTIONS

In dilute solutions there is no apparent difference in the stability of sodium as compared with potassium cyanide; in each case decomposition is greatly increased by access of air and retarded by presence of free alkali.

Two strong solutions were prepared, one containing approximately 10 per cent of commercial sodium cyanide, the other 13 per cent of "straight" potassium cyanide. They were kept in stoppered 200 cc. bottles, which were at first completely filled, but from which small samples were taken at intervals and titrated for cyanogen and for alkalinity toward methyl orange.

	NaCN: CN per 100 cc. Grams	NaCN: $N/10$ H_2SO_4 per cc. Cc.	KCN: CN per 100 cc. Grams	KCN: $N/10$ H_2SO_4 per cc. Cc.
Original solution	5.12	19.2	4.59	17.8
After 20 days	5.09	19.3	4.40	18.1
After 40 days	4.93	19.4	4.24	18.3
After 38 months	3.05	22.4	2.32	20.0
Condition after 3 years	Colorless and clear. Strong odor of ammonia		Clear yellow solution. Very slight brown deposit on glass. Strong odor of ammonia	

This indicates that in strong solutions there is comparatively little difference in stability, the advantage, if any, lying on the side of the sodium compound, which lost about 40 per cent of its cyanogen in 38

months against nearly 50 per cent lost by commercial potassium cyanide.

HOMESTAKE MINE
LEAD, SOUTH DAKOTA

A COMPARISON OF THE PROXIMATE AND MINERAL ANALYSIS OF DESICCATED SKIM MILK WITH NORMAL COWS' MILK

By EVERHART P. HARDING AND HUGO RINGSTROM

Received August 30, 1917

The purpose of this paper was to compare the proximate and mineral analysis of desiccated skim milk with normal cows' milk and to determine, if possible, whether foreign substances had been added before or during desiccation.

METHOD OF DESICCATION

There are two general methods used in making desiccated milk. One is drying the milk on steam-heated drums and the other is spraying the milk into a chamber through which a current of hot air is passing. All drum processes of drying the milk are really modifications of the Just-Hatmaker[1] process, in which the milk is spread in thin films on to drums by a distributing pipe.

In the spraying process, the milk is pumped through a nozzle and delivered in a fine spray into a chamber through which a current of heated air is passing. The extent to which the proteins are coagulated depends largely upon the method used in desiccating the milk. To increase the emulsifying power of the casein different substances may be used.

PROXIMATE ANALYSIS

The composition of the different desiccated skim milks is surprisingly uniform with the exception of the moisture content which varies from 2 to 9 per cent or even more.

The fat content, of course, depends upon the extent to which the fat is removed before the milk is desiccated. The amount present is very small, rarely exceeding 2 per cent.

A number of proximate analyses have been made from time to time, but the majority have been made within the last 10 years. Of the eight analyses given in Table I, all except the first have been reported since 1905.

EXPERIMENTAL PART

Four different samples of desiccated skimmed milk were purchased on the market or obtained from users of milk powders. Sample I was made by the International Milk Products Company, Detroit, Michigan; Sample II by the Minnesota Dry Milk Company, Anoka, Minnesota; Sample III by the International Milk Company, Plymouth, Michigan; and Sample IV by the California Central Creameries, San Francisco, California.

TABLE I—PERCENTAGE COMPOSITION OF SKIM MILK POWDERS

	Milchindust(*a*)	Max Popp(*b*)	Mansfield(*c*)	Teichert(*d*)	Fleming(*e*)	Teichert(*f*)	Goy(*g*)	Mohan(*h*)
Water	4.17	4.54	8.96	8.54	2.53	7.40	2.81	8.3
Fat	1.65	1.25	0.57	1.31	1.81	1.56	2.10	1.7
Protein	35.56	35.01	30.59	32.71	38.16	32.50	33.51	33.8
Lactose	52.37	51.22	48.62	50.24	49.32	52.57	53.43	49.3
Ash	7.51	7.98	8.10	7.20	8.21	6.27	8.04	6.9

(*a*) *Milchindust*, **1889**, 90; VNa., **4**, 419; *Chem. Zentr.*, **61** (1890), 72. (*b*) *Chem.-Ztg.*, **33** (1909), 647. (*c*) *XVIII Jahresbericht der unter.-anstalt des allgem. öster. Apotheker Vereins*, **1905–6**, 8; *Z. Nahr. Genussm.*, **13** (1907), 285. (*d*) *Jahr. Milch. Unter. Allgau zu Memmingen*, **1909**, 11; *Z. Nahr. Genussm.*, **20** (1910), 476. (*e*) THIS JOURNAL, **4** (1912), 543. (*f*) *Allgauer Monatschr. f. Milchwirtsch. u. Vieh.*, **1** (1913), 31; *Z. Nahr. Genussm.*, **26** (1913), 109. (*g*) *Ibid.*, **25** (1913), 445. (*h*) *J. Soc. Chem. Ind.*, **34** (1915), 109.

TABLE II—PERCENTAGE COMPOSITION OF SKIM MILK POWDERS AS GIVEN IN TABLE I COMPUTED ON MOISTURE-FREE BASIS

	Milchindust	Max Popp	Mansfield	Teichert	Fleming	Teichert	Goy	Mohan
Fat	1.72	1.31	0.62	1.43	1.85	1.62	2.16	1.85
Protein	37.09	36.77	33.60	35.76	39.03	35.07	34.48	36.86
Lactose	54.65	53.66	53.40	54.90	50.44	56.44	54.97	53.76
Ash	7.83	8.36	8.89	7.87	8.39	6.77	8.27	7.52

ODOR AND COLOR—The color of the powders was yellowish white, except Sample III, which had a brownish tinge and an unpleasant odor. The other three samples had a milk-like odor.

EMULSIFYING QUALITY—The emulsifying power of the powders was tried with water at room temperature and at 40° C. Approximately 2 g. of milk powder were stirred up with a little water to a uniform paste. Water was then added slowly with vigorous stirring until about 20 cc. had been added, giving an emulsion of approximately the same consistency and composition as normal skim milk. Samples I and II emulsified well with water at room temperature, giving a milk-like emulsion, without any settling of protein in 4 hours. Sample III gave a very poor emulsion, yellowish brown in color. A flocculent

TABLE III—PERCENTAGE MINERAL COMPOSITION OF MILK ASH AND WHOLE MILK

	Marchand 1000 Parts of Milk	Bunge(*a*) 1000 Parts of Milk	Per cent in Ash	Fleischmann(*b*)	Schrodt Per cent in Ash	Richmond Per cent in Ash	Babcock Per cent in Ash	Babcock Per 1000 Parts Milk
Potassium oxide	1.071	1.766	22.14	21.539	25.42	28.71	25.02	1.75
Sodium oxide	0.636	1.110	13.91	11.817	10.94	6.67	10.01	0.70
Calcium oxide	1.864	1.599	20.05	20.383	21.45	20.27	20.01	1.40
Magnesium oxide	0.299	0.210	2.63	3.120	2.54	2.80	2.42	0.17
Ferric oxide	0.127	0.0035	0.04	0.300	0.11	0.40	0.13	0.01
Chlorine	0.751	1.697	21.27	12.813	14.60	14.00	14.28	1.00
Phosphoric anhydride	2.102	1.974	24.75	29.000	25.11	29.33	24.29	1.70
Sulfuric anhydride	0.323	....	....	2.378	4.11	trace	3.84	0.27
Carbon dioxide	0.277	....	....	0.533	....	0.97	....	....
Silica	0.006	....	....	....	....	....	....	....
Moisture	...	....	....	0.300	....	....	....	....
Carbon and impurities	...	....	....	0.250	....	....	....	....
Loss	....	....	....	0.353	....	....	....	....
Total ash	7.456	8.360	104.79	102.886	103.28	...	....	....
Oxygen corresponding to chlorine	0.176	0.383	4.79	2.886	3.28	...	....	....
Corrected ash	7.28	7.977	100.00	100.000	100.00	...	100.00	7.10

(*a*) *Z. Biol.*, **10**, 295. (*b*) *Ber.*, Raden, **1885–6**, 64.

[1] J. A. Just, U. S. Patent 712,545, Nov. 4, 1912; *J. Soc. Chem. Ind.*, **21** (1902), 1548; J. R. Hatmaker, English Patent 21,617, Oct. 4, 1902; *J. Soc. Chem. Ind.*, **22** (1903), 1145.

precipitate collected immediately on top of the emulsion, and a precipitate settled to the bottom in a short time. After 4 hours the emulsion was stratified, the middle stratum having a serum-like, but turbid, appearance. Sample IV gave a fair emulsion from which some protein settled in 4 hours. With water at 40° C., Samples I, II and IV gave good emulsions without any settling of protein in 4 hours. Sample III gave the same kind of an emulsion as with water at room temperature, except that stratification proceeded more slowly.

PROXIMATE ANALYSIS—The powders were analyzed for moisture, ash, fat, protein, lactose and acid content and the acidity recorded as free lactic acid. The following results were obtained:

TABLE IV—PROXIMATE ANALYSIS

	Sample I Per cent	Sample II Per cent	Sample III Per cent	Sample IV Per cent
Ash	7.89	7.98	7.45	7.49
Fat	1.42	1.82	1.01	0.85
Protein	32.86	33.72	37.01	33.41
Moisture	5.60	4.71	7.09	6.60
Lactose	48.49	47.67	41.38	47.13
Acidity	1.58	1.57	1.43	1.69
	97.84	97.47	95.37	97.17
Hydration of lactose	2.43	2.38	2.07	2.37
TOTAL	100.27	99.85	97.44	99.54

TABLE V AVERAGES OF THE PROXIMATE ANALYSIS ON MOISTURE-FREE BASIS

	Sample I Per cent	Sample II Per cent	Sample III Per cent	Sample IV Per cent
Ash	8.36	8.37	8.02	7.02
Fat	1.50	1.91	1.08	0.91
Protein(a)	34.81	35.38	39.83	35.77
Lactose	53.94	52.52	46.76	53.00
Acidity	1.67	1.64	1.54	1.81
	100.28	99.82	97.23	99.42

(a) With one molecule of water of crystallization.

TABLE VI—PROXIMATE ANALYSIS COMPUTED ON MILK CONTAINING NINE PER CENT "SOLIDS-NOT-FAT"

	Sample I Per cent	Sample II Per cent	Sample III Per cent	Sample IV Per cent
Ash	0.75	0.75	0.72	0.72
Fat	0.135	0.179	1.097	0.082
Protein	3.13	3.18	3.58	3.22
Lactose	4.85	4.73	4.20	4.78
Acidity	0.16	0.15	0.14	0.16

TABLE VII—ASH, PROTEIN, AND LACTOSE CONTENT COMPARED WITH THE AMOUNT FOUND IN NORMAL MILK

	Ash Per cent	Protein Per cent	Lactose Per cent
Richmond	0.73	3.41	4.70
Leach	0.71	3.55	4.88
Babcock	0.70	3.80	4.50
Sample I	0.75	3.12	3.45
Sample II	0.75	3.18	4.73
Sample III	0.72	3.58	4.20
Sample IV	0.72	3.22	4.78

With the exception of Sample III, the proximate analyses of the powders compared favorably with the analyses made by others on skim milk powders. In Sample III the lactose is extremely low and the protein extremely high and these results were confirmed by repeated determinations. The use of some other number than 9 for "total solids-not-fat" would either increase the protein still more or decrease the lactose still more. This ratio of protein to lactose is abnormally high for herd milk.

TABLE VIII—THE MINERAL CONSTITUENTS IN THE ASH

	Sample I Per cent	Sample II Per cent	Sample III Per cent	Sample IV Per cent
Potassium oxide	24.05	25.49	22.44	25.81
Sodium oxide	8.35	9.37	9.60	8.02
Calcium oxide	23.57	21.99	25.86	23.32
Magnesium oxide	3.18	2.92	3.07	3.08
Ferric oxide(a)	0.035	0.035	0.034	0.049
Sulfuric anhydride(b)	0.38	12.14	13.69	12.15
Phosphoric anhydride(b)	32.69	31.44	32.78	34.25
Chlorine(c)	12.46	14.28	14.04	12.37

(a) The iron was determined volumetrically by Lacks and Friedenthal's modification of the potassium sulfocyanide method.

(b) The sulfur and phosphorus were determined on the milk powders. The organic matter was completely oxidized in a closed cartridge with sodium peroxide and the phosphorus determined by the titration method.

(c) The chlorine was determined by the method of Paul Poetschke, THIS JOURNAL, 2 (1910), 210.

TABLE IX—MINERAL CONSTITUENTS IN THE COMMERCIAL POWDERS COMPUTED ON THE MOISTURE FREE POWDER, ASH AND NORMAL MILK BASIS

	Commercial Sample Per cent	Dry Powder Per cent	Ash Per cent	Normal Milk 9% Solids Parts per 1000
Sample I				
Potassium oxide	1.90	2.01	24.05	1.809
Sodium oxide	0.66	0.700	8.35	0.630
Calcium oxide	1.86	1.97	23.57	1.773
Magnesium oxide	0.251	0.266	3.18	0.239
Ferric oxide	0.00273	0.0029	0.035	0.026
Sulfuric anhydride	0.897	0.951	11.38	0.856
Phosphoric anhydride	2.58	2.73	32.69	2.457
Chlorine	0.981	1.04	12.46	0.936
Sample II				
Potassium oxide	2.03	2.13	25.49	1.917
Sodium oxide	0.746	0.783	9.37	0.705
Calcium oxide	1.75	1.84	21.99	1.656
Magnesium oxide	0.232	0.244	2.92	0.220
Ferric oxide	0.0027	0.0029	0.035	0.0026
Sulfuric anhydride	0.971	1.02	12.14	0.918
Phosphoric anhydride	2.51	2.63	31.44	2.367
Chlorine	1.14	1.20	14.28	1.080
Sample III				
Potassium oxide	1.68	1.80	22.44	1.620
Sodium oxide	0.715	0.77	9.60	0.693
Calcium oxide	1.92	2.07	25.86	1.863
Magnesium oxide	0.228	0.246	3.07	0.221
Ferric oxide	0.0025	0.0027	0.034	0.0024
Sulfuric anhydride	1.02	1.10	13.69	0.990
Phosphoric anhydride	2.45	2.63	32.78	2.367
Chlorine	1.05	1.13	14.04	1.017
Sample IV				
Potassium oxide	1.93	2.07	25.81	1.863
Sodium oxide	0.600	0.643	8.02	5.787
Calcium oxide	1.75	1.87	23.32	1.683
Magnesium oxide	0.230	0.247	3.08	0.222
Ferric oxide	0.0036	0.0039	0.049	0.0035
Sulfuric anhydride	0.909	0.974	12.15	0.876
Phosphoric anhydride	2.57	2.75	34.25	2.475
Chlorine	0.926	0.992	12.37	0.893

The mineral constituents are found in Tables VIII and IX.

Tables IX and III give a comparison of the percentages of mineral constituents found in the milk powders and their ash and that found in normal cows' milk and its ash. In reducing the percentages of the mineral constituents as found in the milk powder to corresponding percentages in normal cows' milk, 9 per cent was assumed as representing the total solids-not-fat in normal cows' milk.

CONCLUSION

The percentages of the mineral constituents in the four samples agree quite closely, but do not agree very well with those found by other analyses. The potassium oxide and chloride agree well. The sulfuric anhydride is much higher than that found by others; this is due to the method used in its determination. The calcium oxide, magnesium oxide and phosphoric anhydride are all higher than the values found by others. The higher phosphorus content may be due entirely to the method used in its determination or also in part due to the addition of some phosphate used as an emulsifier. The calcium is also much higher and may have been added in some form as an emulsifier. The ferric oxide content is lower and this is probably due to the method used in its determination. A low percentage of ferric oxide in milk has been found by the "cupferon" method.[1] This method was tried but did not give consistent results.

The color, odor, emulsifying power, high protein, low lactose, high calcium and phosphorus content, and low total approximate analysis would indicate

[1] *Z. Nahr. Genussm.*, **23** (1912), 514.

that Sample III was not genuine desiccated skimmed milk powder.

CHEMICAL LABORATORY
UNIVERSITY OF MINNESOTA
MINNEAPOLIS, MINNESOTA

AN IMPROVED AUTOMATIC PIPETTE-WASHING DEVICE

By AUBREY VAIL FULLER

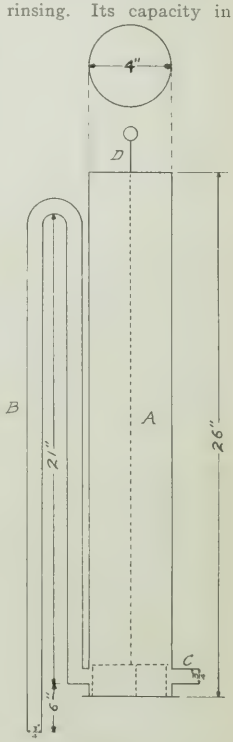
Received November 17, 1917

Since his publication of an article in THIS JOURNAL, Vol. 9, p. 1046, entitled "A Convenient Automatic Device for Rapidly Washing Pipettes," the author has designed a modified form of the apparatus referred to, which embodies several improvements.

In the accompanying illustration *A* is a cylindrical metal tank, provided with a siphon, *B*, and an inlet pipe, *C*. *D* is a brass rod which carries at its lower extremity a disk of rather heavy brass gauze, to which is fastened three legs of such length that when placed in the cylinder the gauze is supported at a level slightly above the tops of the two lower orifices. There should be about $^1/_{16}$ in. clearance all around between disk and tank.

The operation of the device is as follows: Water is admitted through the inlet *C* which is connected to the supply tap, at such a rate that the speed at which the siphon empties the tank is somewhat greater than the speed at which the tank is filled. The pipettes to be washed are then placed, tip up, in the tank, the lower ends resting on the gauze. As the tank is alternately filled and emptied the pipettes are rinsed. To remove the pipettes they are raised to within easy reach by means of the "lifter" *D*.

With an apparatus of the dimensions of that pictured, the period of a complete cycle is approximately 45 sec. Inasmuch as two cycles are required for the average pipette, only about one and one-half minutes are necessary for thorough rinsing. Its capacity in terms of 25 cc. transfer pipettes is 13, and in terms of 1 cc. measuring pipettes about 100, when loosely packed. The time economy of such a device over hand washing is thus apparent.



The points in superiority of this device over the one previously described are: (1) greater capacity, (2) smaller table space occupied, (3) lower first cost, (4) cleansing of both outside and inside of pipette.

It might be mentioned that an apparatus of this type would find particular application in laboratories conducting serological work, where large numbers of pipettes must be rinsed before sterilization. Its field of usefulness is, however, entirely general and the details of its construction admit of wide variations to suit peculiar conditions.

BIOCHEM. DIVISION
BUREAU OF ANIMAL INDUSTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

ADDRESSES

METHODS OF GAS WARFARE[1]

By S. J. M. AULD, British Military Mission

All I can do in the short time available is to give you, if I can, a general idea of what gas warfare really means on the Western Front at the present time. Some of you may have gotten the idea that gas is just an incident, and that there is not as much attention being paid to it as there was two years ago. That idea is entirely wrong. Gas is used to a tremendous extent, and the amount that has been and is being hurled back and forth in shells and clouds is almost unbelievable. I will try to give you a general idea of what is occurring and make the lecture rather a popular than a technical description. I shall also, for obvious reasons, have to confine myself to describing what the Germans have been doing, and will say nothing about what we are doing.

Possibly the best plan would be to state more or less chronologically what occurred. I happened to be present at the first gas attack and saw the whole gas business from the beginning. The first attack was made in April 1915. A deserter had come into the Ypres salient a week before the attack was made, and had told us the whole story. They were preparing to poison us with gas, and had cylinders installed in their trenches. No one believed him at all, and no notice was taken of it.

[1] Report of a lecture delivered before the Washington Academy of Sciences on January 17, 1918. Reprinted from the *Journal of the Washington Academy of Sciences*, **8**, No. 3, February 4, 1918.

Then came the first gas attack, and the whole course of the war changed. That first attack, of course, was made against men who were entirely unprepared—absolutely unprotected. You have read quite as much about the actual attack and the battle as I could tell you, but the accounts are still remarkably meager. The fellows who could have told most about it didn't come back. The Germans have claimed that we had 6000 killed and as many taken prisoners. They left a battlefield such as had never been seen before in warfare, ancient or modern, and one that has no compeer in the whole war except on the Russian front.

What the Germans expected to accomplish by it I am not sure. Presumably they intended to win the war, and they might conceivably have won it then and there if they had foreseen the tremendous effect of the attack. It is certain that they expected no immediate retaliation, as they had provided no protection for their own men. They made a clear and unobstructed gap in the lines, which was only closed by the Canadians, who rallied on the left and advanced, in part through the gas cloud itself.

The method first used by the Germans, and retained ever since, is fairly simple, but requires great preparation beforehand. A hole is dug in the bottom of the trench close underneath the parapet, and a gas cylinder is buried in the hole. It is an ordinary cylinder, like that used for oxygen or hydrogen. It is then covered first with a quilt of moss, containing potassium car-

bonate solution, and then with sand bags. When the attack is to be made the sand bags and protecting cover are taken off the cylinder, and each cylinder is connected with a lead pipe which is bent over the top of the parapet. A sand bag is laid on the nozzle to prevent the back "kick" of the outrushing gas from throwing the pipe back into the trench. Our own methods are practically identical with those first used by the Germans.

The success of a cloud gas attack depends on thorough preparation beforehand. The attackers must know the country, the layout of the trenches, and the direction and velocity of the wind with certainty. Favorable conditions are limited practically to wind velocities between 12 and 4 miles an hour. A wind of more than 12 miles an hour disperses the gas cloud very rapidly. An upward current of air is the worst foe of gas. The weight of the gas is not an important factor in carrying it along, for it mixes rapidly with air to form the moving "cloud." The time occupied by a gas attack is too short to permit of much diffusion of the gas out of the original mixture.

The gas attack must be planned very carefully. If the trench line is very irregular it is likely that the gas will flow into a portion of one's own trenches. The limits of safety in wind direction are thus determined by the direction of the lines of the trenches. The Germans use a 40° angle of safety; that means that on a given straight portion of the front the wind direction must lie between the two directions which make angles of 40° with the neighboring sections of the front. The most suitable type of country is where the ground slopes gently away from where the gas is being discharged. The Germans made one mistake in believing that hilly or wooded country would not do. This was refuted by the French, who made a successful gas attack in hilly and wooded country in the Vosges, as admitted in a captured German report. If the country is flat like that about Ypres, and the wind direction is right, there is very little difficulty about making an attack, especially if the enemy does not know anything about it. The element of surprise is important.

German gas attacks are made by two Regiments of Pioneers, with highly technical officers, including engineers, meteorologists, and chemists. They brought their first cylinders into the line without our knowing anything about it, except from the deserter's report which was not believed. The element of surprise was greatly lessened when we began to know what to look for and to recognize the sounds incident to the preparation of a gas attack.

The first attack was made with chlorine. If a gas attack is to be made with gas clouds, the number of gases available is limited. The gas must be easily compressible, easily made in large quantities, and should be considerably heavier than air. If to this is added the necessity of its being very toxic and of low chemical reactivity, the choice is practically reduced to two gases: chlorine and phosgene. Chlorine is to gas warfare what nitric acid is to high explosives. Pure chlorine did not satisfy quite all the requirements, as it is very active chemically and therefore easily absorbed. Many men in the first attack who had sufficient presence of mind saved themselves by burying their faces in the earth, or by stuffing their mufflers in their mouths and wrapping them around their faces.

There were several gas attacks of almost exactly the same kind early in 1915. There was no gas between the end of May 1915 and December 1915, and by that time adequate protection had been provided.

The first protection was primitive. It consisted largely of respirators made by women in England in response to an appeal by Kitchener. They were pads of cotton wool wrapped in muslin and soaked in solutions of sodium carbonate and thiosulfate; sometimes they were soaked only in water. A new type appeared almost every week. One simple type consisted of a pad of cotton waste wrapped up in muslin together with a separate wad of cotton waste. These were kept in boxes in the trenches, and on the word "gas" six or eight men would make a dive for the box, stuff some waste into their mouths, then fasten on the pad and stuff the waste into the space around the nose and mouth. But this got unpopular after a bit, when it was discovered that the same bits of waste were not always used by the same men. During the early part of 1915 this was the only protection used.

Then came the helmet made of a flannel bag soaked in thiosulfate and carbonate, with a mica window in it. A modified form of this device with different chemicals is still used in the British army as a reserve protection. It is put over the head and tucked into the jacket, and is fool-proof as long as well tucked down. This stood up very well against chlorine.

In 1915 we got word from our Intelligence Department of a striking kind. It consisted of notes of some very secret lectures given in Germany to a number of the senior officers. These lectures detailed materials to be used, and one of them was phosgene, a gas which is very insidious and difficult to protect against. We had to hurry up to find protection against it. The outcome was a helmet saturated with sodium phenate. The concentration of gases when used in a cloud is small, and 1 to 1000 by volume is relatively very strong. The helmet easily gave protection against phosgene at a normal concentration of 1 part in 10,000. That helmet was used when the next attack came in Flanders, on the 19th of December. This attack was in many ways an entirely new departure and marked a new era in gas warfare.

There are three things that really matter in gas warfare, and these were all emphasized in the attack of December. They are: (1) increased concentration; (2) surprise in tactics; (3) the use of unexpected new materials.

Continued efforts have been made on both sides to increase the concentration. The first gas attack, in April 1915, lasted about one and a half hours. The attack in May lasted three hours. The attack in December was over in thirty minutes. Thus, assuming the number of cylinders to be the same (one cylinder for every meter of front in which they were operating), the last attack realized just three times the concentration of the first, and six times the concentration obtained in May. Other cloud gas attacks followed, and the time was steadily reduced; the last attacks gave only ten to fifteen minutes for each discharge. We believe that the cylinders are now put in at the rate of three for every two meters of front, and may even be double banked.

The element of surprise came in an attack by night. The meteorological conditions are much better at night than during the day. The best two hours out of the twenty-four, when steady and downward currents exist, are the hour between sunset and dark and the hour between dawn and sunrise. Gas attacks have therefore been frequently made just in the gloaming or early morning, between lights. This took away one of the easy methods of spotting gas, that of seeing it, and we had to depend upon the hissing noises made by the escaping gas, and upon the sense of smell.

Another element of surprise was the sending out of more than one cloud in an attack. After the first cloud the men would think it was all over, but ten minutes or half an hour later there would come another cloud on exactly the same front. These tactics were very successful in at least one case, namely, the attack near Hulluch in 1916. Some of the troops discarded their helmets after the first wave and were caught on the second, which was very much stronger than the first.

Efforts were also made to effect surprise by silencing the gas. But silencers reduced the rate of escape so greatly that the loss of efficiency from low concentration more than made up for the gain in suddenness. Another method was to mix the gas up with smoke, or to alternate gas and smoke, so that it would be difficult to tell where the gas began and the smoke ended.

The last attack made on the British by this means was in August 1916. Since that time the Germans have used gas three times on the West Front against the French, and have also used it against the Italians and the Russians. It has been practically given up against the British, although the method is by no means dead.

The last attack was a slight set-back in the progress of gas defense. The casualties had been brought down to a minimum, and, as shown by the fact that the percentage of deaths was high, protection was complete in all cases where used, casualties being due to unpreparedness in some form. The attack in question was brought on under difficult conditions for the defenders, as it was made on new troops during a relief when twice as many men were in the trenches as normally. Furthermore, they had to wear helmets while carrying their complete outfit for the relief. This was the second time the Germans caught us in a relief, whether through information or luck we cannot say.

The protection that had been devised against phosgene proved effective at the time, but provision was made to meet increased concentration of phosgene. We never had any actual evidence during the attack that phosgene was being used, as no samples were actually taken from the cloud, but cylinders of phosgene were captured later. Glass vacuum tubes, about 10 by 30 cm., with a tip that could be broken off and then closed by a plasticine-lined glass cap, were distributed, but the only one that came back was an unopened tube found in a hedge, and marked by the finder "Dangerous; may contain cholera germs." In a gas attack everybody keeps quiet or else has a job on hand, and conditions are not conducive to the taking of gas samples. The original types of vacuum tube were smaller than those now used.

There was a long search for materials that would absorb phosgene, as there are few substances that react readily with it. The successful suggestion came from Russia. The substance now used very extensively by all is hexamethylenetetramine (urotropine), $(CH_2)_6N_4$, which reacts very rapidly with phosgene. Used in conjunction with sodium phenate, it will protect against phosgene at a concentration of 1 : 1000 for a considerable period. An excess of sodium hydroxide is used with the sodium phenate, and a valve is provided in the helmet for the escape of exhaled air. The valve was originally devised so that the hydroxide would not be too rapidly carbonated, but it was found in addition that there is a great difference in ease of breathing and comfort if a valve is placed in the mask. The helmet is put on over the head, grasped with left hand around the neck and tucked into the jacket. This form is still used in reserve.

By this time gas shells were beginning to be used in large numbers, and it became evident that protection by a fabric could not be depended on with certainty. The box type of respirator was the next development. Respirators have to fulfil two requirements which are quite opposed to one another. In the first place they should be sufficiently large and elaborate to give full protection against any concentration of any gas, whereas military exigency requires that they be light and comfortable. It is necessary to strike a balance between these two. Upon a proper balance depends the usefulness of the respirator. Oxygen apparatus will not do on account of its weight and its limited life. Two hours' life is excessive for that type. The side that can first force the other to use oxygen respirators for protection has probably won the war.

The concentrations of gas usually met with are really very low. As has been said, a high concentration for a gas cloud is 1 part in 1000, whereas concentrations of 2 or 3 per cent can be met by respirators depending on chemical reactivity. One such respirator is a box of chemicals connected by a flexible tube with a face-piece fitting around the contours of the face, and provided with a mouthpiece and nosepiece.

As regards the chemicals used there is no secret, for the Germans have many of the same things. Active absorbent charcoal is one of the main reliances, and is another suggestion that we owe to the Russians. Wood charcoal was used in one of their devices and was effective, but most of the Russian soldiers had no protection at all.

We wanted to protect against chlorine, acids and acid-forming gases, phosgene, etc., and at one time were fearful of meeting large quantities of hydrocyanic (prussic) acid (HCN). At one period every prisoner taken talked about the use of prussic acid, saying that the Kaiser had decided to end the war and had given permission to use prussic acid. Protection was evidently needed against it. The three things that then seemed most important were: (1) chlorine and phosgene; (2) prussic acid; (3) lachrymators. Charcoal and alkaline permanganate will protect against nearly everything used, even up to concentrations of 10 per cent for short periods.

The German apparatus, developed about the same time, is of different pattern, and is still employed. It consists of a small drum, attached directly to the front of the face-piece, and weighs less than the British respirator but must be changed more frequently. It has no mouthpiece. The chemicals are in three layers: first, an inside layer of pumice with hexamethylenetetramine; in the middle, a layer of charcoal (sometimes blood charcoal); and outside, baked earth soaked in potassium carbonate solution and coated with fine powdered charcoal.

As regards the future of the gas cloud, it may be looked upon as almost finished. There are so many conditions that have to be fulfilled in connection with it that its use is limited. It is very unlikely that the enemy will be able to spring another complete surprise with a gas cloud.

The case is different with gas shells. The gas shells are the most important of all methods of using gas on the Western Front, and are still in course of development. The enemy started using them soon after the first cloud attack. He began with the celebrated "tear" shells. A concentration of one part in a million of some of these lachrymators makes the eyes water severely. The original tear shells contained almost pure xylyl bromide or benzyl bromide, made by brominating the higher fractions of coal-tar distillates.

The German did his bromination rather badly. As you know, it should be done very carefully or much dibromide is produced, which is solid and inactive. Some of the shells contained as much as 20 per cent dibromide, enough to make the liquid pasty and inactive. The shells used contain a lead lining, and have a partition across the shoulder, above which comes the T. N. T. and the fuse. These shells had little effect on the British, but one attack on the French, accompanied by a very heavy bombardment with tear shells, put them out badly. The eyes of the men were affected, and many of the men were even anesthetized by the gas, and were taken prisoner.

Our first big experience was an attack at Vermelles. The Germans put down a heavy barrage of these shells and made an infantry attack. The concentration was great, the gas went through the helmets, and the men even vomited inside their helmets. But it is difficult to put down a gas barrage, and there is danger that it will not be a technical success. In the instance cited certain roads were not cut off sufficiently, so that reinforcements got up. This attack, however, opened our eyes to the fact that, as in the case of gas clouds, concentration would be developed so as to make it high enough to produce the required effect under any circumstances.

When the Germans started using highly poisonous shells, which was at the Somme in 1916, they did not attend to this sufficiently, although enormous numbers of shell were used. The substance used was trichloromethyl-chloroformate, but not in great strength. It had no decided reaction on the eyes, hence the men were often caught.

The quantity of gas that can be sent over in shells is small. The average weight in a shell is not more than 6 pounds, whereas the German gas cylinders contain 40 pounds of gas. To put over the same amount of gas as with gas clouds, say in five minutes per thousand yards of front, would require a prohibitive number of guns and shells. It becomes necessary to put the shells on definite targets, and this, fortunately, the Germans did not realize at the Somme, although they have found it out since.

The use of gas out of a projectile has a number of advantages over its use in a gas cloud. First, it is not so dependent on the wind. Again, the gunners have their ordinary job of shelling, and there is no such elaborate and unwelcome organization to put into the front trenches as is necessary for the cloud. Third, the targets are picked with all the accuracy of artillery fire. Fourth, the gas shells succeed with targets that are not accessible to high explosives or to gas clouds. Take, for instance, a field howitzer dug into a pit with a certain amount of overhead cover for the men, who come in from behind the gun. The men are safe from splinters, and only a direct hit will put the gun out of action. But the gas will go in where the shell would not. It is certain to gas some of the men inside the emplacement. The crew of the gun must go on firing with gas masks on, and with depleted numbers. Thus it nearly puts the gun out of commission, reducing the number of shots say from two rounds a minute to a round in two minutes, and may even silence it entirely. Another example is a position on a hillside with dugouts at the back, just over the crest, or with a sunken road behind the slope. Almost absolute protection is afforded by the dugouts. The French tried three times to take such a position after preparation with high explosives, and each assault failed. Then they tried gas shells, and succeeded. The gas flows rapidly into such a dugout, especially if it has two or more doors.

Among the effective materials used by the Germans for gas shells were mono- and trichloromethyl-chloroformate. Prussic acid never appeared; the Germans rate it lower than phosgene in toxicity, and the reports concerning it were obviously meant merely to produce fear and distract the provisions for protection.

During the last five months the actual materials and the tactics used by the Germans have undergone a complete change. The lachrymator shells are less depended upon than formerly for "neutralization," but are still a source of annoyance. Mere annoyance, however, may be an effective method of neutralizing infantry. For instance, where large amounts of supplies and ammunition are being brought up there are always cross-roads where there is confusion and interference of traffic. A few gas shells placed there make every man put on his mask, and if it is a dark night and the roads are muddy the resulting confusion can be only faintly imagined. It may thus be possible to neutralize a part of the infantry by cutting down their supplies and ammunition.

The use of a gas shell to force a man to put on his mask is practically neutralization. If at the same time you can hurt him, so much the better. Hence the change in gas-shell tactics, which consists in replacing the purely lachrymatory substance by one that is also poisonous.

One substance used for this method of simultaneously harrassing and seriously injuring was dichloro diethylsulfide (mustard gas). Its use was begun in July of last year at Ypres, and it was largely used again at Nieuport and Armentières. A heavy bombardment of mustard-gas shells of all calibers was put on these towns, as many as 50,000 shells being fired in one night. The effects of mustard gas are those of a "super-lachrymator." It has a distinctive smell, rather like garlic than mustard. It has no immediate effect on the eyes, beyond a slight irritation. After several hours the eyes begin to swell and inflame and practically blister, causing intense pain, the nose discharges freely, and severe coughing and even vomiting ensue. Direct contact with the spray causes severe blistering of the skin, and the concentrated vapor penetrates through the clothing. The respirators of course do not protect against this blistering. The cases that went to the hospitals, however, were generally eye or lung cases, and blistering alone took back very few men. Many casualties were caused by the habit that some of the men had fallen into of letting the upper part of the mask hang down so as not to interfere with seeing. The Germans scored heavily in the use of this gas at first. It was another example of the element of surprise in using a new substance that produces new and unusual symptoms in the victims.

Up to the present time there has been no material brought out on either side that can be depended on to go through the other fellow's respirator. The casualties are due to surprise or to lack of training in the use of masks. The mask must be put on and adjusted within six seconds, which requires a considerable amount of preliminary training, if it is to be done under field conditions.

Among other surprises on the part of the Germans were phenylcarbylamine chloride, a lachrymator, and diphenylchloroarsine, or "sneezing gas." The latter is mixed in with high explosive shells or with other gas shells, or with shrapnel. It was intended to make a man sneeze so badly that when he puts on his mask he is not able to keep it on. The sneezing gas has, however, not been a very great success.

All bombardments now are of this mixed character. The shells used are marked with differently colored crosses, and definite programs are laid down for the use of the artillerymen.

As regards the future of gas shells, it should be emphasized that the "gas shell" is not necessarily a gas shell at all, but a liquid or solid shell, and it opens up the whole sphere of organic chemistry to be drawn upon for materials. The material placed inside the shell is transformed into vapor or fine droplets by the explosion and a proper adjustment between the bursting charge and the poisonous substance is necessary. Both sides are busy trying to find something that the others have not used, and both are trying to find a "colorless, odorless, and invisible" gas that is highly poisonous. It is within the realm of possibilities that the war will be finished, literally, in the chemical laboratory.

The Germans have not altered their type of respirator for some time, and it is not now equal in efficiency to the British or American respirator. The German respirator, even in its latest form, will break down at a concentration of 0.3 per cent of certain substances. The German design has given more weight to military exigency, as against perfect protection, than has the British. Another thing that weighs against changes in design is the fact that the German, already handicapped by the lack of certain materials, must manufacture 40,000,000 respirators a year in order to supply his Austrian, Bulgarian, and Turkish allies, as well as his own army.

In the British and American armies the respirator must always be carried with the equipment when within 12 miles of the front. Between 12 and 5 miles a man may remove the respirator box in order to sleep, but within 5 miles he must wear it constantly. Within 2 miles it must be worn constantly in the "alert" position (slung and tied in front). When the alarm is given he must get the respirator on within six seconds. The American respirator is identical with the British. The French have a fabric mask made in several layers, the inner provided with a nickel salt to stop HCN, then a layer with hexamethylenetetramine; it has no valve and is hot to wear. The French also use a box respirator, consisting of a metal box slung on the back, with a tube connecting to the face-mask, the latter is of good Para rubber and is provided with a valve. One disadvantage of this form is the danger of tearing the single rubber sheet. The German mask now contains no rubber except one washer; the elastics consist of springs inside a fabric, and the mask itself

is of leather. It hardens and cracks after being wet, and is too dependent upon being well fitted to the face when made.

(The lecturer exhibited various types of gas shells, helmets, masks, and respirators.)

The following compounds have been used by the Germans in gas clouds or in shells:

1—Allyl-iso-thiocyanate (allyl mustard oil), C_3H_5NCS (shell).
2—Benzyl bromide, $C_6H_5CH_2Br$ (shell).
3—Bromo-acetone, $CH_2Br.CO.CH_3$ (hand grenades).
4—Bromated methyl-ethyl-ketone (bromo-ketone), $CH_2Br.CO.C_2H_5$ or $CH_3.CO.CHBr.CH_3$ (shell). Dibromo-ketone, $CH_3.CO.CHBr.CH_2Br$ (shell).
5—Bromine, Br_2 (hand grenades)
6—Chloro-acetone, $CH_2Cl.CO.CH_3$ (hand grenades).
7—Chlorine, Cl_2 (cloud).
8—Chloromethyl-chloroformate (palite), $ClCOOCH_2Cl$ (shell).
9—Nitro-trichloro-methane (chloropicrin or nitrochloroform), CCl_3NO_2 (shell).
10—Chlorosulfonic acid, $SO_3.H.Cl$ (hand grenades and "smoke pots").
11—Dichloro-diethylsulfide (mustard gas), $(CH_2ClCH_2)_2S$ (shell).
12—Dimethyl sulfate, $(CH_3)_2SO_4$ (hand grenades).
13—Diphenyl-chloro-arsine, $(C_6H_5)_2AsCl$ (shell).
14—Dichloromethyl ether, $(CH_2Cl)_2O$ (shell).
15—Methyl-chlorosulfonate, CH_3ClSO_3 (hand grenades).
16—Phenyl-carbylamine chloride, $C_6H_5NCCl_2$ (shell).
17—Phosgene (carbonyl chloride), $COCl_2$ (cloud and shell).
18—Sulfur trioxide, SO_3 (hand grenades and shell).
19—Trichloromethyl-chloroformate (diphosgene, superpalite), $ClCOOCCl_3$ (shell).
20—Xylyl bromide (tolyl bromide), $CH_3C_6H_4CH_2Br$ (shell).

THE CONSUMPTION AND COST OF ECONOMIC POISONS IN CALIFORNIA IN 1916[1]

By George P. Gray

Intimately associated with the production and storage of both animal and vegetable foods is the problem of the control of insects, plant diseases, and rodents, the importance of which is scarcely realized except by those directly concerned. A recent proclamation of the President, however, has given the matter definite recognition by placing the distribution of arsenical insecticides under authority of the Food Administrator. The quantity and kinds of chemicals used in this way as well as in the control of flies, mosquitoes, etc., in the interest of the public health, is of especial interest at the present time to an audience of chemists.

In view of the prevailing high prices of all economic poisons[2] and the acute shortage of others, it seemed of the highest importance to know as fully as possible the normal consumption in California and to make an estimate of probable increased demands in the future. Steps were therefore taken to collect statistics on consumption, and to ascertain, if possible, whether or not serious shortage of important materials were to be anticipated, and whether conditions could be relieved by the substitution of cheaper materials for more expensive. It also appeared that if the facts were known concerning the normal consumption, the prospective producer of raw materials would have valuable information concerning the advisability of developing new sources of supply.

In the collection of statistics the writer is indebted to Mr. G. H. Hecke, State Commissioner of Horticulture. Through his office, reports were received from 28 county horticultural commissioners, representing 71.67 per cent of the total acreage of fruits in the state, exclusive of grapes. These reports have been compiled and are shown in Table I. It seems reasonable to assume that the consumption of economic poisons is roughly proportional to the acreage of fruits. The figures shown in the last column of Table I are estimated on that basis.

While it is known that there are inaccuracies in the reports submitted, it is believed that the information received from them is of sufficient value to warrant its publication. It will be noticed that many of the materials listed have important uses other than as economic poisons, but so far as possible the amounts represent only that consumed in the control of pests. The commissioners went to unusual pains in segregating the amounts used in that way.

In order that these data may be more intelligible to producers of raw materials, some of the more important items have been reduced to tons of raw materials required for their production, or of the better-known commodities which are quoted in the New York market, and are given in Table II.

COMMENTS

Extended comment will not be made at this time on the situation as a whole, but only such observations as seem justified by the information at hand.

ARSENICALS—It is interesting to note that of the 6000 odd tons of white arsenic normally consumed in the United States, about one-sixtieth was used in California alone in the control of insects. Aside from the use of arsenic in the control of insects, some little interest is now being taken in the possible utility of arsenicals in the control of weeds. During the past year there were used in California about three tons of white arsenic in weed control experiments.

The unusual fluctuation in the price of arsenic during the period of the war has caused no little apprehension concerning the adequacy of the supply of this material. The New York price of white arsenic at one time was five hundred per cent above normal. In January 1918 it was still quoted four hundred per cent above normal. The reason commonly assigned for the high prices of arsenic is that the importations, which usually amount to about 3000 tons annually, have been stopped, thus depleting the stocks on hand and severely taxing the output of domestic producers, which is normally about equal to the imports. It is believed, however, that many times more than the normal consumption of arsenic in the United States can be produced as a by-product from smelter smoke and that the high price of arsenic is artificial. It is sincerely to be hoped that the government control will relieve the situation in respect to this very important economic poison.

COPPER SULFATE—The price of this raw material for the preparation of copper fungicides was for a short time nearly four times normal, but during the past year, it has been slightly less than double. The great demand for copper during the war will hold the price high, although not as high as many other chemicals. Much of it is a by-product in the production of other materials and uses up copper which is not salable in other forms. Sulfur fungicides have been substituted for copper compounds to a large extent, where possible.

SULFUR—Sulfur prices held practically normal until after declaration of war by the United States, but are now about one hundred per cent above normal. Reliable information indicates that this country may face an actual shortage of sulfur. Enormous quantities of pyrites are used in the manufacture of sulfuric acid, much of this being imported from Spain. Importations have now ceased, so that the sulfuric acid plants are obliged to use sulfur or obtain local pyrites. The American producers of sulfur are developing new deposits and it is reported that promising deposits of pyrites are being investigated by the Government so that production may meet consumption

SODIUM CYANIDE—A shortage of sodium cyanide for fumigating citrus trees, and other purposes, occurred during the fumigating

[1] Address before the California Section of the American Chemical Society, San Francisco, January 12, 1918.

[2] The term "economic poisons" was suggested by the writer's associate, Mr. M. R. Miller, as being appropriate in referring to the diversified and yet closely related group of materials used for the control of weeds, insects, fungi, and rodents. The qualifying word "economic" serves to distinguish between poisons which are made to serve useful purposes in the control of pests, and the more popular conception of poisons as being harmful to man, and often used with criminal intent. *Science*, N. S., 44, No. 1185, 264.

TABLE I.—CONSUMPTION AND COST OF ECONOMIC POISONS IN CALIFORNIA IN 1916

MATERIAL	Consumption in 28 counties reporting	Average price to consumer Dollars	Cost in 28 counties reporting Dollars	Totals in 28 counties reporting Dollars	Estimated totals for entire state Dollars
White Arsenic	14,686 lbs.	0.183	2,688		
Paris Green	13,610 lbs.	0.435	5,923		
Lead Arsenate, Paste	633,428 lbs.	0.110	69,677		
Lead Arsenate, Dry	100,067 lbs.	0.225	22,515		
Zinc Arsenite	32,575 lbs.	0.300	9,772		
ARSENICALS				110,575	154,284
Copper Sulfate	729,850 lbs.	0.142	103,639		
Bordeaux Pastes	103,754 lbs.	0.124	12,865		
Bordeaux Powders	37,625 lbs.	0.120	4,515		
COPPER COMPOUNDS				121,019	168,856
Sodium Cyanide	2,119,557 lbs.	0.284	601,954		
Sulfuric Acid	3,682,306 lbs.	0.017	62,599		
CYANIDE AND ACID				664,553	927,240
Sulfur	4,514,103 lbs.	0.037	167,022		
Coml. Lime-sulfur	18,201 bbls.	9.957	181,287		
Sulfur Pastes	160,536 lbs.	0.082	13,164		
Sodium Sulfide	121,023 lbs.	0.080	9,682		
SULFUR AND COMPOUNDS				371,155	517,867
Kerosene	58,448 gals.	0.106	6,254		
Other Petrol. Dist	125,701 gals.	0.065	8,171		
Crude Petroleum	234,620 gals.	0.043	10,840		
Coml. Emulsions	286,400 gals	0.106	30,358		
Miscible Oils	40,400 gals.	0.283	11,433		
Coal-tar "Dips"	11,637 gals.	1.200	13,964		
OILS AND EMULSIONS				81,020	113,046
Fish-Oil Soap, Hard	203,918 lbs.	0.047	9,584		
Fish-Oil Soap, Liquid	59,669 lbs.	0.067	3,998		
Coml Emulsifiers	3,700 gals.	0.400	1,480		
Soap Powders	600,729 lbs.	0.040	14,019		
SOAPS AND EMULSIFIERS				29,081	40,576
Quicklime	5,454 bbls.	2.100	11,453		
Hydrated Lime	337,202 lbs.	0.011	3,709		
Caustic Soda and Lye	508,169 lbs.	0.070	35,572		
LIME AND CAUSTICS				50,734	70,788
Tobacco Leaves	55,175 lbs.	0.036	1,986		
Tobacco Extracts	60,224 lbs.	1.033	62,211		
TOBACCO AND EXTRACTS				64,197	89,573
Strychnine	16,979 ozs.	1.102	18,711	18,711	26,107
Formaldehyde	9,065 gals.	2.091	18,955	18,955	26,448
Carbon Bisulfide	56,741 gals.	1.603	90,956	90,956	126,909
Pyrethrum	7,724 lbs.	0.971	6,400	6,400	8,930
Quassia	103 lbs.	0.220	23	23	32
Hellebore	666 lbs.	0.404	269	269	375
Iron Sulfate	75,527 lbs.	0.056	4,230	4,230	5,902
Corrosive Sublimate	1,951 lbs.	1.824	3,559	3,559	4,966
Cost of Standard Remedies				1,635,437	2,281,899
Cost of Proprietary Preparations				133,856	186,767
TOTAL				$1,769,293	$2,468,666

season of 1916. There was an ample supply during the past season, owing to the output of new plants which started operations.

CARBON BISULFIDE—Carbon bisulfide is rather a novelty in the chemical line, as its price has been scarcely affected by the war. It was quoted in New York at 6½ cents in January 1914 and at 7½ cents in January 1918, this being scarcely more than the normal fluctuation. This fact is especially gratifying in view of the fact that this is the most important fumigant for use in the control of insects infesting stored grain, beans, and many other products. It is also the most approved material for the winter control of ground squirrels.

TABLE II.—RAW MATERIALS REQUIRED FOR THE PREPARATION OF SOME OF THE MORE IMPORTANT ECONOMIC POISONS CONSUMED IN CALIFORNIA DURING THE YEAR 1916

White Arsenic	105 tons
Blue Vitriol	558 tons
Litharge	187 tons
Zinc	11 tons
Acetic Acid	1 ton
Sodium Cyanide	1,479 tons
Sulfuric Acid (66° Baumé)	2,569 tons
Sulfur	1,988 tons
Crude Petroleum and Distillates	934,000 gals.
Coal-tar Creosote	12,000 gals.
Soaps (chiefly fish oil and soap powders)	777 tons
Cresol	9 tons

RODENT POISONS—Strychnine is now selling about two hundred per cent above normal. Saccharine, used as a "camouflage" in strychnine-coated barley to mask the intensely bitter taste of the strychnine, is now being quoted at over $50 per lb. and at times is very difficult to obtain at any price. Some other equally effective, but cheaper "camouflage" is much needed for use in preparing squirrel and gopher poisons.

INCREASED CONSUMPTION—The commissioners were asked to give an estimate of any probable increase or decrease in the demand for economic poisons in the future. Not enough of the commissioners, however, were willing to venture an estimate for one to foresee the future in this respect. The agriculturist has so many problems staring him in the face for solution—labor high price of supplies, marketing, etc.—that he, himself, is scarcely able to predict whether or not his efforts at pest control will have to be relaxed, as we go deeper and deeper into the war, or whether this vital factor in the production of most foodstuffs can be given even greater attention than in the past.

It is quite certain that the consumption of rodent poisons, strychnine, saccharine, and carbon bisulfide, will be enormously increased in California during 1918. In the interest of the public health and in the conservation of the agricultural resources of the state, all federal, state, and county organizations concerned are making a united and special effort in a state-wide campaign against the ground squirrel.

It seems quite unlikely that the consumption of the other economic poisons will be less in the future than in the past. In fact, there are many reasons for anticipating a greater demand: the coming into bearing of new acreages of fruit; more extensive inter-cropping; higher prices for farm products, especially, wheat, beans, etc., which heretofore had been so low as to discourage, in a large measure, the control of pests. Control measures will now in many cases be profitable which ordinarily are unprofitable. Let us hope that the prices of the economic poisons will not be artificially inflated, and that the agriculturist will not be unduly exploited by the "profiteer."

INSECTICIDE AND FUNGICIDE LABORATORY
AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF CALIFORNIA, BERKELEY

THE DEBT OF PREVENTIVE MEDICINE TO CHEMISTRY[1]

By George W. Goler

In attempting to discuss this subject, I feel very much in the position of the college president who, when addressing his students on the difficulty of acquiring knowledge and the ease of forgetting facts, said, "I once studied chemistry and I perhaps had a fair student's knowledge of that useful branch of science, but while my course in chemistry enabled me better to understand some of the commoner things in the world about me, the only chemical fact that I now recall is, that the chemical formula for water is HO_2."

Chemistry has done so much for preventive medicine, that just to indicate the debt that the latter science, preventive medicine, owes to the former, chemistry, would take all the time you ought to spare for the purpose, and the facts presented would be more clearly and succinctly stated in various articles to be found both in books of reference and in the technical journals. I have therefore thought that it might be useful briefly to review the part chemistry has played in the promotion of health and the prevention of some of the commoner diseases. And when I speak upon this subject, it is as one whose early acquaintance with chemistry dates from the lectures of Chandler of New York, more than 30 years ago, and a few years later those of Witthaus, whose talks of two hours with five minutes intermission served, with small laboratory training, to make of me all the chemist that I am. So, with this training, permit me to tell you of part of the debt which medicine owes to chemistry.

Out of the mystery which the Greek alchemists sought for in the four elements and out of their failure to find the "philosopher's stone" and to transmute the baser metals into gold, came the rise of a new group of men, the iatro chemists, chief among them the 15th century chemists, Basil Valentine, and his later prototype, Paracelsus, half charlatan, half scientist. These and their followers, unfortunately, agreed that the true use of chemistry is not to make gold but to prepare medicine. This step led men insensibly away from the early teaching of the Greek physicians concerning baths, diet, regimen, and all the things that really obtain for the promotion of health and the prevention of disease. The simple rules of the Greeks whereby, in pneumonia for instance, they bathed and annointed the patient, washed out his mouth and cared for his teeth, laid him on a soft bed under the trees and prayed to the gods, were displaced by the unfortunate teaching of Valentine, Paracelsus and others, who rather sought for a mysterious something in chemistry that should cure disease. We have, therefore, to thank the chemists for the drug instead of the hygienic treatment of disease. Of course the chemists of the iatro-chemical school, as they were called, failed in their treatment; first, because no drug or drugs then known could materially affect disease, and second, because the causes of disease were unknown. The early chemist, having failed in this respect, even tried to devise methods of disinfection that he might fight the foul smells of disease with a substance that smelled as bad as or worse than some of the horrid diseases that prevailed in the period we are considering.

But we owe so much to the chemist for what he has done, that we ought not to blame him because his chemicals failed. The doctor without the chemists has been responsible for quite as many failures; for is it not the doctor who evolved the humoral theory of disease for which the four humors, bile, black bile, blood and phlegm gave rise to the bilious, sanguine, choleric and melancholic temperaments? And these humors rose, clouded the brain, became crossed in 80,000 different ways; and if you wanted to prescribe for the patient, the only thing you had to do, beside finding the remedy, was to find in which of the 80,000 ways the humors were crossed. Of course, if the doctor didn't find out, he either gave a small handful of calomel, or better still, and much more dramatic, he bled the patient. Half a pint, a pint or a quart was not an uncommon bleeding. And if he didn't get enough blood out by opening a vein, he opened an artery. And if the humor still persisted, he inserted a pump, that is, if the patient still lived. Tradition and authority descended from Valentine, Paracelsus and Galen are largely responsible for the introduction of drug methods of treating disease.

While these are interesting examples of speculation and conjecture in medicine and chemistry, there was no less of guesswork in much of the chemistry and medicine of even 50 years ago. From the early workers in both branches of science, we have the development of the miasmatic theory of disease, formulated by Pettinkofer, who was the first real health officer of Berlin 50 years ago. While Pettinkofer is to be credited with much good chemical work, it was he who devised the theory that ground water and ground air were the causes of such disorders as typhoid fever. He and his workers did much to keep alive the sewer gas theory in its relation to infections, and it was his work which probably prevented the earlier recognition of malaria as a mosquito-borne disease and not a *malaria*, and typhoid as a water and food rather than a sewer-gas-borne disease.

Now while the early laboratory workers were obsessed by the teachings of the fathers of chemistry and medicine, there were a few brave men of independent thought who applied themselves to new and original methods of research in an endeavor to discover the elusive things of the air which they believed caused disease. They, like Spallanzani (1776), successfully overthrew the general accepted theory of spontaneous generation of microorganisms, by showing that if putrescible fluids were heated to a sufficiently high temperature they remained unchanged for indefinite periods. And, while discussing the manner in which air was admitted to the flasks in which the fluids were kept, occupied various chemical observers for years, it was not until three-quarters of a century later that Schroeder (1854) showed that a loose plug of cotton wool in the mouth of a flask containing boiled putrescible fluid excluded the organisms of the air and prevented fermentation in the fluid. But not all fluids kept in such protected flasks remained unfermented, for occasionally the contents of such a flask would spoil. It was the genius of Pasteur that explained the phenomena, as he made clear other similar, inexplicable things.

Pasteur, in 1865, showed that certain organisms and dormant stages or spores that resisted one or more boilings, and that the repeated application of heat was required to destroy these bodies and prevent the fluids containing them from fermenting. Here, by chemists, were two great contributions, not only to preventive medicine but to all medicine and surgery, the cotton air-filter and sterilization by heat.

The next great discovery by a chemist, probably the one great discovery that has made it possible for medicine to make the advances it has made in the last quarter of a century, was the discovery of aniline by the German chemist Runge in 1854, and five years later (1859), the discovery of the first aniline dye, mauve, by the English chemist, Perkin. Then in rapid succession came a number of other aniline colors.

For many years all the scientific workers in cellular physiology and pathology had sought new methods for bringing more clearly into view the secrets believed to be held within and around the cell. For this purpose various chemicals and dyestuffs, both those derived from logwood, iodine, cochineal and other substances have been used, but it was not until the coal tars yielded their dyes that the mysteries of many bacterial cells were revealed.

Between 1850 and 1863, Davaine, a distinguished French physician, had been working on the cause of anthrax, a virulent and fatal disease of wool sorters. As early as 1850 Davaine had seen the anthrax organism, but it was not until 1863, 13 years later, that he was able to prove the exact relationship between the an-

[1] Address before the Rochester Section of the American Chemical Society, December 19, 1917.

thrax bacillus and anthrax. Then, in 1873, Obermeier discovered in the blood of patients suffering from a relapsing fever an organism which proved to be the cause of the fever. These two workers then laid the foundation for the germ theory of disease, the first stone of which had been cut by that "skeptical chemist," Boyle, more than 200 years before, when he said, "The problem of infectious disease will be solved by him who discovers the nature of putrefaction."

Then, in 1877, came Weigert, who showed that many organisms otherwise translucent might be stained by aniline dyes. So, following closely upon the heels of the discovery of these dyes by the chemists, came their application to the revelation of new forms of bacteria by staining them.

About this time Koch showed, by the use of solid culture media and the plate method, a way of obtaining bacteria in pure cultures. Still further advances in the domain of preventive medicine were thus made possible and the demonstration of the bacterial cause of infectious disease further extended. Thus, by methods of staining and plate culture, and pure culture work, and the development of other modes of bacterial research numerous discoveries in preventive medicine were made possible, among them the following:

Neisser in 1879 showed the gonococcus within the cells of gonorrheal pus. In 1880 Eberth and Koch, and in 1884 Gaffky, discovered the bacillus of typhoid fever, first by seeing them as unstained organisms and later by viewing them as stained bodies under the microscope. While in 1865 Villemin, and later Conheim in 1877, showed that tuberculosis might be transmitted to healthy animals by the inoculation of tuberculous material, it remained for Koch, in March 1882, to demonstrate by stained specimens of the tubercle bacillus its presence in the sputum and tissues of tuberculous animals and man. While the glanders bacillus discovered by Loeffler and Stats (1882) and the spirillum of Asiatic cholera discovered by Koch in 1884 were first viewed without stains, their further study and the development of methods of diagnosis and immunization were the results of the combined methods of chemical and bacteriological research.

In 1884 Pasteur discovered the present known method of treatment for rabies, a disease that had previously caused a mortality of 100 per cent, and reduced the mortality to a fraction of 1 per cent in those bitten by dogs known to be rabid.

Of world-wide interest was and is the discovery of the bacillus of diphtheria by Klebs and Loeffler in 1884. From 1659, when in New England there was first described an epidemic of diphtheria, known as "bladders in the windpipe," diphtheria had exacted an annual toll of thousands of deaths and hundreds of heart, kidney and blood vessel diseases as its late, remote consequences. So when Loeffler announced that by using staining methods he had discovered the bacillus which is the cause of diphtheria, the scientific world almost paused for breath, and then resumed its labors with renewed hope for the conquest of this most dread disease of childhood.

The writer remembers attending a reception at Washington, given in the splendid Hall of The American Republics, to the foreign and American delegates at the International Congress of Hygiene and Demography in 1912. In the receiving line, next to the venerable Dr. Samuel P. Wolcott, stood the commanding figure of Koch and next beyond him the slight, boyish Loeffler. As I went down the receiving line accompanied by Dr. McKay of Saskatoon, B. C., and shook the distinguished guests by the hand, McKay, a highly patriotic Canadian, turned at the end of the line and said, speaking of Loeffler, "I'd rather shake hands with him than with my Sovereign."

Shortly after Loeffler found the diphtheria bacillus, two French investigators, Roux and Yersin, discovered by chemical methods the diphtheria toxin. They and others having paved the way, Von Behring in 1893 succeeded in preparing diphtheria antitoxin. Time does not permit me to relate what has been accomplished in preventive medicine by the methods of O'Dwyer for intubation, combined with the administration of diphtheria antitoxin in laryngeal diphtheria. Suffice it to relate that in our city of Rochester the deaths from diphtheria have fallen from 189 per thousand in the year before diphtheria antitoxin was introduced, to less than 9 per thousand in 1915. In 1884 Nicola, a German, and Kitasato, a Japanese, simultaneously discovered the bacillus of tetanus or lockjaw. This disease had been known since man began to record his observations in writing. It accompanied wounds in war as noted by Larrey, Napoleon's chief surgeon. It is to-day one of the most feared complications of wounds, not only in the army and navy, but in civil life as well. Its dangers have been very greatly diminished by the preparation and introduction of tetanus antitoxin, both for immunization and treatment. The bacillus of epidemic influenza was discovered by Pfeiffer of Berlin in 1892, the bacillus of plague by Yersin in 1893. By various complex physiochemical procedures, first Neisser and later others, including Bordet and Gengou, succeeded in showing that when an antigen, *i. e.*, bacteria, blood cells and body cells, meets in the body of a treated animal a receptor with which it unites certain reactions are produced, known as fixation of the complement. With this work as a basis of procedure, the long search for ultramicroscopic or faintly staining organisms was prosecuted with vigor. Then, too, the developing science of serology, founded upon physiochemical reactions of great delicacy, helped to advance the new work in preventive medicine. The field of research in syphilis offered wide opportunity. In 1903 Metchnikoff and Roux demonstrated the inoculability of syphilis from man to apes, and in 1905 Schaudin showed by biochemical methods the presence in the sera of inoculated animals of a faintly staining spiral, the cause of syphilis, the *spirochita pallada*. In 1906, Wasserman, applying the serum complement reaction of Bordet-Gengou, discovered the test for syphilis known as the Wasserman test. Four years later, in 1911, Noguchi, a Japanese at the Rockefeller Institute, succeeded in cultivating the spirillum of syphilis in pure culture, demonstrating it both by staining methods and by powerfully transmitted light; he also discovered a valuable test, the Luetin test for obscure cases of syphilis. Almost simultaneously Erlich in Germany by a masterly series of chemical experiments, using the work of Ehenhuth, succeeded in introducing arsenic within the benzol ring and gave to us a compound, salvarsan or 606, for the treatment of syphilis.

Little more than a year later Bordet and Gengou made another remarkable discovery. While ten years before they had announced the discovery of the bacillus of whooping-cough, it was not until 1912 that their work was confirmed by other observers. To them we owe not only the discovery of the bacillus of whooping-cough, but the ability to produce a vaccine for the successful prevention of that most dangerous disease of childhood.

In this résumé I must not neglect to mention the discovery of the organism of epidemic cerebrospinal meningitis and the development of a serum for its successful treatment; also the discovery of the organism of infantile paralysis: all done at the Rockefeller Institute by Flexner. Nor must we forget that most remarkable discovery of Henry Plotz, a young physician in Mt. Sinai Hospital, of the bacillus of typhus. Though much remains to be accomplished by the combined methods of work of the chemist and biologist, we may readily see that much has already been done. The secrets of measles and scarlet fever and cancer still remain secrets. They are as hidden as the cause of the common cold.

The length of this paper forbids me to speak of many other debts which medicine owes to chemistry, but I must refer to the work of Carrell and Dakin, who have devised methods for both the prevention and the treatment of disease by disinfecting the nose, nasopharynx and mouth so that those who are carriers of such diseases as infectious meningitis may be rendered less dangerous as contacts, and the same workers have succeeded in

perfecting a method which promises much for the antiseptic treatment of deep, contused and dirty wounds.

Chemical methods are responsible for the clearing up of much that is obscure in that class of diseases of the kidney usually known as Bright's disease. In the treatment of that super-devil of nutritional disturbances, diabetes, the chemistry of nutrition has taught us practically all we know. To chemistry we are indebted for chloroform, quinine, ether and cocaine, and for the methods of water, milk and food analysis, and to the chemist we largely owe the newer methods of sewage purification. For all these we thank you, and we trust that the professions united may labor still further for the betterment of the race.

HEALTH BUREAU
ROCHESTER, NEW YORK

WILLIAM H. NICHOLS MEDAL AWARD

INTRODUCTORY ADDRESS

By CHARLES H. HERTY

It is a striking fact that in the midst of feverish war preparations, while our minds are filled with death-dealing chemical reactions, we are met together this evening to pay tribute to a quiet worker in the university laboratory, who with infinite patience and consummate skill has accomplished brilliant results in an extremely complex and difficult field of chemical research, that dealing with the fundamental processes of life. I take it as a healthy sign and one presaging great good to chemistry in America that in these days of intense application of science to industrial processes the worker in pure chemistry has been chosen as the recipient of the Nichols Medal.

Under the terms stipulated by its donor, Dr. William H. Nichols, whom happily we have with us to-night in the capacity of leader of the organized chemists of this country, this medal is awarded annually by our Section to the author of the best original article published during the preceding year in the journals of the AMERICAN CHEMICAL SOCIETY. In reaching its decision the Committee has construed broadly the conditions of award, realizing fully that in certain lines of research results cannot be withheld indefinitely in order to present in one contribution a comprehensive report of an entire investigation. Such action might lead to loss of priority, and would undoubtedly diminish that stimulative effect which follows the publication of definite chapters in the progress of investigation which in its very nature must require years for completion. On the basis of such broader interpretation of the terms of award, the Committee has this year unanimously awarded the medal to Dr. Treat B. Johnson, Professor of Organic Chemistry in the Sheffield Scientific School of Yale University. During the past year Dr. Johnson contributed four articles to the *Journal of the American Chemical Society*. A fair measure of his activity can be gained from the fact that these four constitute the continuation of a series of one hundred and fifty-four contributions on which his name has appeared as author.

Through this multitudinous array of original communications Dr. Johnson has shown his courage and ability in bringing light into one of the darkest and yet most important fields of chemistry. In reading the advanced copy of his address, and noting the brilliant progress he has made through calling the element sulfur to his aid, I am almost forced to describe his activity as devilish. Beginning in 1898, the output of papers from his laboratory has been continuous—two decades of accomplishment to which we all join in paying heartiest tribute. While his name is almost intimately associated with the chemistry of pyrimidine compounds, he has included within the scope of his fertile investigative spirit the subjects of the hydantoins, furfurans, the thiocyanates, hippuric acid, the phthalimides, acetamide, pyrrole compounds, thiopolypeptides, thioamides, the higher phenols, the purines, sarcosine, divicine, vitiatine, etc.

We are interested to-night, however, not only in the scientific achievements but in the personality of the man whom it is our privilege to honor. Like so many other great Americans, he was born "down on the farm," near Bethany, Conn., on March 29, 1875. In 1898 he graduated from the Sheffield Scientific School with the degree of Ph.B., and three years later received his doctorate from Yale University, having specialized in organic chemistry. A laboratory assistant during his post-graduate course, Dr. Johnson was in 1902 appointed instructor in chemistry in the Sheffield Scientific School. In 1909 he was promoted to an assistant professorship, and in 1914 was advanced to professor of organic chemistry.

In addition to his work as an investigator, his sterling traits as a teacher have impressed themselves upon many of the younger men now active in chemical work. Through his force of character he has proved himself an excellent organizer and executive. His interests have not been confined solely within university walls. He has taken frequent opportunity to visit chemical plants, and in many has coöperated with their staffs. In one particular case his suggestions proved so valuable that he was urged to leave university work at a decided increase in salary, but declined.

Upon inquiry I learned that his principal recreation is work, that between the writing of his papers he finds time to drive his auto, which in itself sometimes means work, takes delight in "canned" music, as any other human being would, and gets constant inspiration and refreshment from trips back to the farm. To those of us who have had the pleasure of associating with him at the meetings of the AMERICAN CHEMICAL SOCIETY it is needless to emphasize his genial temperament and charming personality.

In this incomplete manner I have tried to picture to you something of the personality and activities of Dr. Johnson, and it now becomes my pleasant duty to present to you Dr. William H. Nichols, president of the AMERICAN CHEMICAL SOCIETY, who in his life has taken part in many presentations, and who I am sure will sanction the statement that in no similar occasion has he taken greater pleasure than in this.

NEW YORK CITY

PRESENTATION ADDRESS

By WILLIAM H. NICHOLS

It is true, as the Chairman remarked, that I have taken part in many presentations, but it is interesting to me that on such occasions I have never acted as the recipient. My situation on such occasions is best described by paraphrasing a familiar expression and saying, "It is easier to give than to receive."

As to the Nichols Medal, I must say that this was in no wise an original idea with me, but was suggested by a group of friends interested in the New York Section of the AMERICAN CHEMICAL SOCIETY. Fortunately I was able to dissuade them from carrying out their original intention of placing my features upon the medal, but they insisted on giving it its present name, though I feel, and always have felt, that it should be called the New York Section Medal.

Before presenting the medal to Dr. Johnson may I be pardoned a few words concerning the work to which I have been called by the members of the AMERICAN CHEMICAL SOCIETY? This is the first time since my election to office as president that I have had opportunity to meet with any large group of its members, and I desire to express here the feeling of astonishment at the great growth of this organization. When I think

of its earliest days, and of the association at that time with my friend Dr. Charles F. Chandler, we two being the only surviving charter members, it seems like a romance that its membership now should exceed 11,000; and I have been informed tonight by the secretary of the New York Section that within the past two years this Section, at that time the largest Section of the Society, had increased in membership fifty per cent. What a striking commentary is furnished by these figures on the increased appreciation of chemistry in this country!

In looking around for the duties I might have to perform I have been amazed at the remarkable piece of organization machinery which my predecessors have constructed. So admirably has this work been done that there seems little left for me to do. While I cannot hope to do much to better the fine record they have already made, nevertheless I pledge myself to every effort to prevent any retrogression.

As to the subject of the evening, I must be frank in saying that I know nothing of pyrimidine chemistry, but am expecting to learn much from Dr. Johnson's address tonight. I have been deeply interested, however, in the account of his career, and in looking over the list of his numerous publications, that which has impressed me most of all has been the fact that in the great majority of his papers his name appears in joint authorship with those of his students. This fact is a clear indication of his magnanimity, of his willingness to share high honor, to give every credit to those associated with him, and to encourage his younger coworkers. I desire to congratulate Professor Johnson on the fine influence he is exerting through this evident close and congenial association with the young men who come under the influence of this great teacher, and it gives me the utmost pleasure to present to him herewith this medal which has been unanimously awarded to him by the Committee.

NEW YORK CITY



TREAT B. JOHNSON, WILLIAM H. NICHOLS MEDALIST, 1918

ACCEPTANCE OF MEDAL

By TREAT B. JOHNSON

MR. CHAIRMAN, LADIES AND GENTLEMEN:

I thank you heartily for this honor the New York Section has conferred upon me.

The reward of a scientific man is not in the money he gets for his services, but more than anything else, in the feeling of satisfaction that comes from the knowledge that he has accomplished something which his colleagues recognize as a valuable contribution to science.

By conferring this honor on me to-night I see such a recognition of the value of my work, and I assure you that I deeply appreciate the honorable distinction. I also desire to express my heartfelt thanks for the kind words the representatives of your Section have spoken.

The credit for the work upon which you have made this award to-night does not belong to me alone. The investigations are the result of the energy of several men who have studied under my direction. I take pleasure at this opportune time in expressing my appreciation of their support and spirit of cooperation.

THE DEVELOPMENT OF PYRIMIDINE CHEMISTRY

MEDAL ADDRESS

By TREAT B. JOHNSON

We are celebrating to-night the one-hundredth anniversary of the discovery of the first pyrimidine compound to be described in the chemical literature.

One hundred and forty-two years ago, in 1776, Scheele made the interesting observation that, if uric acid is treated on a porcelain dish with a few drops of nitric acid, the uric acid dissolves and after drying leaves behind a characteristic, red, amorphous residue. In 1817, or forty-one years after this historical observation, the behavior of uric acid on oxidation was investigated by Brugnatelli.[1] He showed that this naturally occurring substance is destroyed by oxidation with nitric acid and chlorine water and actually succeeded in isolating from the products of reaction a definite oxidation product, which was afterwards proved to be the pyrimidine — *alloxan*.

The following year, in 1818, Brugnatelli's publication was followed by that of the English chemist, Prout,[2] also dealing with the chemistry of uric acid. Prout had repeated the work of Scheele and observed that the product obtained by interaction of uric acid and nitric acid reacts with ammonia, giving an intense red color which is destroyed by acids. This observation led to the development of the well known *murexide test* for uric acid and related purines. Prout believed that he was dealing here with the ammonium salt of a complex acid and found that his deeply colored product interacted with mineral acids with formation of a colorless, crystalline substance. It was afterwards shown that Prout was not dealing with the true nucleus of murex-

[1] *Phil. Mag.*, **52**, 30; *Ann. chim. phys.*, **8**, 201.

[2] *Phil. Trans.*, **1818**, 420.

ide, but actually had in hand the cyclic compound *uramil* or the second pyrimidine compound to be described in the chemical literature.

Later in 1820, Prout[1] showed that the pyrimidine *alloxan* is also formed by the oxidation of murexide. In other words, the first pyrimidine combinations to be recorded in the chemical literature were hexahydro derivatives of pyrimidine, and were revealed to us by the study of reactions which were applied to determine the constitution of the naturally occurring purine—*uric acid*.

Ever since the discovery of these two pyrimidine compounds, purine and pyrimidine chemistry have closely interlocked. The development has been reciprocative and a revelation of chemical facts has been made, which constitutes one of the most interesting and important chapters of organic chemistry. We now know that representatives of both series of compounds function in vital changes taking place in both the plant and animal kingdom, and it is on account of this biochemical connection that the study of the chemistry of cyclic compounds of these two series has received and deserves so much attention.

A careful review of the pyrimidine literature will reveal the fact that, while the development of this field of chemistry has been progressive and the investigations very productive both from a chemical and a biochemical standpoint, there were, however, certain periods of activity which were characterized by the number of original contributions to the literature that were fundamental in character, and which had a directing influence on the later lines of pyrimidine investigation. The number of investigators who made such contributions to chemical literature was not large, but the results of their labors were like sign posts by the roadside. Not only have their deductions proven to be sound, but the way was opened up by their work for later discoveries, which progressively revealed to us our present knowledge of the physiological importance of certain representatives of this interesting series of compounds.

In order to bring to your attention, in the time at my disposal, the most important developments in pyrimidine chemistry, I have subdivided our one hundred years of research activity into the following six periods:

1817–1838	1863–1883	1893–1903
1838–1863	1883–1893	1903–1918

No attempt will be made to review completely the pyrimidine chemistry of any one period, but it is my purpose to present briefly a periodical succession of experimental discoveries, which I believe to be the most important, and to lay emphasis on those that were the most ingenious and original, and consequently contributed the most to the development of our subject.

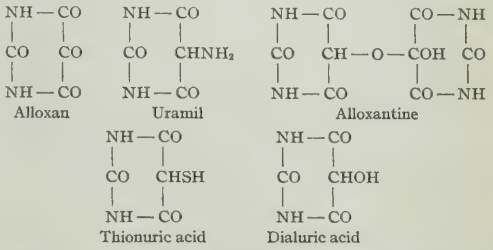
1817–1838

For a period of twenty years after Prout's pioneer work dealing with the action of nitric acid on uric acid, one can search chemical literature in vain for any work that may be considered as an important contribution to pyrimidine chemistry. The state of chemistry at that time was one of transition, and it was not until the beginning of our second period of development, or ten years after Wöhler had given to chemistry his synthesis of urea from ammonium cyanate, that important and successful investigations were carried out, which directed the attention of organic investigators to the chemistry of pyrimidine compounds.

1838–1863

The great achievement of our second period of pyrimidine history was the discovery of chemical reactions, which gave us the first conception of the possible transformations of uric acid. These facts were revealed to us by the joint investigations of Liebig and Wöhler on the nature of this physiologically important acid. Their first paper was published in the *Annalen* in 1838,[2] and was followed by a series of publications on the chemistry of uric acid which have since become classic. When one considers that they were working at a time when organic chemistry—or what now is called organic chemistry—had no existence, it seems marvelous that their experimental work was so well done and that it has survived the test of careful experimental investigation.

Liebig and Wöhler established by their experimental work the important transition changes effected by the oxidation of uric acid under different conditions, and revealed to us the existence of several pyrimidine combinations of biochemical interest, which have since been the subject of very extensive research. Of these compounds may be mentioned, for example, alloxan, uramil, alloxantine, thionuric acid and dialuric acid.



While the structure of these compounds was not established until several years after the activity of Liebig and Wöhler, nevertheless, so clear a picture of the chemical relationship existing between these compounds was revealed by their work that it excited the chief attention of several investigators for many years afterwards.

Schlieper and Gregory, pupils of Liebig and Wöhler, also contributed to the development of this period, and published important papers dealing with the chemistry of alloxantine, hydurilic acid, nitrohydurilic, alliturie and diliturie acids.

1863–1883

The work which stands out most prominently in our third period of pyrimidine development is that of four investigators, namely:

1. Baeyer
2. Medicus
3. Mulder
4. Grimaux

It was Baeyer,[1] a pupil of Schlieper, who continued the work of Liebig and Wöhler on the structure of uric acid, and who first gave us a correct idea of the chemical relationship existing between dialuric acid, alloxan, hydurilic acid, pseudouric acid, alloxantine and uramil. He established the fact that all of these compounds are derivatives of a cyclic amide of malonic acid to which he assigned the name—*barbituric acid*, and showed that they can be made synthetically from this cyclic ureide. The correct constitution was assigned to barbituric acid by Mulder[2] in 1873.

Baeyer prepared his pyrimidine (barbituric acid) by the reduction of its dibrom derivative, which was prepared from Schlieper's violuric acid, and showed that it is easily decomposed by fusion with alkali giving carbon dioxide, ammonia and malonic acid. In other words, Baeyer unraveled by his investigations the whole chemistry of this interesting series of uric acid derivatives, and, by revealing their generic relationship to malonic acid of the aliphatic series, opened the way for new developments which finally led to the preparation of these same combinations by synthetical methods.

Baeyer's work was followed, in 1878, by that of Grimaux,[3] who accomplished the first synthesis of barbituric acid by allowing malonic acid to interact with urea in the presence of phos-

[1] *Annals of Philosophy (London)*, **14**, 363
[2] *Ann.*, **26**, 241.
[1] *Ann.*, **127** (1863), 1, 199; **130**, 129.
[2] *Ber.*, **6** (1873), 1235.
[3] *Compt. rend.*, **87**, 752.

phorus oxychloride. The contribution to literature of this important synthesis, together with the results of Baeyer's investigations, and the appearance of the classic paper by Medicus[1] in 1875, in which he proposed structural formulas for uric acid, xanthine, guanine, theobromine and caffeine, that were afterwards proven to be correct, were the crowning features of a period of activity which will always be conspicuous for its productiveness and originality.

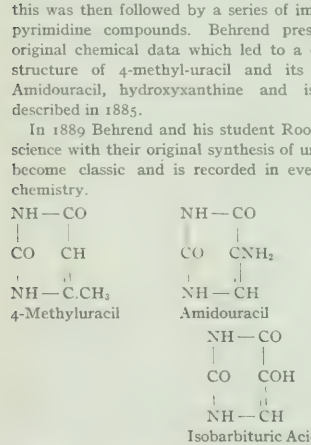
1883–1893

A new chemistry of pyrimidine and its derivatives began to undergo development in the year 1883. The work of Grimaux on barbituric acid, to which I have just referred, and that of Emil Fischer in the field of purine chemistry from 1881 to 1883 not only completely established the importance of the chemistry of cyclic ureides, but also was the beginning of developments in a field of research which gave to us a new chapter of pyrimidine chemistry.

Three investigators, whose interest was excited by the activities of these pioneers in synthetic chemistry, and who foresaw the possibilities of opening up new lines of research by the application of synthetical methods, were Robert Behrend, Adolph Pinner and Ernst von Meyer. Their work stands out as the crowning achievements of our fourth period of pyrimidine history.

Behrend's preliminary paper on the behavior of urea towards ethyl acetoacetate was published in the *Berichte der Deutsche Chemische Gesellschaft*[2] in 1883. An interpretation of the reaction between these reagents was given the following year, and this was then followed by a series of important publications on pyrimidine compounds. Behrend presented in these papers original chemical data which led to a clear recognition of the structure of 4-methyl-uracil and its important derivatives. Amidouracil, hydroxyxanthine and isobarbituric acid were described in 1885.

In 1889 Behrend and his student Roosen[3] were able to enrich science with their original synthesis of uric acid, which has since become classic and is recorded in every textbook of organic chemistry.



Behrend confined his attention in his researches to the study of pyrimidine condensations produced by the interaction of ureas and thioureas with β-ketone esters. Immediately after he had announced his synthesis of 4-methyluracil, Pinner entered this field of investigation and extended the application of Behrend's reaction by showing that amidines also condense with β-ketone esters, in a manner similar to urea, giving pyrimidines. This new reaction was applied successfully by Pinner[4] and his coworkers with a great variety of amidine combinations, thereby opening up a new class of pyrimidine compounds which were characterized by their basic properties. Much attention has been paid to this series since the investigation of Pinner but, so far as the writer is aware, no representative of this class of pyrimidines has been shown to occur in nature, or has found any commercial application.

[1] *Ann.*, **75** (1875), 230.
[2] *Ber.*, **16**, 3027.
[3] *Ann.*, **251**, 235.
[4] *Ber.*, **17** (1884), 2519, **18**, 759, 2845; **20**, 2361.

It was Pinner who first proposed and used the name—*pyrimidine*—to designate the mother substance of this group of cyclic ureides.

E. von Meyer,[1] the third member of our group, enriched science with a new method of entering the pyrimidine series, by applying and correctly interpreting an old reaction which was discovered by Frankland and Kolbe, in Bunsen's laboratory at Marburg in 1848. These earlier investigators had shown that an aliphatic nitrile like ethylcyanide is changed by heating with sodium or potassium into a crystalline substance having basic properties. Baeyer later showed that a similar change can be brought about with methylcyanide.

These unique transformations were thoroughly investigated by von Meyer and shown to be processes of polymerization, whereby the aliphatic nitrile enters first a dimolecular condition. In some cases these simpler polymerized forms were isolated. If, however, the process of heating with sodium is continued a further polymerization can be brought about and the dimolecular nitrile transformed into a pyrimidine compound. This type of change is of special significance because it is the only nucleus-synthetic or polymerization reaction connecting the aliphatic with the pyrimidine series.

Besides the work of the three investigators—Behrend, Pinner and von Meyer—there is one other important contribution that was made in this period, to which I must call attention. I refer to the work of Arthur Michael, the first American investigator to contribute to pyrimidine chemistry. It was Michael who recommended, in 1887, the use of sodium ethylate as a condensing agent, and who was the first one to show that the sodium salts of diethylmalonate and ethylacetoacetate condense with urea, thiourea and guanidine compounds, in the presence of this reagent, to form pyrimidines.[2] The introduction of this reagent opened up an almost unlimited field of investigation which has led to discoveries having far-reaching consequences.

1893–1903

During these earlier periods of activity, which I have hastily reviewed, physiological chemistry had not been concerned with any special pyrimidine compounds, although derivatives of this class of compounds had been given special prominence by the investigations of Behrend who began his synthesis of uric acid with a substance of this class. This condition of affairs prevailed until about the year 1892 when important researches were executed which opened up new paths and founded lines of pyrimidine research which have since proved very fruitful.

The leading spirit in this progress, and the one who was instrumental in promoting this change, was Kossel, whose important investigations dealing with the constitution of nucleic acids were at this time attracting the attention of physiologists and organic chemists throughout the scientific world.

Nucleic acids had been known to chemistry since 1874 when they were discovered by Miescher, but practically nothing was revealed regarding their constitution until Kossel undertook their chemical investigation. Through his brilliant work the chemistry of these acids was advanced to a point where they were disentangled from proteins and were recognized by physiologists as one of the normal constituents of the animal cell.

Kossel had already enriched science with his important discovery of the "alloxuric bases" among the products of hydrolysis of these acids. Three of these purine compounds—namely, guanine, xanthine and hypoxanthine—were known to chemistry, while the fourth, *adenine*, was a new combination. Notwithstanding the advance which was made by these discoveries the chemistry of nucleic acids was still in a state of chaos at the beginning of our sixth period 1893. The nucleic acids of different origin differed in regard to the relative quantities of the purine

[1] *J. prakt. Chem.* **22**, 261; **26**, 337; **39**, 156.
[2] *Am. Chem. J.*, **9**, 219; *J. prakt. Chem.*, [2] **35**, 456.

bases formed on hydrolysis and it was questionable whether previous investigations had been conducted with impure or partly decomposed acids. In order to obtain further data which would give character to these acids as a class and furnish a definition which would sharply distinguish them from other constituents of the animal body, Kossel and Neuman subjected thymus nucleic acid, in 1893, to a very careful chemical examination. As a result of that investigation chemistry was enriched with the discovery of two new pyrimidine compounds, namely: thymine and cytosine. Thymine was discovered in 1893[1] and in the following year cytosine was isolated as a cleavage product of thymus nucleic acid. Eight years later appeared the publication of Ascoli[2] announcing the discovery of *uracil* among the cleavage products of yeast nucleic acid.

These three pyrimidines are now recognized as normal constituents of nucleic acids. Cytosine and uracil are produced by the hydrolysis of both animal and plant nucleic acids, while thymine results only from animal nucleic acids.

The first structural investigation of the pyrimidine compounds formed by hydrolysis of nucleic acid was made with *thymine*. The researches of Kossel, Steudel and Jones[3] were especially fruitful and showed the similarity of this substance in chemical properties to Behrend's 4-methyluracil, but they completely excluded their identity. Cytosine was next examined by Kossel and Steudel[4] and shown to be an amino combination, and its relation to uracil was established by the action of nitrous acid. By oxidation with barium permanganate thymine and cytosine were converted into urea and biuret, respectively, thereby completing the evidence upon which Kossel constructed the formulas of these three combinations. Whether this evidence was sufficient to constitute proof of their structure or not is now a matter of little importance. Kossel concluded that all three combinations were pyrimidines and represented them by structural formulas which were later proven to be correct by the synthetical work of Emil Fischer and that of Wheeler and Johnson.

It is impossible for me to take up at this time the later physiological development in this interesting field and I shall refer hereafter to this phase of pyrimidine chemistry only in so far as the development has been associated with my own individual work.

Such was the state of affairs at the end of our period 1893–1903. Again biochemistry and organic chemistry had been brought closer together, and a prominence given to the chemistry of pyrimidines which it had never had before.

1903–1918

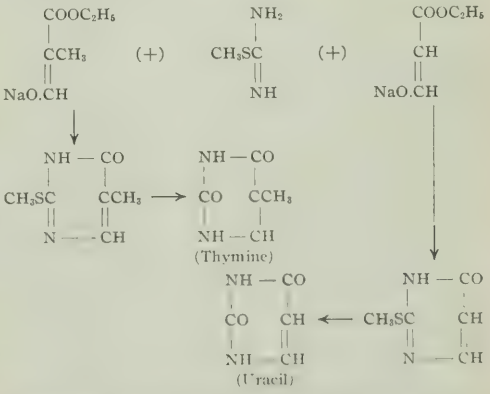
If we disregard the important work of the two German investigators, Gabriel and Traube, the more important developments in pyrimidine chemistry during our last period of pyrimidine history can be traced to the activities of investigators in this country, namely: my colleague, Levene, and the organic chemists of the Sheffield Laboratory. It was in 1903, or the beginning of our last period, that attention was first directed to the study of pyrimidines in our laboratory. The work of Kossel and his coworkers on nucleic acids was then beginning to excite the attention of leading biochemists in this country, and his deductions regarding the constitution of uracil and thymine had been proven to be correct by Fischer and Roeder[5] who had prepared these two pyrimidines by means of an interesting synthesis.

It was during this period of activity that my predecessor, Professor Henry L. Wheeler, started his investigations in pyrimidine chemistry and opened up a field of research for our laboratory, which has been very productive both from a synthetical and a biochemical standpoint. Since that time we have contributed to chemical literature about eighty-five publications dealing with various phases of pyrimidine chemistry.

Our first work on pyrimidines was really an extension of Pinner's researches on amidines, in which we made use of a new type of amidine combinations, namely: *pseudothioureas* in condensation reactions. Previous to our work amidines of this type had never been utilized in synthetical processes. Their salts were well known, but the free bases had previously been considered as unstable combinations, which were incapable of existing in a free condition. We found by investigation that this conclusion was based on incomplete evidence. We not only were able to show that these bases are quite stable in aqueous solution at low temperature, but also found them to be far more reactive towards various reagents than urea. The simple combinations interacted smoothly with β-ketone-esters in alkaline solution giving representatives of a new class of pyrimidines, which have since proven very valuable to us for developing new synthetical processes. It was the discovery of this reaction that gave us an entrance to a new field for research and led to the development of new syntheses of uracil, thymine and cytosine.

The importance of our method of pyrimidine synthesis is illustrated by the reaction between pseudomethylthiourea and the sodium salt of ethyl formylacetate or the first step in the process leading to the formation of uracil. As is well known the sodium salt of this ester and also those of the higher ester homologues fail to react with urea in alkaline solution with production of pyrimidine compounds. Behrend prepared his 4-methyluracil by allowing ethyl acetoacetate to interact with urea in the presence of hydrochloric acid. A similar reaction cannot be applied with esters of the simplest β-ketonic acids because such combinations show a great tendency to undergo molecular condensations in the presence of acids giving derivations of benzene. On the other hand, their sodium salts condense smoothly with the simple pseudothioureas in aqueous solution giving 2-mercaptopyrimidines.

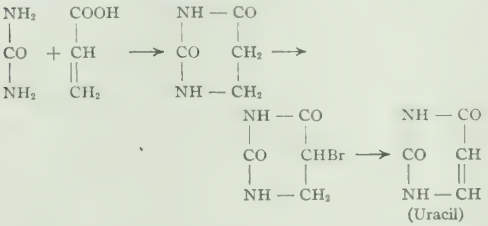
Ethyl formylacetate and ethyl formylpropionate, for example, condense with pseudomethylthiourea giving 2-methylmercapto-6-oxypyrimidine and 2-methylmercapto-5-methyl-6-oxypyrimidine, respectively. These compounds are characterized by the ease with which they undergo hydrolysis. When digested with hydrochloric acid the mercapto group is removed almost quantitatively with formation of uracil and thymine, respectively. The complete synthesis of these two naturally occurring pyrimidines[1] is represented as follows:



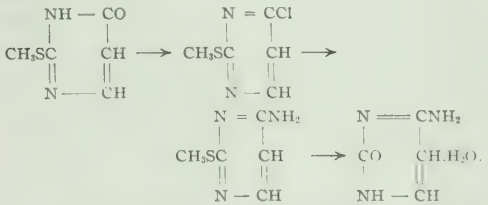
Fischer and Roeder's method of synthesizing these two pyrimidines consists in heating urea with acrylic and α-methylacrylic acids, respectively, and brominating the hydrouracils thus formed.

[1] *Ber.*, **26**, 2753.
[2] *Z. physiol. Chem.*, **31**, 161.
[3] *Ibid.*, **29**, 20, 303, **30**, 539.
[4] *Z. physiol. Chem.*, **37** (1902), 245; **37**, 527, 377; **38**, 49.
[5] *Ber.*, **34**, 3751, 4129.
[1] *Am. Chem. J.*, **29** (1903), 478

The bromine derivatives are then converted into uracil and thymine by treatment with alkali or pyridine. Fischer's method has the disadvantage that the unsaturated acids are not easily accessible combinations and the yields are much below those obtained by our method. Fischer's synthesis of uracil is represented by the following expression:



Having succeeded in perfecting new and practical syntheses of uracil and thymine we naturally turned our attention next to the problem of preparing cytosine from nucleic acids synthetically. Our 2-methylmercapto-6-oxypyrimidine resulting from the condensation of pseudomethylthiourea and the sodium salt of ethyl formylacetate proved to be an excellent starting point for a synthesis of this base. It interacted smoothly with phosphorus halides with destruction of the acidamide grouping giving a 2-mercapto-6-chlorpyrimidine. This combination proved to be an oil which could be distilled without decomposition. When heated with alcoholic ammonia under pressure it was transformed smoothly into the corresponding aminopyrimidine. The latter compound is stable in cold acid solution, but when such solutions are heated mercaptan is evolved and the pyrimidine is transformed quantitatively into cytosine. The compound formed by this reaction agrees in all its properties with *cytosine*[1] obtained by hydrolysis of nucleic acids. The complete synthesis is represented as follows:



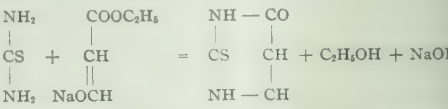
This is the only practical method for the preparation of cytosine, which has so far been developed. The method is one of general application and has been utilized by us for the preparation of several derivatives of this interesting pyrimidine base.

The identity of our synthetical cytosine with the natural product was established by direct comparison with a sample of the base from the nucleic acid of the spleen, which was kindly sent to us at that time by Dr. Levene, and also by comparison with a natural specimen which we succeeded in isolating from the uracil fraction after hydrolysis of tritico-nucleic acid of the wheat embryo.[2] This was the first time that cytosine was shown to be a constituent of a plant nucleic acid.

Following our work on the synthesis of uracil, thymine and cytosine the problem of pyrimidine formation by condensation of pseudothioureas with β-ketone esters received much attention. It was found by experimentation with a great variety of esters that our method of operating, while original, had, however, its limitations. Thiourea gave better yields of pyrimidines when condensed in aqueous solution with some ketone esters than when pseudothioureas were employed, and it also reacted better in alcohol solution in the presence of sodium ethylate than under any other condition. We also found that while practically every β-ketone ester, which we carefully examined, interacted with a pseudothiourea with formation of a pyrimidine, on the other hand, it was impossible to obtain a satisfactory condensation of a malonic ester or cyanacetic ester or any of their derivatives with a pseudothiourea with formation of a barbituric acid compound. Urea and thiourea, as is well known, interact smoothly with these esters in the presence of sodium ethylate.

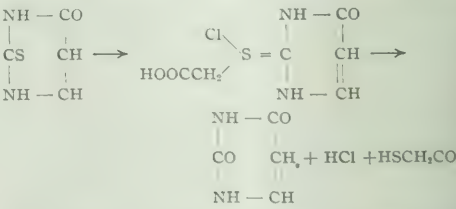
The one objectionable feature of our method of synthesizing uracil and thymine from a pseudothiourea is the disagreeable odor produced by hydrolysis of the mercaptopyrimidine due to the formation of mercaptan. The study of thiourea condensations led to important results in that we were able to develop a synthesis of uracil and thymine that is an improvement over the pseudothiourea method.

When this reagent is condensed with the sodium salt of ethyl formylacetate a much larger yield of pyrimidine is obtained than when a pseudothiourea is employed. The condensation takes place with formation of 2-thiouracil as follows:



The thiouracil is many times less soluble than any corresponding 2-mercaptopyrimidine which we have examined.

Having obtained this sulfur derivative it remained to discover a simple method of replacing the sulfur with oxygen and converting it into uracil. This was accomplished by applying a new method of desulfurization, which depends on the action of chloroacetic acid on a cyclic thiourea grouping of this character. The change is brought about by digesting the pyrimidine in aqueous solution with the halogen acid when the sulfur is removed in the form of thioglycollic acid and uracil is formed. The process involves, first, an addition of the halogen acid to sulfur and, secondly, a hydrolysis of the addition-product with formation of uracil.[1] Thymine is easily prepared by application of similar reactions with thiourea and ethyl formylpropionate.



This method of desulfurizing has been widely applied in our laboratory and is applicable not only for desulfurizing pyrimidines, but also thiohydantoins and thiopurines.

In the time at my disposal it is impossible to give you a comprehensive view of all our earlier work on mercaptopyrimidines. As is the case in the early development of every new field of research, a large amount of information was acquired, which now appears unessential, and it is not my desire to discuss to-night phases of our work which have a purely abstract interest only.

The most important developments of our earlier activities, from a biochemical standpoint, were the discovery of a color test for uracil and cytosine[2] which is extremely delicate and should prove of great value for the detection of these pyrimidines, and, secondly, the development of a method of separating uracil

[1] *Am. Chem. J.*, **29**, 492.
[2] *Ibid.*, **29**, 505.

[1] *Am. Chem. J.*, **40**, 547.
[2] *J. Biol. Chem.*, **1907**, 183.

from thymine and determining them quantitatively in mixtures of these substances.[1]

Another line of investigation which led to important conclusions was that dealing with the question of substitution in pyrimidine compounds when such combinations are subjected to the process of alkylation. While many of the derivatives synthesized and studied had in themselves only a purely chemical interest, nevertheless by the systematic application of certain color tests to various representatives of this class, we were able to reveal some very interesting structural relationships.

The reagents productive of color reactions, which have been found to be very useful in these developments are diazobenzenesulfuric acid, which was introduced into biochemistry by Pauly and Burian, and the uric acid and phenol reagents of Folin and Denis.[2] These are prepared from sodium tungstate, phosphomolybdic acid and phosphoric acid. In our work on alkylation we were enabled by use of the diazo reagent to determine, with a considerable degree of certainty, the position of substitution, namely, 1 or 3, in a uracil combination.[3] Our work with Folin's reagents revealed the interesting fact that these were specific for amino groups, and could be employed to determine whether such a radicle is substituted in the 5-position of a uracil compound. The further application of these reagents is still under investigation.

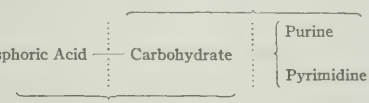
While these investigations to which I have been referring were in progress, we constantly had in mind the importance of obtaining experimental data, which would aid in elucidating the nature of the linking of the pyrimidines—uracil, thymine and cytosine—in the nucleic acids. These natural products were known to be composed of phosphoric acid, purines, pyrimidines and sugars, but ten years ago, we had practically no knowledge of the way in which these four constituents were linked together in these complicated molecules. Furthermore, there was much doubt at that time whether the pyrimidines actually existed as such in these combinations.

Burian[4] made the assumption that the pyrimidines result from purines by degradation of the purine constituents of nucleic acids through hydrolysis and supported his deductions indirectly by showing that such cyclic combinations can be transformed into pyrimidines by digestion with acids in the presence of carbohydrates. Osborne,[5] Levene and Steudel produced evidence showing that Burian's conclusions were incorrect, and that pyrimidines do not result from purine bases. They postulated, furthermore, that uracil and thymine are primary products of hydrolysis, and do not result from any process involving the removal of an amino group from any aminopyrimidine of the nature of cytosine or isocytosine, but are present in the nucleic acids in their simple forms.

It was Levene and his coworkers who cleared up this controversy on constitution, and whose investigations advanced our knowledge to such a degree that we were finally able to obtain a picture of the molecular structure of these acids. Levene succeeded in showing that these combinations are composed of characteristic complexes to which he assigned the name—*nucleotides*. The latter are compounds consisting of phosphoric acid conjugated with a complex composed of a carbohydrate and a purine or pyrimidine. In other words, according to Levene, a nucleic acid may be a single nucleotide or composed of several nucleotides. Regarding the nature of the union of the individual nucleotides in a nucleic acid we have no very definite knowledge.

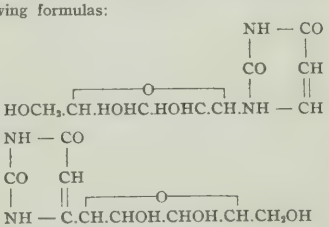
The constitution of nucleotides has been partly elucidated by the work of Levene.[6] He has been able to prove the order of the groups in these combinations by showing that they may be transformed by hydrolysis into two types of complexes depending upon the experimental conditions employed.

For example, it is possible to detach from a nucleotide phosphoric acid giving a simpler complex containing sugar in combination with a purine or pyrimidine. To such combinations Levene assigned the name *nucleosides*. The second decomposition involves a removal of the nitrogenous nucleus leaving the phosphoric acid in combination with the carbohydrate.



Direct proof of the presence of the *nucleoside* combinations has been presented by the isolation of the pentose nucleosides, namely, guanosine, adenosine, uridine and cytidine from yeast nucleic acid and of guanine hexoside from thymus nucleic acid.

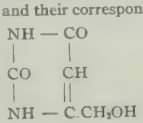
Of these various nucleosides the only ones in which we are interested to-night are uridine and cytidine. These are combinations of uracil and cytosine, respectively, with the pentose sugar-ribose. Regarding the nature of this nucleoside union and the position substituted by the sugar in the pyrimidine ring, sufficient data have not been presented to enable us to express structurally the exact constitution of these compounds. Levene and LaForge[1] have concluded, however, from very good evidence, which we have not time to discuss to-night, that this linking is probably of a glucosidic nature, and that the carbohydrate may be joined to the pyrimidine in one of two positions, *viz.*, the 3- or 4-position of the ring. If these assumptions be correct then the constitution of uridine, for example, may be expressed by one of the two following formulas:



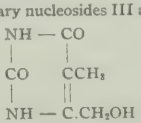
In order to throw further light on the question of constitution of these pyrimidine nucleosides, we have been making a study, during the past three years, of pyrimidine combinations containing as side chains groups having the structure of alcohols. This work has been developed from the assumption that the pyrimidines—uracil, thymine and cytosine—are linked to carbohydrates at position 4 in nucleosides, and that this linkage is between two carbon atoms as represented in Levene's formula for uridine.

The simplest representatives of this class of compounds are the monatomic primary and secondary alcohol derivatives of uracil, thymine and cytosine. Such combinations may be considered as the prototypes of their respective series, and therefore would be expected to exhibit a chemical behavior similar to that of the natural nucleosides.

We have synthesized, in the course of our work, four representatives of this class of compounds, namely, the two primary nucleosides of uracil and thymine represented by Formulas I and II, and their corresponding secondary nucleosides III and IV.



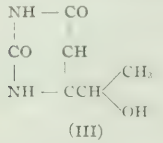
(I)



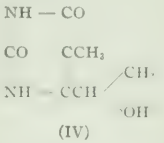
(II)

[1] *J. Biol. Chem.*, **1908**, 407.
[2] *J. Am. Chem. Soc.*, **36** (1914), 970.
[3] *J. Biol. Chem.*, **1908**, 163.
[4] *Z. physiol. Chem.*, **51**, 438.
[5] *Am. J. Physiol.*, **21**, 157.
[6] *J. Am. Chem. Soc.*, **35** (1913), 586.
[1] *Ber.*, **45**, 608.

Previous to our investigations we had absolutely no knowledge of hydroxypyrimidine combinations of this type.



(III)



(IV)

Our investigations have revealed to us the facts that these simple nucleosides behave in an entirely different manner from the natural nucleosides when subjected to intense hydrolysis. In no case have we been able to break down such a combination into uracil or thymine and an aldehyde. This would involve a cleavage of the side chain from the pyrimidine ring.

The primary nucleosides obtained by synthesis are characterized by their great stability. They exhibit the normal behavior of primary alcohols and, when subjected to the action of acids, interact with these reagents to form esters. In other words, they react as might be predicted, and do not conform in chemical behavior to that of a natural nucleoside like uridine.

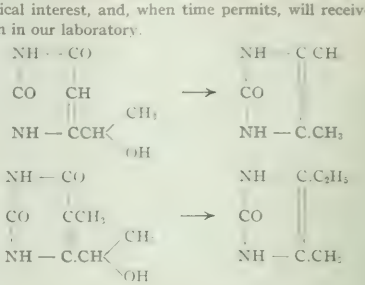
In the light of these interesting developments it became of the greatest interest for us to extend our investigations to a study of the behavior of secondary nucleosides on hydrolysis. Such combinations (Formulas III and IV) approach in constitution still closer to that which has been assigned to natural nucleosides.

We found to our surprise that these pyrimidines are far less resistant to the action of acids than the primary nucleosides. They did not respond, however, to a chemical change on hydrolysis that was productive of either uracil or thymine with cleavage of the secondary alcoholic side chain. On the other hand, they underwent a transformation which is unique and sharply differentiates them from primary nucleosides.

The two nucleosides III and IV undergo a profound molecular change on prolonged heating with acids and are transformed, with evolution of carbon dioxide, into derivatives of glyoxaline. In other words, the introduction of a secondary alcohol group into the 4-position of uracil and thymine tends to decrease the stability of the pyrimidine nucleus to such an extent that it can easily be ruptured by hydrolytic agents.

In the case of the uracil nucleoside the product of hydrolysis is identical with 2-oxy-4,5-dimethylimidazol which has previously been described by Kunne[1] and Biltz.[2] The identity of the two products was established by the fact that both substances interact with acetic anhydride with formation of the same acetyl derivative.

The thymine nucleoside undergoes hydrolysis with evolution of carbon dioxide, and formation of 2-oxy-4,5-ethylmethylimidazol which has already been described by Gabriel and Posner.[3] In other words, the two nucleosides react in a perfectly analogous manner. The transformation is one which has the greatest biochemical interest, and, when time permits, will receive more attention in our laboratory.



This reaction, which we have discovered, suggests again a genetic relationship between naturally occurring pyrimidines and imidazoles. As far as the writer is aware, this is the first time that it has been shown that a pyrimidine can be transformed into a glyoxaline combination by hydrolysis. Liebig and Wöhler made the interesting discovery that uric acid can be transformed smoothly into allantoin with destruction of the pyrimidine nucleus of the purine. Behrend later showed that 4-methyl uracil also can be transformed under certain conditions into parabanic acid, but in both cases the transformations were brought about by the combined effect of oxidation and hydrolysis.

Our rearrangements are unique in that they can be effected by hydrolysis alone and without first destroying the unsaturated condition of the uracil and thymine molecule. Whether a lengthening of the carbon side chain and the introduction of more hydroxyl groups will weaken the attraction between the carbon atom in position 4 and permit of hydrolysis to take place without destruction of the pyrimidine ring remains to be determined.

SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY
NEW HAVEN, CONNECTICUT

MESSAGE FROM PROF. BOGERT

Professor M. T. Bogert, who was to have been present to address the meeting on "Organic Chemistry in Modern Warfare," sent the following message:

"Urgent war business will prevent my attending the meeting Friday night for which I am very sorry. Permit me to congratulate Dr. Johnson upon the honor he has received and the AMERICAN CHEMICAL SOCIETY upon the recipient selected. Few men in our country have done so much for the cause of synthetic organic chemistry as Dr. Johnson. He has been a wonderfully prolific worker and is a recognized leader of not only national, but international, reputation. Greetings to Johnson, Nichols, and all fellow members."

WASHINGTON, D. C.

CURRENT INDUSTRIAL NEWS

THE EKENBERG PEAT PROCESS

Experiments on the treatment of peat by a modified Ekenberg process are being conducted at Châteauneuf, Bretagne, France. According to a paper in *Comptes Rendus* of September 3, the peat is first compressed in presses of the Mabille or Aurep types to reduce the water in it from about 90 to 60 per cent. The peat is then treated with superheated steam at 160° C. for 25 min. and then either compressed again or at once dried, which is best done in special chambers, though air drying may be applied. The product which is called *turbon* still contains 20 to 25 per cent of moisture but does not absorb moisture as it would do if the cellulose in the peat had not been destroyed by the steam heat. The calorific value is stated to be raised by 10 per cent over that of dried peat; the *turbon* yields 61 per cent volatile matter, 30 per cent fixed carbon, 3 per cent ash. With suitable arrangement of the batteries of autoclaves and utilization of exhaust steam, a heat efficiency of from 85 to 91 per cent is claimed to be realized in this process, which can be worked throughout the year. The *turbon* is fired directly or sent to gas works (with ammonia recovery) or converted into power gas for internal-combustion engines. This last mentioned utilization has so far proved the most satisfactory.—A. MCMILLAN.

[1] *Ber.*, **28**, 2040.
[2] *Ibid.*, **40**, 4801.
[3] *Ibid.*, **27**, 1037.

NORWEGIAN IRON INDUSTRY

The present situation has taught Norway how dangerous it is to be dependent on foreign supplies of pig iron, steel and steel plates, says the *Anglo-Norway Trade Journal*. The problem has been under consideration for some time and one of the chief points to be settled was the geographical position of the new works. A number of Stravanger people working in connection with a large English company have formulated plans for works at Straumpol in Tysfjorden near Narvik for the production of 250,000 tons of pig iron annually and for the provision of a large rolling mill. The close proximity of Narvik, which is the shipping port for Swedish ore, and also of Kirkenaes, the shipping port for the best Norwegian ore, is, of course, an obvious advantage but, in addition to this, Straumpol is reported to be a natural harbor with good industrial sites having easy access to water power. The transportation of coal from England would be cheap but, beyond this, the geographical position in relation to Spitzbergen should not be overlooked, seeing that a Norwegian group is now working energetically to develop the Spitzbergen coal field. The total capital required is estimated at $5,500,000.—M.

MAGNETIC SEPARATIONS AND THE RARER METALS

The use of magnetic separators in treating minerals in a fine state of division has reached a high point of efficiency, says a contemporary. Thus in treating monazite sand, magnetite is removed by the weakest magnet, ilmenite by the intermediate and monazite by the strongest magnet. The use of a series of magnets of different strengths enables discrimination to be made between substances of varying magnetic susceptibility. Magnetic separators of the multipolar type have proved of great utility in purifying some classes of zinc ores, while the magnetic tungsten materials, wolframite and ferberite, appear to lend themselves particularly well to magnetic treatment.—M.

NEW SOURCE OF ALCOHOL

As a commercial possibility, says a contemporary, the nipa palm, abounding in the swamps of the Philippine Islands, seems to be unusually attractive, both as a producer of sugar and of alcohol. Already a quantity of the sap is used by Manila distillers in making what is regarded by many persons as the best alcohol manufactured. It is claimed that nipa furnishes the cheapest raw material in the world for the manufacture of alcohol and that denatured alcohol made in this way is a fuel for gasoline motors which is cheaper than gasoline and fully as efficient. It is further stated that with a motor built for the use of alcohol this fuel would be twenty to thirty per cent better than gasoline. There are over one hundred thousand acres of nipa swamp now available in the Archipelago, of which about 90 per cent have never been touched, and it is estimated that the untapped swamp area of the island would yield fifty million gallons of alcohol fuel every season.—M.

NEW RUST PREVENTION

According to *Metal Industry*, 11 (1917), 527, a new rust-prevention process recommended for small machine parts is an application to the surface of the iron or steel of iron phosphates. After thorough cleaning, the articles are immersed in a bath containing ferric and ferrous phosphates with a little manganese dioxide and, at boiling water temperature, they are left until hydrogen is no longer given off. The articles are then air-dried when they may be treated with mineral oil or painted, japanned or otherwise finished. As the phosphate surface is attached chemically to the metal no rust forms even in cracks in the paint.—M.

TRANSVAAL DEPOSITS OF CHROME ORE AND MAGNESITE

The British Trade Commissioner in South Africa reports the discovery of deposits of chrome ore and magnesite on a farm situated on the Oliphants River, Lydenberg District, Northern Transvaal. Reliable authorities report the existence of both minerals in large bodies and of high quality. This is understood to be the first important discovery of chrome ore in South Africa outside of Rhodesia. The ore yields 44.6 per cent Cr_2O_3, besides iron and magnesium oxide. The magnesite shows the following analysis: MgO = 45.75 per cent, CO_2 = 49.17 per cent, with silica, lime, iron oxide and alumina. It is said to be almost equal to the best Greek magnesite. The area of the reefs in question extends to more than 3,000 acres.—M.

NEW OIL NUTS

"Tucan" or "large Panama" kernels are harder and tougher than palm kernels or copra, and, according to the *Times Trade Supplement*, yield 37 to 48 per cent of a cream-colored and fairly hard fat resembling palm kernel oil, but having a slightly higher melting point. The residual meal is inferior to coconut or palm kernel meal and is likely to be indigestible judging by the toughness of the kernels. The kernels are said to be sold at a cheaper rate than fine palm kernels. "Paraguay" kernels are small and round and weigh about 28 to the oz. The skin of the kernels is almost as black and the flesh is softer than that of the palm kernels. They contain 65 per cent of fat which is softer than coconut or palm oil and is only semi-solid at ordinary temperatures. The residual meal is richer in proteins than coconut cake and should have a high feeding value. The market value of the kernels would be a little above that of palm kernels and below that of copra. There does not seem to be any particular difficulty in the way of exploiting either of these nuts. The shells can be cracked by machinery such as is used for palm nuts in West Africa.—M.

CATALYTICAL BLEACHING OF OILS

The use of catalytic agents, such as finely divided nickel in the hydrogenation of oils, says the *Oil and Color Trade Journal*, 53 (1918), 123, having proved so successful, it is probable that the employment of them in other directions may follow as a matter of course. In the bleaching of oils, for instance, catalytic agents such as finely divided lead and animal charcoal have been of service, as well as oleate of manganese, etc. In a paper recently published in a contemporary, experiments were described showing the influence of several catalytic agents upon tallow, palm oil and beeswax when a current of air is blown through the melted material. The catalysts employed were air-bleached palm oil, oleates of manganese, copper, cobalt, lead, iron and nickel, the silkstone soap of A. Finlay and Company, Belfast, and the cobalt soap preparation from the latter. In the case of the palm oil, bleaching occurred both with and without the catalysts, but with the latter the time requisite for bleaching was shortened, especially with cobalt and manganese salts. The experiments with beeswax and tallow were not so successful.—M.

GAS-HEATED ISOTHERMAL ROOM

In the Physical Institute of Konigsberg, a constant temperature room had been made by providing double walls with insulating layers. The room, however, proved damp in summer, dry in winter, but never comfortable. It was heated by hot water pipes. A gas heater with automatic control has been added and a pleasant temperature is maintained within 0.04° C. The electrically controlled gas valve, which is described by G. Hoffmann in the *Physikalische Zeitschrift* of July 15, 1917, has the shape of a U. The limbs are wound with coils like an

electro-magnet and the passage connecting the two limbs at the bottom is closed when the magnet is energized and a plate raised. A small pilot jet is always left burning and the control is effected by a spiral built up of strips of zinc and iron like a compensating pendulum. The spiral ends in a contact arm, bearing against an adjustable screw. The device is inserted in a shunt of the lighting circuit and the gas when the temperature sinks below the normal. The device thus operates intermittently and keeps the temperature within the limits 18.1° and 18.2° C. [Compare THIS JOURNAL, 10 (1918), 38.]—M.

MAGNETO IGNITION

According to the *Gas World*, 68 (1918), 11, it is true that continued use tends to strengthen the permanent magnetism in a magneto machine and not to weaken it, as is generally supposed to be the case. It is, therefore, very rarely necessary to re-magnetize the steel pole pieces and usually only when the instrument has been exposed to undue heat. Apart from defects due to over-lubrication or lack of lubrication or wear of incorrectly designed bearings or dirty contacts of the brush-gear, experience has shown that very little trouble indeed arises so far as magneto construction is concerned. Ignition difficulties far more frequently result from broken wires, dirty contacts, incorrect timing due to wear of pins and catch points, or worn make-or-break sparking points, if low tension machines are employed, or too large a spark gap or defective insulation of the plug, if of high tension type. Cases are occasionally met with, where, in a gas engine room, two or more displaced magnetos are to be seen and it would surprise the owners of such engines if they were made to realize how these could be set to work equal to new with a very slight amount of overhauling.—M.

DETACHABLE ENGINES FOR SHIPS

The idea of an "economic ship" proposed by Mr. H. de M. Snell, says the *Times Engineering Supplement*, is to have the propelling machinery detachable, so that it may be moved from hull to hull, his estimate being that one set would serve for three hulls, or even for five or six in the case of coastwise or cross-channel traffic. For propulsion he would employ electric drive, the current being derived from alternators worked by oil engines or steam turbines. The motors and reduction gearing would remain permanently in the ship but the generating plant would be held in place by mechanical attachments which would be secured or released in a few seconds, and would collectively be able to resist a working stress of over 1000 tons. A pamphlet dealing with the proposal shows designs for four ships ranging in carrying capacity from 1,200 to over 10,000 tons. In some cases, the "electromobile," as the power unit is termed, contains accommodation for officers and engineers in addition to the machinery, and is sometimes placed amidships and sometimes on the poop. Its transference from one hull to another will be effected at the terminal ports by means of pontoons. Among the advantages Mr. Snell claims for his scheme are that it would mean a large saving in capital outlay for a given carrying capacity, with a reduction in the interest charges and in the cost of wages of officers and crews; that it would effect a great saving in the time and labor required for construction, particularly in the case of the machinery; and that the area of the machinery exposed to damage by submarine or mine would be reduced to a minimum.—M.

SYNTHETIC MATERIALS

Numerous synthetic perfumes, says the *Oil and Color Trade Journal*, 53 (1918), 209, are getting very scarce and are hardly obtainable on the spot. Forward orders for aubepine are being declined owing to the scarcity of the raw materials necessary. As much as $19 has been paid for small parcels. Coumarin, of which supplies are very short, is offered without engagement to come forward at $39 and, on the spot, as much as $40 has been asked and paid. Heliotropine has further advanced and at $8 is regarded as cheap. Bromo-styrol and vanillin are scarce and very dear, but methyl salicylate and benzaldehyde are rather easier and more plentiful. Phenylmethyl alcohol is $31.50 to $37.50 according to quality, there being several grades of this article to be found at present on the market.—M.

INSULATING MATERIAL

An insulating material lately patented is composed of 52 per cent pulverized asbestos, 14 per cent sifted mica, 20 per cent mineral caoutchouc, 10 per cent rubber solution, 3 per cent sulfur and 1 per cent resin. The proportions can be varied as required. The mixture is hard, claimed to be almost incombustible, can be molded and wrought and, for insulation and other purposes, it is proposed as a substitute for porcelain, marble, slate, and vulcanized substances.—M.

LAMINATED BELTING

The introduction of high-speed steel, says the *Times Engineering Supplement*, has demonstrated the necessity of increasing the power of machine tools and has emphasized the need for the highest efficiency possible in the transmission of the power required to drive them. The Tullis protection edge laminated belt, which has been designed to suit the new conditions, with certain machine tool drives, is claimed to be efficient, because it transmits the full power without slip, and economical because it gives a longer life and increases the output of the tool. With the usual laminated belting the constant contact with the belt forks cuts up the outside strands and, though the center strands may still be in excellent condition, before the belt can again be put into order, it has to be completely taken down and reassembled with new outer strands. In the Tullis belt the patent edge is designed to resist the action of the forks, with increase in the life of the belt. The edge also binds the threads which hold the strands together in such a manner that even if one of the stitches becomes cut or broken the others are not affected. The ends of the strands are drawn together by pins which are removed as the cross sewing progresses. When this is complete the edges are sewn down. As an alternative to sewing the edges, they may be held together by ordinary metal clasps, which is a quicker method and makes a simple joint.—M.

BRITISH BOARD OF TRADE

During the month of January the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding the things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

MACHINERY AND PLANT FOR
- Tarring felt
- Making oilskin
- Splitting ostrich quills for making brushes—scrubbing brushes and dandy brushes
- Automatic, for the serial numbering of protractors, etc.
- Coloring typewriter ribbons
- Covering copper wire for magnets with insulating material, the wire to be drawn through a liquid mixture with rubber as a basis
- Manufacturing macaroni, vermicelli
- Manufacturing surgical needles
- Pin-making (safety and ordinary)
- Appliances for removing the husks of almonds or nuts when being blanched
- Charcoal, nut, lump and flake
- Copper tubes, made by electrolytic process
- Die-casting machines
- Dies for die-casting machines
- Electro-deposition of copper for various purposes as a substitute for castings
- Electro-tinning plant
- Hollow steel wire, suitable for production of hypodermic needles
- Light mineral oil (182,600 gal.)
- Paraffin oil lamps, cheap; glass or china
- Raw photographic paper
- Tinder lighters
- Ultramarine blue

—M.

SCIENTIFIC SOCIETIES

TENTATIVE STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF COMMERCIAL FATS AND OILS

Adopted September 22, 1916, and January 13, 1918[1]

The following methods have been adopted by the *Committee on the Analysis of Commercial Fats and Oils* of the *Division of Industrial Chemists and Chemical Engineers* of the AMERICAN CHEMICAL SOCIETY as tentative standards for the use of the trade, pending their official adoption by the American Chemical Society.

They are the result of three years of continuous and conscientious effort on the part of the Committee and they have given excellent satisfaction in the hands of the members of the Committee and others who have used them, and have been found to answer the commercial needs of the fat and oil industry in a satisfactory manner.

They are published for the purpose of adoption by any contracting parties so desiring and for the purpose of eliciting suggestions and criticisms from fat and oil chemists. Communications on the subject of the methods should be addressed to W. D. RICHARDSON, c/o SWIFT AND COMPANY, CHICAGO, and will be presented to the Committee at their regular monthly meeting next following.

The Committee is now working on methods for cold and flow tests, melting point, and moisture in oils of the coconut group in the presence of free acids.

SAMPLING

TANK CARS

1. SAMPLING WHILE LOADING—Sample shall be taken at discharge of pipe where it enters tank car dome. The total sample taken shall be not less than 50 lbs. and shall be a composite of small samples of about 1 pound each, taken at regular intervals during the entire period of loading.

The sample thus obtained is thoroughly mixed and uniform 3-lb. portions placed in air-tight 3-lb. metal containers. At least three such samples shall be put up, one for the buyer, one for the seller, and the third to be sent to a referee chemist in case of dispute. All samples are to be promptly and correctly labeled and sealed.

2. SAMPLING FROM CAR ON TRACK[2]—(*a*) *When contents are solid.*[3] In this case the sample is taken by means of a large tryer measuring about 2 in. across and about $1^1/_2$ times the depth of the car in length. Several tryerfuls are taken vertically and obliquely toward the ends of the car until 50 lbs. are accumulated, when the sample is softened, mixed and handled as under (1). In case the contents of the tank car have assumed a very hard condition, as in winter weather, so that it is impossible to insert the tryer and it becomes necessary to soften the contents of the car by means of the closed steam coil (in nearly all tank cars the closed steam coil leaks) or by means of open steam in order to draw a proper sample, suitable arrangements must be made between buyer and seller for the sampling of the car after it is sufficiently softened, due consideration being given to the possible presence of water in the material in the car as received and also to the possible addition of water during the steaming. The Committee knows of no direct method for sampling a hard-frozen tank car of tallow in a satisfactory manner.

(*b*) *When contents are liquid.* The sample taken is to be a 50-lb. composite made up of numerous small samples taken from the top, bottom and intermediate points by means of a bottle or metal container with removable stopper or top. This device attached to a suitable pole is lowered to the various desired depths when the stopper or top is removed and the container allowed to fill. The 50-lb. sample thus obtained is handled as under (1).

(*c*) *When contents are in semi-solid condition, or when stearine has separated from liquid portions.* In this case a combination of (*a*) and (*b*) may be used or by agreement of the parties the whole may be melted and procedure (*b*) followed.

BARRELS, TIERCES, CASKS, DRUMS, AND OTHER PACKAGES

All packages shall be sampled, unless by special agreement the parties arrange to sample a lesser number; but in any case not less than 10 per cent of the total number shall be sampled. The total sample taken shall be at least 20 lbs. in weight for each 100 barrels, or equivalent.

1. BARRELS, TIERCES AND CASKS—(*a*) *When contents are solid.* The small samples shall be taken by a tryer through the bunghole or through a special hole bored in the head or side for the purpose, with a 1-in. or larger auger. Care should be taken to avoid and eliminate all borings and chips from the sample. The tryer is inserted in such a way as to reach the head of the barrel, tierce, or cask. The large sample is softened, mixed and handled according to TANK CARS (1).

(*b*) *When contents are liquid.* In this case use is made of a glass tube with constricted lower end. This is inserted slowly and allowed to fill with the liquid, when the upper end is closed and the tube withdrawn, the contents being allowed to drain into the sample container. After the entire sample is taken it is thoroughly mixed and handled according to TANK CARS (1).

(*c*) *When contents are semi-solid.* In this case the tryer or a glass tube with larger outlet is used, depending on the degree of fluidity.

(*d*) *Very hard materials, such as natural and artificial stearines.* By preference the barrels are stripped and samples obtained by breaking up contents of at least 10 per cent of the packages. This procedure is to be followed also in the case of cakes shipped in sacks. When shipped in the form of small pieces in sacks they can be sampled by grab sampling and quartering. In all cases the final procedure is as outlined under TANK CARS (1).

2. DRUMS—Samples are to be taken as under (1), use being made of the bunghole. The tryer or tube should be sufficiently long to reach to the ends of the drum.

3. OTHER PACKAGES—Tubs, pails and other small packages not mentioned above are to be sampled by tryer or tube (depending on fluidity) as outlined above, the tryer or tube being inserted diagonally whenever possible.

4. MIXED LOTS AND PACKAGES—When lots of tallow or other fats are received in packages of various shapes and sizes, and especially wherein the fat itself is of variable composition, such must be left to the judgment of the sampler. If variable, the contents of each package should be mixed as thoroughly as possible and the amount of the individual samples taken made proportional to the sizes of the packages.

ANALYSIS

SAMPLE

The sample must be representative and at least three pounds in weight and taken in accordance with the STANDARD METHODS FOR THE SAMPLING OF COMMERCIAL FATS AND OILS. It must be kept in an air-tight container in a dark, cool place.

Soften the sample if necessary by means of a gentle heat, taking care not to melt it. When sufficiently softened, mix the sample thoroughly by means of a mechanical egg beater or other equally effective mechanical mixer.

MOISTURE AND VOLATILE MATTER

APPARATUS: *Vacuum Oven*—The committee Standard Oven.

DESCRIPTION—The Standard F. A. C. Vacuum Oven has been designed with the idea of affording a simple and compact vacuum

[1] Published by the Committee February 1918. Superseding and cancelling previous issues.

[2] Live steam must not be turned into tank cars or coils before samples are drawn, since there is no certain way of telling when coils are free from leaks.

[3] If there is water present under the solid material this must be noted and estimated separately.

oven which will give as uniform temperatures as possible on the shelf. As the figure shows, it consists of an iron casting of rectangular sections with hinged front door made tight by means of a gasket and which can be lowered on opening the oven so as to form a shelf on which samples may be rested. The oven contains but one shelf which is heated from above as well as below by means of resistance coils. Several thermometer holes are provided in order to ascertain definitely the temperature at different points on the shelf. In a vacuum oven where the heating is done almost entirely by radiation it is difficult to maintain uniform temperatures at all points, but the F. A. C. oven accomplishes this rather better than most vacuum ovens. Larger ovens containing more than one shelf have been tried by the Committee, but have been found to be lacking in temperature uniformity and means of control. The entire oven is supported by means of a 4-in. standard pipe which screws into the base of the oven and which in turn is supported by being screwed into a blind flange of suitable diameter which rests on the floor or work table.

Moisture Dish—A shallow, glass dish, lipped, beaker form, approximately 6 to 7 cm. diameter and 4 cm. deep shall be standard.

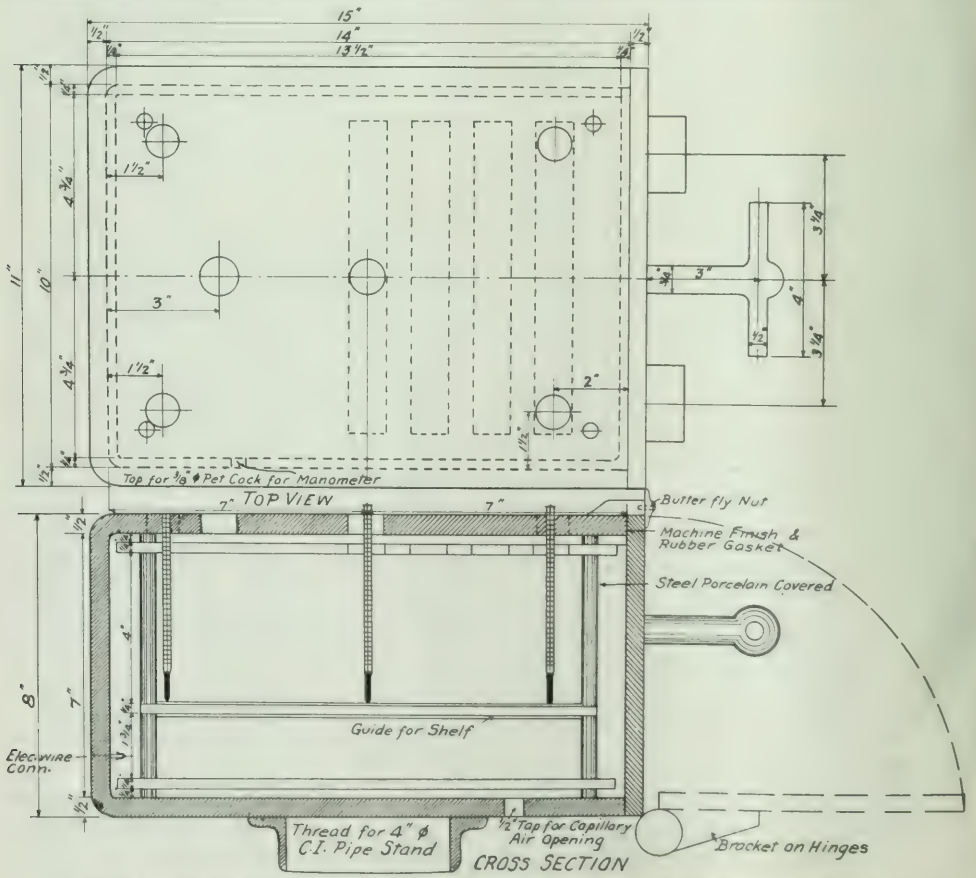
DETERMINATION—Weigh out 5 grams (±0.2 g.) of the prepared sample into a moisture dish. Dry to constant weight *in vacuo* at a uniform temperature, not less than 15° C., not more than 20° C. above the boiling point of water at the working pressure, which must not exceed 100 mm. of mercury.[1] Constant weight is attained when successive dryings for 1-hr. periods show an additional loss of not more than 0.05 per cent. Report loss in weight as MOISTURE AND VOLATILE MATTER.[2]

The vacuum oven method cannot be considered accurate in the case of fats of the coconut oil group containing free acid and the Committee recommends that it be used only for oils of this group when they contain less than 1 per cent free acid. In

[1] Boiling point of water at reduced pressures

Pressure mm Hg	Boiling point to 1° C	Boiling point ± 1.5° C.	Boiling point ± 2° C.
100	52° C.	67° C.	72° C.
90	50	65	70
80	47	62	67
70	45	60	65
60	42	57	62
50	38	53	58
40	34	49	54

[2] Results comparable to those of the Standard Method may be obtained on most fats and oils by drying 5-gram portions of the sample, prepared and weighed as above, to constant weight in a well-constructed and well-ventilated air oven held uniformly at a temperature of 105–110° C. The thermometer bulb should be close to the sample. The definition of constant weight is the same as for the Standard Method.



STANDARD FAT ANALYSIS COMMITTEE VACUUM OVEN FOR DETERMINING MOISTURE AND VOLATILE MATTER IN FATS AND OILS

the case of oils of this group containing more than 1 per cent free acid, recourse should be had temporarily to the routine control method for moisture and volatile matter[1] until the Committee develops a more satisfactory method.

The air-oven method cannot be considered even approximately accurate in the case of the drying and semi-drying oils and those of the coconut oil group. Therefore, in the case of such oils as cottonseed oil, maize oil (corn oil), soy bean oil, linseed oil, coconut oil, palm kernel oil, etc., the vacuum-oven method should always be used, except in the case of fats of the coconut group containing more than 1 per cent free acid, as noted above.

INSOLUBLE IMPURITIES

Dissolve the residue from the moisture and volatile matter determination by heating it on a steam bath with 50 cc. of kerosene. Filter the solution through a Gooch crucible properly prepared with asbestos,[2] wash the insoluble matter five times with 10-cc. portions of hot kerosene, and finally wash the residual kerosene out thoroughly with petroleum ether. Dry the crucible and contents to constant weight as in the determination of moisture and volatile matter and report results as INSOLUBLE IMPURITIES.

SOLUBLE MINERAL MATTER

Place the combined kerosene filtrate and kerosene washings from the insoluble impurities determination in a platinum dish. Place in this an ashless filter paper folded in the form of a cone, apex up. Light the apex of the cone, whereupon the bulk of the kerosene burns quietly. Ash the residue in a muffle, to constant weight, taking care that the decomposition of carbonates is complete, and report the result as SOLUBLE MINERAL MATTER.[3] When the percentage of soluble mineral matter amounts to more than 0.1 per cent, multiply the percentage by 10 and add this amount to the percentage of free fatty acids as determined.

FREE FATTY ACIDS

The ALCOHOL[4] used shall be approximately 95 per cent ethyl alcohol, freshly distilled from sodium hydroxide, which with phenolphthalein gives a definite and distinct end-point.

DETERMINATION—Weigh 1 to 15 g. of the prepared sample into an Erlenmeyer flask, using the smaller quantity in the case of dark-colored, high acid fats. Add 50 to 100 cc. hot, neutral alcohol, and titrate with $N/2$, $N/4$ or $N/10$ sodium hydroxide, depending on the fatty acid content, using phenolphthalein as indicator. Calculate to oleic acid, except that in the case of palm oil the results may also be expressed in terms of palmitic acid, clearly indicating the two methods of calculation in the report. In the case of coconut and palm kernel oils, calculate to and report in terms of lauric acid in addition to oleic acid, clearly indicating the two methods of calculation in the report. In the case of fats or greases containing more than 0.1 per cent of soluble mineral matter, add to the percentage of free fatty acids as determined 10 times the percentage of soluble mineral matter as determined. This addition gives the equivalent of fatty acids combined with the soluble mineral matter.

TITER

STANDARD THERMOMETER—The thermometer is graduated at zero and in tenth degrees from 10° C. to 65° C., with one auxiliary reservoir at the upper end and another between the zero mark and the 10° mark. The cavity in the capillary tube between the zero mark and the 10° mark is at least 1 cm. below the 10° mark, the 10° mark is about 3 or 4 cm. above the bulb, the length of the thermometer being about 37 cm. over all. The thermometer has been annealed for 75 hrs. at 450° C. and the bulb is of Jena normal 16''' glass, or its equivalent, moderately thin, so that the thermometer will be quick-acting. The bulb is about 3 cm. long and 6 mm. in diameter. The stem of the thermometer is 6 mm. in diameter and made of the best thermometer tubing, with scale etched on the stem, the graduation is clear-cut and distinct, but quite fine. The thermometer must be certified by the U. S. Bureau of Standards.

GLYCEROL CAUSTIC SOLUTION—Dissolve 250 g. potassium hydroxide in 1000 cc. dynamite glycerin with the aid of heat.

DETERMINATION—Heat 75 cc. of the glycerol-caustic solution to 150° C. and add 50 g. of the melted fat. Stir the mixture well and continue heating until the melt is homogeneous, at no time allowing the temperature to exceed 150° C. Allow to cool somewhat and carefully add 50 cc. 30 per cent sulfuric acid. Now add hot water and heat until the fatty acids separate out perfectly clear. Draw off the acid water and wash the fatty acids with hot water until free from mineral acid, then filter and heat to 130° C. as rapidly as possible with stirring. Transfer the fatty acids, when cooled somewhat, to a 1-in. by 4-in. titer tube, placed in a 16-oz. salt-mouth bottle of clear glass, fitted with a cork that is perforated so as to hold the tube rigidly when in position. Suspend the titer thermometer so that it can be used as a stirrer and stir the fatty acids slowly (about 100 revolutions per minute) until the mercury remains stationary for 30 seconds. Allow the thermometer to hang quietly with the bulb in the center of the tube and report the highest point to which the mercury rises as the titer of the fatty acids. The titer should be made at about 20° C. for all fats having a titer above 30° C. and at 10° C. below the titer for all other fats.

UNSAPONIFIABLE MATTER

EXTRACTION CYLINDER—The cylinder shall be glass-stoppered, graduated at 40 cc., 80 cc. and 130 cc., and of the following dimensions: diameter about $1^3/_8$ in., height about 12 in.

PETROLEUM ETHER—Redistilled petroleum ether, boiling under 75° C., shall be used. A blank must be made by evaporating 250 cc. with about 0.25 g. of stearine or other hard fat (previously brought to constant weight by heating) and drying as in the actual determination. The blank must not exceed a few milligrams.

DETERMINATION—Weigh 5 g. (±0.20 g.) of the prepared sample into a 200-cc. Erlenmeyer flask, add 30 cc. of redistilled 95 per cent (approximately) ethyl alcohol and 5 cc. of 50 per cent aqueous potassium hydroxide, and boil the mixture for one hour under a reflux condenser. Transfer to the extraction cylinder and wash to the 40-cc. mark with redistilled 95 per cent ethyl alcohol. Complete the transfer, first with warm, then with cold water, till the total volume amounts to 80 cc. Cool the cylinder and contents to room temperature and add 50 cc. of petroleum ether. Shake *vigorously* for one minute and allow to settle until both layers are clear, when the volume of the upper layer should be about 40 cc. Draw off the petroleum ether layer as closely as possible by means of a slender glass siphon into a separatory funnel of 500 cc. capacity. Repeat

[1] The following method is suggested by the Committee for routine control work: Weigh out 5- to 25-gram portions of prepared sample into a glass or aluminum (*Caution:* Aluminum soap may be formed) beaker or casserole and heat on a heavy asbestos board over burner or hot plate, taking care that the temperature of the sample does not go above 130° C. at any time. During the heating rotate the vessel gently on the board by hand to avoid sputtering or too rapid evolution of moisture. The proper length of time of heating is judged by absence of rising bubbles of steam, by the absence of foam or by other signs known to the operator. Avoid overheating of sample as indicated by smoking or darkening. Cool in desiccator and weigh.

[2] For routine control work, filter paper is sometimes more convenient than a prepared Gooch crucible. It must be very carefully washed to remove the last traces of fat, especially the rim.

[3] For routine work, an ash may be run on the original fat, and the soluble mineral matter obtained by deducting the ash on the insoluble impurities from this. In this case the Gooch crucible should be prepared with an ignited asbestos mat so that the impurities may be ashed directly after being weighed. In all cases ignition should be to constant weight so as to insure complete decomposition of carbonates.

[4] For routine work methyl or denatured ethyl alcohol of approximately 95 per cent strength may be used. With these reagents the end-point is not sharp.

extraction four more times, using 50 cc. of petroleum ether each time. Wash the combined extracts in a separatory funnel three times with 25-cc. portions of 10 per cent alcohol, shaking vigorously each time. Transfer the petroleum ether extract to a wide-mouth tared flask or beaker, and evaporate the petroleum ether on a steam bath in an air current. Dry as in the method for MOISTURE AND VOLATILE MATTER. Any blank must be deducted from the weight before calculating unsaponifiable matter. Test the final residue for solubility in 50 cc. petroleum ether at room temperature. Filter and wash free from the insoluble residue, if any, evaporate and dry in the same manner as before. The Committee wishes to emphasize the necessity of thorough and vigorous shaking in order to secure accurate results. The two phases must be brought into the most intimate contact possible, otherwise low and disagreeing results may be obtained. When the unsaponifiable matter runs over 5 per cent, more extractions are recommended.

WIJS METHOD FOR THE DETERMINATION OF IODINE VALUE

PREPARATION OF REAGENTS—*Wijs Iodine Solution*—(1) Dissolve separately 7.9 g. of iodine trichloride and 8.7 g. of iodine in glacial acetic acid on the water bath, taking care that the solutions do not absorb moisture. The two solutions are then poured into a 1000-cc. flask and the flask is filled up to the mark with glacial acetic acid.

Or (2) dissolve 6.5 g. of resublimed iodine in one liter of C. P. glacial acetic acid and pass in washed and dried chlorine gas until the original thiosulfate titration of the solution is just doubled. This is then preserved in amber glass-stoppered bottles, sealed with paraffin until ready for use.

N/10 Sodium Thiosulfate Solution—Dissolve 24.8 g. of C. P. sodium thiosulfate and dilute with water to one liter at the temperature at which the titrations are to be made.

Starch Paste—Boil 1 g. of starch in 200 cc. of distilled water for 10 min. and cool to room temperature.

Potassium Iodide Solution—Dissolve 150 g. of potassium iodide in water and make up to one liter.

N/10 Potassium Bichromate—Dissolve 4.903 g. of C. P. potassium bichromate in water and make the volume up to one liter at the temperature at which titrations are to be made.

Standardization of the Sodium Thiosulfate Solution—Place 20 cc. of the potassium bichromate solution, to which has been added 10 cc. of the solution of potassium iodide, in a glass-stoppered flask. Add to this 5 cc. of strong hydrochloric acid. Dilute with 100 cc. of water, and allow the *N*/10 sodium thiosulfate to flow slowly into the flask until the yellow color of the liquid has almost disappeared. Add a few drops of the starch paste, and with constant shaking continue to add the *N*/10 sodium thiosulfate solution until the blue color just disappears.

DETERMINATION—Weigh accurately from 0.10 to 0.50 g. (depending on the iodine number) of the melted and filtered sample into a clean, dry, 16-oz. glass-stoppered bottle containing 15–20 cc. of carbon tetrachloride or chloroform. Add 25 cc. of iodine solution from a pipette, allowing to drain for a definite time. The excess of iodine should be from 50 per cent to 60 per cent of the amount added, that is, from 100 per cent to 150 per cent of the amount absorbed. Moisten the stopper with a 10 per cent potassium iodide solution to prevent loss of iodine or chlorine but guard against an amount sufficient to run down inside the bottle. Let the bottle stand in a dark place for $^1/_2$ hr. at a uniform temperature. At the end of that time add 20 cc. of 10 per cent potassium iodide solution and 100 cc. of distilled water. Titrate the iodine with *N*/10 sodium thiosulfate solution which is added gradually, with constant shaking, until the yellow color of the solution has almost disappeared Add a few drops of starch paste and continue titration until the blue color has entirely disappeared. Toward the end of the reaction stopper the bottle and shake violently so that any iodine remaining in solution in the tetrachloride or chloroform may be taken up by the potassium iodide solution. Conduct two determinations on blanks which must be run in the same manner as the sample except that no fat is used in the blanks. Slight variations in temperature quite appreciably affect the titer of the iodine solution, as acetic acid has a high coefficient of expansion. It is, therefore, essential that the blanks and determinations on the sample be made at the same time. The number of cc. of standard thiosulfate solution required by the blank, less the amount used in the determination, gives the thiosulfate equivalent of the iodine absorbed by the amount of sample used in the determination. Calculate to centrigrams of iodine absorbed by 1 g. of sample (= per cent iodine absorbed).

SAPONIFICATION NUMBER (KOETTSTORFER NUMBER)

PREPARATION OF REAGENTS—*N/2 Hydrochloric Acid*—Carefully standardized.

Alcoholic Potassium Hydroxide Solution—Dissolve 40 g. of pure potassium hydroxide in one liter of 95 per cent redistilled alcohol (by volume). The alcohol should be redistilled from potassium hydroxide over which it has been standing for some time, or with which it has been boiled for some time, using a reflux condenser. The solution must be clear and the potassium hydroxide free from carbonates.

DETERMINATION—Weigh accurately about 5 g. of the filtered sample into a 250 to 300 cc. Erlenmeyer flask. Pipette 50 cc. of the alcoholic potassium hydroxide solution into the flask, allowing the pipette to drain for a definite time. Connect the flask with an air condenser and boil until the fat is completely saponified (about 30 minutes). Cool and titrate with the *N*/2 hydrochloric acid, using phenolphthalein as an indicator. Calculate the Koettstorfer number (mg. of potassium hydroxide required to saponify 1 g. of fat). Conduct 2 or 3 blank determinations, using the same pipette and draining for the same length of time as above.

NOTES ON THE ABOVE METHODS

SAMPLING

The standard size of sample adopted by the Committee is at least 3 lbs. in weight. The Committee realizes that this amount is larger than any samples usually furnished even when representing shipments of from 20,000 to 60,000 lbs., but it believes that the requirement of a larger sample is desirable and will work toward uniform and more concordant results in analysis. It will probably continue to be the custom of the trade to submit smaller buyers' samples than required by the Committee, but these are to be considered only as samples for inspection and not for analysis. The standard analytical sample must consist of 3 lbs. or more.

The reasons for keeping samples in a dark, cool place are obvious. This is to prevent any increase in rancidity and any undue increase in fatty acids. In the case of many fats the Committee has found in its coöperative analytical work that free acid tends to increase very rapidly. This tendency is minimized by low temperatures.

MOISTURE AND VOLATILE MATTER

After careful consideration the Committee has decided that moisture is best determined in a vacuum oven of the design which accompanies the above report. Numerous results on check samples have confirmed the Committee's conclusions. The oven recommended by the Committee is constructed on the basis of well-known principles and it is hoped that this type will be adopted generally by chemists who are called upon to analyze fats and oils. The experiments of the Committee indicate that it is a most difficult matter to design a vacuum oven which will produce uniform temperatures throughout; and one of the principal ideas in the design adopted is uniformity of temperature over the entire single shelf. This idea has not quite been realized in practice but, nevertheless, the present design approaches much closer to the ideal than other vacuum ovens

commonly used. In the drawing the essential dimensions are those between the heating units and the shelf and the length and breadth of the outer casting. The standard Fat Analysis Committee oven (F. A. C. oven) can be furnished by Messrs. E. H. Sargent & Company, 125 West Lake Street, Chicago.

The Committee realizes that for routine work a quicker method is desirable and has added one such method and has also stated the conditions under which comparable results can be obtained by means of the ordinary well-ventilated air oven held at 105 to 110° C. However, in accordance with a fundamental principle adopted by the Committee at its first meeting, only one standard method is adopted and declared official for each determination.

The Committee realizes that in the case of all methods for determining moisture by means of loss on heating there may be a loss due to volatile matter (especially fatty acids) other than water. The title of the determination MOISTURE AND VOLATILE MATTER indicates this idea, but any considerable error from this source may occur only in the case of high acid fats and oils and particularly those containing lower fatty acids such as coconut and palm kernel oil. work on which is now in progress to be reported at a later date. In the case of extracted greases which have not been properly purified, some of the solvent may also be included in the moisture and volatile matter determination, but inasmuch as the solvent, usually a petroleum product, can only be considered as foreign matter, for commercial purposes, it is entirely proper to include it with the moisture. The Committee has also considered the various distillation methods for the determination of moisture in fats and oils, but since according to the fundamental principles which it was endeavoring to follow it could only standardize one method, it was decided that the most desirable one on the whole was the vacuum-oven method as given. There are cases wherein a chemist may find it desirable to check a moisture determination or investigate the moisture content of a fat or oil further by means of one of the distillation methods.

INSOLUBLE IMPURITIES

This determination, the title for which was adopted after careful consideration, determines the impurities which have generally been known as dirt, suspended matter, suspended solids, foreign solids, foreign matter, etc., in the past. The first solvent recommended by the Committee is hot kerosene to be followed by petroleum ether kept at ordinary room temperature. Petroleum ether, cold or only slightly warm, is not a good fat and metallic soap solvent, whereas hot kerosene dissolves these substances readily, and for this reason the Committee has recommended the double solvent method so as to exclude metallic soaps which are determined below as soluble mineral matter.

SOLUBLE MINERAL MATTER

Soluble mineral matter represents mineral matter combined with fatty acids in the form of soaps in solution in the fat or oil. Formerly, this mineral matter was often determined in combination by weighing the separated metallic soap or by weighing it in conjunction with the insoluble impurities. Since the soaps present consist mostly of lime soap, it has been customary to calculate the lime present therein by taking 0.1 the weight of the total metallic soaps. The standard method as given above is direct and involves no calculation. The routine method given in the note has been placed among the methods, although not adopted as a standard method for the reason that it is in use in some laboratories regularly. It should be pointed out, however, that the method cannot be considered accurate for the reason that insoluble impurities may vary from sample to sample to a considerable extent and the error due to the presence of large particles of insoluble impurities is thus transferred to the soluble mineral matter.

FREE FATTY ACID

The fatty acid method adopted is sufficiently accurate for commercial purposes. In many routine laboratories the fat or oil is measured and not weighed, but the Committee recommends weighing the sample in all cases. For scientific purposes the result is often expressed as "acid number," meaning the number of milligrams of KOH required to neutralize the free acids in one gram of fat, but the commercial practice has been, and is, to express the fatty acids as oleic acid or in the case of palm oil, as palmitic acid, in some instances. The Committee sees no objection to the continuation of this custom so long as the analytical report clearly indicates how the free acid is expressed. For a more exact expression of the free acid in a given fat, the Committee recommends that the ratio of acid number to saponification number be used. This method of expressing results is subject to error when unsaponifiable fatty matter is present, since the result expresses the ratio of free fatty acid to total saponifiable fatty matter present.

TITER

At the present time the prices of glycerol and caustic potash are abnormally high but the Committee has considered that the methods adopted are for normal times and normal prices. For routine work during the period of high prices the following method may be used for preparing the fatty acids and is recommended by the Committee:

50 grams of fat are saponified with 60 cc. of a solution of 2 parts of methyl alcohol to 1 of 50 per cent NaOH. The soap is dried, pulverized and dissolved in 1000 cc. of water in a porcelain dish and then decomposed with 25 cc. of 75 per cent sulfuric acid. The fatty acids are boiled until clear oil is formed and then collected and settled in a 150-cc. beaker and filtered into a 50-cc. beaker. They are then heated to 130° C. as rapidly as possible with stirring, and transferred, after they have cooled somewhat, to the usual 1-in. by 4-in. titer tube.

The method of taking the titer, including handling the thermometer, to be followed is the same as that described in the standard method. Even at present high prices many laboratories are using the glycerol-caustic potash method for preparing the fatty acids, figuring that the saving of time more than compensates for the extra cost of the reagents. Caustic soda cannot be substituted for caustic potash in the glycerol method.

UNSAPONIFIABLE MATTER

The Committee has considered unsaponifiable matter to include those substances frequently found dissolved in fats and oils which are not saponified by the caustic alkalies and which at the same time are soluble in the ordinary fat solvents. The term includes such substances as the higher alcohols, such as cholesterol which is found in animal fats, phytosterol found in some vegetable fats, paraffin and petroleum oils, etc. UNSAPONIFIABLE MATTER should not be confused in the lay mind with INSOLUBLE IMPURITIES OF SOLUBLE MINERAL MATTER.

The method adopted by the Committee has been selected only after the most careful consideration of other methods, such as the dry extraction method and the wet method making use of the separatory funnel. At first consideration the dry extraction process would seem to offer the best basis for an unsaponifiable matter method, but in practice it has been found absolutely impossible for different analysts to obtain agreeing results when using any of the dry extraction methods proposed. Therefore, this method had to be abandoned after numerous trials, although several members of the Committee strongly favored it in the beginning.

IODINE NUMBER—The iodine number adopted by the Committee is that determined by the well-known Wijs method. This method was adopted after careful comparison with the Hanus and Hübl methods. The Hübl method was eliminated from consideration almost at the beginning of the Committee's

work for the reason that the time required for complete absorption of the iodine is unnecessarily long and, in fact, even after absorption has gone on over night, it is apparently not complete. In the case of the Hanus and Wijs methods complete absorption takes place in from 15 minutes to an hour, depending on conditions. Formerly, many chemists thought the Hanus solution rather easier to prepare than the Wijs solution, but the experience of the Committee was that the Wijs solution was no more difficult to prepare than the Hanus. Furthermore, absorption of iodine from the Wijs solution appeared to take place with greater promptness and certainty than from the Hanus and was complete in a shorter time. Results by the Wijs method were also in better agreement in the case of oils showing high iodine absorption than with the Hanus solution and showed a slightly higher iodine absorption for the same length of time. However, the difference was not great. The Committee investigated the question of substitution since it has been suggested that in case of the Wijs solution substitution of iodine in the organic molecule might occur, and found no evidence of this in the time required for the determination, namely, $^1/_2$ hr., or even for a somewhat longer period. One member of the Committee felt that it was not desirable to introduce the Wijs method into these standard methods since the Hanus method was already standardized by the Association of Official Agricultural Chemists, but the Committee felt that it must follow the principle established at the commencement of its work, namely, that of adopting the method which appeared to be the best from all standpoints, taking into consideration accuracy, convenience, simplicity, time, expense, etc., without allowing precedent to have the deciding vote.

SAVING FATS FROM GARBAGE

On February 23rd Secretary Parsons offered the assistance of the AMERICAN CHEMICAL SOCIETY to the United States Food Administration in a campaign for the recovery of fats from garbage. The following reply was received:

WASHINGTON, D. C.,
March 5, 1918

MR. CHARLES L. PARSONS,
AMERICAN CHEMICAL SOCIETY,
WASHINGTON, D. C.

DEAR SIR: Beg to acknowledge receipt of your letter of February 23rd and am to-day sending the enclosed letter to the following men, with reference to cities named:

A. D. Camp, Cleveland, Ohio
Cleveland, East Cleveland, Elyria, Loraine, Akron, Canton, Youngstown

H. L. Olin, Columbus, Ohio
Columbus, Dayton

R. J. Quinn, Chicago, Ill.
Chicago, Ill.

R. P. Calvert, Wilmington, Del.
Wilmington, Del.

L. B. Case, Detroit, Mich.
Detroit, Mich.

A. J. Salathe, Schenectady, N. Y.
Schenectady, Utica

H. W. Rhodemamel, Indianapolis, Ind.
Indianapolis, Fort Wayne

E. C. Stone, Hartford, Conn.
Bridgeport, Conn.

Sheppard T. Powell, Baltimore, Md.
Baltimore, Md.

J. H. Graham, Philadelphia, Pa.
Philadelphia, York, Pa., Atlantic City, N. J.

Charles F. Roth, New York City
New York City

David H. Childs, Buffalo, N. Y.
Buffalo, N. Y.

E. C. McKelvey, Washington, D. C.
Washington, D. C.

E. Schragenheim, Toledo, Ohio
Toledo, Ohio

J. M. Johlin Jr., Syracuse, N. Y.
Syracuse, N. Y.

L. F. Nickell, St. Louis, Mo.
St. Louis, Mo.

J. J. Ives, Rochester, N. Y.
Rochester, N. Y.

R. M. Howe, Pittsburgh, Pa.
Pittsburgh, Braddock, Wilkinsburg

S. T. Arnold, Providence, R. I.
Boston, New Bedford, Mass.

Henry L. Payne, Los Angeles, Cal.
Los Angeles, Cal.

M. C. Smeed, Cincinnati, Ohio
Cincinnati, Ohio

The above list of cities includes all that are disposing of their garbage by the reduction process at the present time.

Trusting that the procedure outlined meets with your approval and that you, too, will assist in any way possible to carry out the policy indicated, we are

Very truly yours,
U. S. FOOD ADMINISTRATION
(Signed) F. C. BAMMAN
Garbage Utilization Division

DEAR SIR:

The Secretary of the AMERICAN CHEMICAL SOCIETY, Mr. Charles L. Parsons, has kindly offered the assistance of your Society in a campaign for saving fats from garbage.

We have recently called the attention of certain of our State Administrators to the fact that garbage reduction plants within their respective states were adding to our valuable resources by the recovery of grease and fertilizer tankage; that on an average there was being recovered per annum from the garbage produced by a family of four, sufficient glycerine to furnish, as nitroglycerine, the powder charge of three 75 mm. shells, enough fatty acids for about fifty cakes of soap, and ample fertilizing elements to replace the soil depletion of about three bushels of wheat. We also furnished them with a data sheet of the present extent of this industry, copy of which is attached hereto.

We suggested to the Food Administrators that an active campaign be inaugurated to see that all garbage in cities where such plants were available be utilized in such plants and that private incinerators or the practice of burning garbage in furnaces, etc., be eliminated.

Your city has a reduction plant available and anything you can do to decrease the destruction of garbage will be deeply appreciated.

We are also interested in securing the utilization of garbage in cities not now utilizing their garbage but, with the prevalent shortage of labor and material, the erection of new reduction plants is extremely difficult and our main effort therefore in such cities is to secure utilization by feeding. We understand, however, that some cities are investigating disposal by reduction and anything you can do to secure the introduction of this system in such cities will likewise be of great assistance.

Very truly yours,
U. S. FOOD ADMINISTRATION
(Signed) F. C. BAMMAN
Garbage Utilization Division

29 CITIES ARE DISPOSING OF GARBAGE BY REDUCTION

TOTAL POPULATION ABOUT 13,200,000

Estimated present grease production This amount of grease will produce 10,000,000 lbs. of nitroglycerine, enough for the powder charge of about 16,000,000 of our 3-in. shells or the famous French 75 mm. shells. The fatty acids it contains are sufficient for the manufacture of about 200,000,000 twelve-ounce cakes of soap.	72,000,000 lbs.
Estimated present fertilizer tankage production This amount of tankage contains about 9,000,000 lbs. of nitrogen, 22,000,000 lbs. of phosphate of lime and 2,000,000 lbs. of potash, enough to replace the nitrogen and other elements taken from the soil by 45,000,000 bu. of wheat.	150,000 tons
Estimated present value of the above amounts of grease and fertilizer tankage	$11,100,000
Estimated amount of garbage now destroyed annually in the above 29 cities	150,000 tons
Estimated amount of grease in the above 150,000 tons of garbage This amount of grease will produce about 1,300,000 lbs. of nitroglycerine, enough for the powder charge of about 2,000,000 of our 3-in. shells or the French 75 mm. shells. The fatty acids it contains are sufficient for the manufacture of about 25,000,000 twelve-ounce cakes of soap.	9,000,000 lbs.
Estimated amount of fertilizer tankage in the above 150,000 tons of garbage This amount of fertilizer tankage contains about 1,250,000 lbs. of nitrogen, 3,500,000 lbs. of phosphate of lime and 850,000 lbs. of potash, enough for the replacement of the elements removed from the soil by 1,000,000 bu. of wheat.	22,500 tons

AMERICAN INSTITUTE OF MINING ENGINEERS

The 116th Meeting of the American Institute of Mining Engineers was held in New York City, February 18 to 21, 1918.

PROGRAM OF PAPERS

NON-FERROUS METALLURGY

The Disadvantages of Chrome Brick in Copper Reverberatory Furnaces. F. R. PYNE.
Fine-Grinding and Porous-Briquetting of the Zinc Charge. W. MCA. JOHNSON.
High-Temperature Resistance Furnaces with Ductile Tungsten or Molybdenum Resistors. W. E. RUDER.
Zinc Refining. L. E. WEMPLE
Bone-Ash Cupels. F. P. DEWEY.
An Automatic Filter at Dupue, Illinois. G. S. BROOKS AND L. G. DUNCAN.

MINING AND MILLING

Hints on Bucket-Elevator Operation. A. M. NICHOLAS.
Recent Test on Ball-Mill Crushing. C. T. VANWINKLE.
Theory and Practice of Ball-Milling with Peripheral Discharge Mills. P. R. HINES.
New Method of Separating Materials of Different Specific Gravities. T. M. CHANCE.

IRON AND STEEL

The Erosion of Guns. H. M. HOWE
Transverse Fissures in Steel Rails. J. E. HOWARD.

METALLOGRAPHY

Grain-Size Inheritance in Iron and Carbon Steel. Z. JEFFRIES.
The Time-Effect in Tempering Steel. A. E. BELLIS.
Some Structures in Steel Fusion Welds. S. W. MILLER.
Effect of Copper in Steel. C. R. HAYWARD AND A. B. JOHNSTON.

Two sessions were also devoted to the consideration of employment problems, some of the topics considered being the necessity of a thoroughly capable employment manager, care of workmen while on duty, suitable living conditions for labor, the training of workmen for better positions, and the crippled soldier in industry.

AMERICAN ELECTROCHEMICAL SOCIETY

The board of directors of the American Electrochemical Society, at a meeting held in Philadelphia on February 22, 1918, decided to hold the Spring Meeting in the South during the week of April 28. The meeting will take the form of a trip through the chemical, electrochemical and metallurgical centers of the South, the plan being to leave Washington, D. C., on the evening of Sunday, April 28, and spend April 29 in Kingsport, Tenn., April 30 in Knoxville, May 1 in Chattanooga, May 2 at Muscle Shoals, and May 3 in Birmingham, Ala. Returning, the party will arrive in Washington on Sunday, May 5. Mr. C. F. Roth is chairman of the Committee on Arrangements and may be addressed at Grand Central Palace, New York City.

CALENDAR OF MEETINGS

American Electrochemical Society—Spring Meeting, Southern trip, week of April 28, 1918.

American Society of Mechanical Engineers—Worcester, Mass., June 4 to 7, 1918.

American Institute of Chemical Engineers—Summer Meeting, Berlin, N. H., June 22, 1918.

American Society for Testing Materials—Atlantic City, June 25 to 28, 1918.

NOTES AND CORRESPONDENCE

REVISED STATEMENT FROM THE CHEMICAL SERVICE SECTION

Soon after the March issue had gone to press a revised form of the announcement from the Chemical Service Section was received. It is herewith printed in full, that which is in addition to the statement in the March number being printed black.

OFFICE OF THE CHIEF OF THE CHEMICAL SERVICE SECTION,
1106 NEW INTERIOR BUILDING
WASHINGTON, D. C.

By an order of the Secretary of War the Adjutant General of the Army has authorized the Chief of the Chemical Service Section of the National Army to initiate such measures as are necessary to secure deferred classification for chemists whose services are essential to war industries. Under the Selective Service Regulations such action is limited to a letter of advice to the Local and District Exemption Boards transmitted through the Adjutant General's office, substantially as follows:

"The Chemical Service Section of the War Department has investigated the status of your company in connection with the production of war material and considers it important that the efficiency of your organization be maintained. In this connection the services of ..... as a technical expert in ..... have been investigated and it is believed that his continued employment in war industries would be to the best interests of the Government. You are therefore advised to apply to the local exemption board for deferred classification in his case on the ground that he is a necessary highly specialized technical expert of a necessary industrial enterprise. Such action, of course, should be taken only with Mr .....'s consent. If he prefers to enter the military service, please advise this office of that fact in order that his services may be utilized where most needed."

Under the same order of the Secretary of War the Chief of the Chemical Service Section will initiate action for the return to civil industries of any expert chemist whose service in the industry from which he was taken is of more importance to the Government than are his services in a military capacity. **He must certify that the man is considered indispensable in industry or that his services are essential to the prosecution of the war, and that his place cannot be filled by a man or woman not in the Army.** Except in the cases of members of the Reserve Corps, the action taken will consist of a recommendation to the Adjutant General of the Army, that the man concerned be discharged from the National Army, National Guard or Regular Army, as the case may be, reënlisted or recommissioned in the proper branch of the Reserve Corps, and placed on the inactive list. In the cases of members of the Reserve Corps, the action will consist of a recommendation that the man concerned be placed on the inactive list.

The Secretary of War further directs that upon the transfer to the Enlisted Reserve Corps for this purpose the enlisted man so transferred will be directed to report to the employer who requires his services. The employer in each case will be advised by the man's transfer for the specific purpose intended and will be requested to report to the Department Commander at the end of each month the status of the soldier, and should at any time the soldier separate himself from such employment, the employer will immediately notify the Adjutant General of the Army of such separation and, if practicable, the latest address of the man.

The enclosed forms (printed in March issue) indicate the proper method of requesting action—a separate application must be made for each man.

WM. H. WALKER, Lieut. Col.
Chief, Chemical Service Section, N. A.

PREPAREDNESS CENSUS

The Bureau of Mines has published as *Technical Paper* 179 a classification of the returns of the census of mining engineers, metallurgists, and chemists made at the request of the Council of National Defense. The paper can be obtained from the Bureau of Mines until the limited free edition is exhausted; after that, for 5 cents from the Superintendent of Documents,

Government Printing Office, Washington, D. C. The following excerpt will be of special interest to chemists:

The accompanying table shows the 15,000 chemists classified according to the various industrial groups. The miscellaneous group of 1,130 includes 240 men not actually engaged in laboratory work, but holding administrative positions such as presidents, treasurers and secretaries of chemical companies. It also includes 157 leather chemists, 116 research chemists, a number of dentists, editors, physicians, chemical engineers, and consulting chemists.

CHEMISTS CLASSIFIED BY CHIEF INDUSTRIAL GROUPS

1	Acids, alkalies, and salts	1,405
2	Alcohol and acetone	339
3	Ammonia oxidation	81
4	Analytical chemistry	3,808
5	Barium compounds	208
6	Cement and lime	584
7	Coal, gas, tar, and coke	1,294
8	Dyes and textiles	775
9	Electrochemistry	769
10	Explosives (high)	962
11	Explosives (black powder)	150
12	Fats and soaps	834
13	Fertilizers	844
14	Foods	1,619
15	Glass and ceramics	262
16	Inorganic chemicals	532
17	Nitrogen (synthetic)	128
18	Organic chemicals (other than 2)	888
19	Paints and varnish	577
20	Petroleum and asphalt	769
21	Pharmaceuticals	983
22	Pyrotechnics	42
23	Rubber and allied substances	494
24	Sugar, starch, and gums	592
25	Water, sewage, and sanitation	1,035
26	Wood products	368
27	Metallurgical chemistry	494
27a	Alloys, ferrous	323
27b	Alloys, non-ferrous	360
27c	Aluminum and magnesium	127
27d	Antimony, bismuth, and cadmium	54
27e	Chromium and manganese	82
27f	Copper	379
27g	Gold and silver	337
27h	Iron and steel	1,415
27i	Lead	209
27j	Mercury	25
27k	Nickel and cobalt	68
27l	Platinum metals	75
27m	Radium and uranium	99
27n	Silicon and titanium	89
27o	Zinc	255
27p	Other metallurgy	126
28	Professors and instructors	1,285
29	Miscellaneous	1,130

The following table shows the number of chemists who reported experience in foreign countries:

COUNTRY	CHEMISTS
Africa	13
Australasia	10
Austria-Hungary	24
Canada	203
Central America	15
Cuba	60
Europe	
Belgium	6
Denmark	10
France	38
Great Britain	117
Germany	231
Holland	10
Italy	11
Norway-Sweden	21
Russia	30
Spain	5
Switzerland	18
Others	10
Not specified	171
Far East (including Philippines)	80
Greenland	...
India	
Mexico	117
Newfoundland	
South America	34
West Indies	32

GOVERNMENT CONTROL OF PLATINUM

On Friday, March 1, 1918, the Council of National Defense issued the following statement:

Through Ordnance Requisition No. 510 from the Secretary of War, the Government has taken over control of the production, refining, distribution, and use of crude and refined platinum for the period of the war. The control will be exercised through the Chemical Division of the War Industries Board. The Chemical Division sent out to-day to the industry requests for inventories of the existing stock of crude and refined platinum and platinum-iridium alloys as of March 1, 1918.

The letter stated that it was not the intention of the Government to take over and handle directly the present stock of platinum but to permit its shipment by the producers or dealers subject to certain conditions. Upon the fixing by the Secretary of War of a reasonable price for crude, refined, and alloyed platinum, notice will be given and blanks issued governing delivery and distribution.

DIRECTIONS TO PRODUCERS

The letter sent out by the Chemical Division includes the following directions to producers:

1—That producers, refiners and dealers in platinum continue to dispose of their product for Government purposes, and for that only, as directed by the Chemical Division.

2—That producers, refiners and dealers in platinum who are also consumers use platinum for Government purposes, and for that only, as directed by the Chemical Division.

3—That all obligations arising out of transactions in the production or delivery of crude, alloyed, or refined platinum released as above, including all claims for shortage, poor quality, damage, or loss in transit, be borne by the producer or seller, as the case may be, in accordance with existing trade practices.

Distribution may be made by consent of this board through agencies under existing arrangements, provided that there results no increase over the existing price to the user.

The undersigned, on separate application in each case, will consider permitting the delivery of a limited amount of platinum for essential commercial purposes not for Government account.

Proper blanks upon which application for release of shipment should be made will be furnished on application.

The following list indicates, in general, the order of preference which will be followed in releasing platinum for shipment: first, military needs of the United States Government; second, military needs of allied Governments; third, essential commercial purposes.

SUPPLEMENTARY STATEMENT

On March 4 the following statement was published as a supplement to that of March 1:

The Council wishes to state that in issuing Ordnance Requisition No. 510, commandeering crude or raw platinum now in the hands of importers or refiners of this precious metal, it is to be understood that this commandeering order does not apply to or interfere with the purchase by the consumer of any manufactured articles containing platinum.

This explanation is made so that the public may clearly understand the purpose of this action by the Government.

. . . . . .

This action of the Government will be welcomed by those who have been concerned lest the available supplies should be insufficient to meet our war needs, especially since affairs have taken such a turn in Russia as to make it very improbable that we may hope to draw further from that source, "where the mines are mostly shut down and a commercial market does not exist." Even so, it is doubtful if the unmanufactured stocks in the hands of dealers and refiners will begin to be enough. If not, the sole resource is to take possession of manufactured articles at a valuation.

It is regrettable that our Government did not clearly cover in its order all the metals of the platinum group. It does not appear from the statement of the Council of National Defense above quoted that there is any restriction on dealings in the other metals of the group that are free from platinum. Yet there seems to be an even greater relative scarcity of much needed iridium than of platinum. A supplementary order should be issued without delay so worded as to include all the metals of the group.

How far the present action of our Government follows what has been done by the British Government is made evident by the official documents and a letter from the Ministry of Munitions of War on January 31, 1918, to the American Embassy in London, copies of which have been placed at my service by the Bureau of

Foreign and Domestic Commerce. The official documents are six in number: Letter sent to all persons likely to hold platinum; Order placing platinum under the Defense of the Realm Act; Copy of the Regulation; Requisition Notice; Form of Permit authorizing dealers and dental manufacturers to dispose of their stocks which were fully manufactured prior to the date of the order.

From the letter referred to, it appears that the use of platinum for jewelry and other non-essential purposes has been absolutely prohibited. Dental manufacturers were rationed but were allowed to reconvert their old stocks which contained large quantities of platinum so that they could make them into new stock containing less platinum. The Controller of Non-Ferrous Materials Supply became the only purchaser of platinum outside the country and the only seller of platinum inside the country. No platinum can be sold without a permit from the Department and no permits are granted unless the platinum is required for an approved purpose. Persons authorized to buy scrap platinum must sell it to one of four designated firms, who in turn have to sell all that they have obtained to the Government. So successful has this method of collecting scrap been that more than 75 per cent of the platinum sold by the Department per month is covered by scrap purchased for more than two years. At present the amount purchased represents only 50 per cent of the sales, which it should be understood do not include the very large quantities of platinum supplied for certain war purposes.

It may be added that the fixed price in England for platinum was increased in December 1916 from 210 shillings to 290 shillings per ounce and that in February 1918 the price for scrap was further increased to £18 and for new platinum to £20 per ounce.

WASHINGTON, D. C. W. F. HILLEBRAND
March 14, 1918

PLATINUM RESOLUTION BY THE ARGENTINE CHEMICAL SOCIETY[1]

To the President of the American Chemical Society:

I have the honor to address you as President of the Argentine Chemical Society in view of the resolution of our Directors in one of its last meetings.

The Argentine Chemical Society is advised as to the vote cast by the AMERICAN CHEMICAL SOCIETY recommending to all persons in the United States a restriction in the use of platinum in view of the high price it has reached, and the recommendation that all this metal be employed for the scientific and technical uses for which it must be employed.

The Board of Directors of the Argentine Chemical Society, over which I have the honor to preside, deems that this proposition of the AMERICAN CHEMICAL SOCIETY is extremely favorable and essential to science, and in this view has voted to make common cause with it in the hope that it will be considered by all the countries which it will benefit.

I greet you with the greatest consideration, and remain

(Signed) G. F. SCHAEFER
President

SOCIEDAD QUIMICA ARGENTINA
CALLE LAVALLE 1790
BUENOS AIRES, January 15, 1918

[Signature illegible]
Secretary

. . . . . .

SEÑOR G. F. SCHAEFER, *Presidente*,
Sociedad Quimica Argentina,
Calle Lavalle 1790,
Buenos Aires, Argentina, S. A.

DEAR SIR:

I was much gratified to receive your esteemed favor of January 15th in which you announce that the Sociedad Quimica Argentina has taken action similar to that taken by the AMERICAN CHEMICAL SOCIETY on the subject of the use of platinum. This gives me double pleasure; first, that the action of our Society should meet with favorable consideration by yourself, and, second, that it should have been the means of bringing from you a communication which I sincerely trust will be followed by many others. We are much interested in progress of all kinds in Argentina, and will be delighted to be kept in touch particularly with its progress in chemistry. I trust, therefore, that you will from time to time honor us with further communications.

With cordial greetings from this Society to yourself and the great Society over which you preside, I have the honor to remain,

Yours very truly,

(Signed) WILLIAM H. NICHOLS
President

NEW YORK CITY
February 26, 1918

[1] The first letter is a translation.

LICENSING OF FERTILIZER INDUSTRY ORDERED

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

WHEREAS under and by virtue of an act of Congress entitled "An act to provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of food products and fuel," approved by the President on the 10th day of August 1917, it is provided, among other things, as follows:

That by reason of the existence of a state of war it is essential to the national security and defense, for the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to assure an adequate supply and equitable distribution, and to facilitate the movement of foods, feeds, fuel, including fuel oil and natural gas, and fertilizer and fertilizer ingredients, tools, utensils, implements, machinery, and equipment required for the actual production of foods, feeds, and fuel, hereafter in this act called necessaries; to prevent, locally or generally, scarcity, monopolization, hoarding, injurious speculation, manipulations, and private controls, affecting such supply, distribution, and movement; and to establish and maintain governmental control of such necessaries during the war. For such purposes the instrumentalities, means, methods, powers, authorities, duties, obligations, and prohibitions hereinafter set forth are created, established, conferred, and prescribed. The President is authorized to make such regulations and to issue such orders as are essential effectively to carry out the provisions of this act.

AND WHEREAS it is further provided in said act as follows:

That from time to time, whenever the President shall find it essential to license the importation, manufacture, storage, mining, or distribution of any necessaries, in order to carry into effect any of the purposes of this act, and shall publicly so announce, no person shall, after a date fixed in the announcement, engage in or carry on any such business specified in the announcement of importation, manufacture, storage, mining, or distribution of any necessaries as set forth in such announcement, unless he shall secure and hold a license issued pursuant to this section. The President is authorized to issue such licenses and to prescribe regulations for the issuance of licenses and requirements for systems of accounts and auditing of accounts to be kept by licensees, submission of reports by them, with or without oath or affirmation, and the entry and inspection by the President's duly authorized agents of the places of business of licensees.

AND WHEREAS it is essential, in order to carry into effect the purposes of said act and in order to secure an adequate supply and equitable distribution and to facilitate the movement of certain necessaries hereafter in this proclamation specified, that the license powers conferred upon the President by said act be at this time exercised to the extent hereinafter set forth.

Now, therefore, I, Woodrow Wilson, President of the United States of America, by virtue of the powers conferred on me by

said act of Congress, hereby find and determine and by this proclamation do announce that it is essential, in order to carry into effect the purposes of said act, to license the importation, manufacture, storage, and distribution of the following necessaries: Fertilizers and fertilizer ingredients, including sulfuric acid, phosphate rock, acid phosphate, bones (raw, ground, or steamed), bone-black, basic slag, sodium nitrate, ammonia sulfate, cottonseed meal, slaughterhouse tankage, garbage tankage, castor pomace, fish scrap, base goods, cyanamid, calcium nitrate, dried blood, acidulated leather, hair, hoof meal, horn dust, ground leather, other unacidulated ammoniates, potash salts, cement dust, blast-furnace dust, kelp ash, kelp char, dried kelp, wood ashes, cottonseed hull ashes, potassium nitrate, tobacco waste, mixed fertilizers, sulfur, and all other fertilizers and fertilizer ingredients.

All individuals, partnerships, associations, and corporations engaged in the business of importing, manufacturing, storing, or distributing fertilizers or fertilizer ingredients (except those specifically exempted by said act of Congress, and except to the extent to which licenses have been issued under the proclamation of the President of January 3, 1918, relating to ammonia, ammoniacal liquors, and ammonium sulfates) are hereby required to secure licenses on or before March 20, 1918, which will be issued under such rules and regulations governing the conduct of the business as may be prescribed.

The Secretary of Agriculture shall carry into effect the provisions of said act, and shall supervise and direct the exercise of the powers and authority thereby given to the President, as far as the same apply to fertilizers and fertilizer ingredients, and to any and all practices, procedure, and regulations applicable thereto, authorized or required under the provisions of said act, and in this behalf he shall do and perform such acts and things as may be authorized or required of him from time to time by direction of the President and under such rules and regulations as may be prescribed by the President from time to time. All departments and agencies of the Government are hereby directed to coöperate with the Secretary of Agriculture in the performance of the duties hereinbefore set forth.

Applications for licenses must be made to the Law Department, License Division, United States Food Administration, Washington, D. C., upon forms prepared for that purpose.

Any individual, partnership, association or corporation, other than as hereinbefore excepted, who shall engage in or carry on the business of importing, manufacturing, storing, or distributing fertilizers or fertilizer ingredients, after the date aforesaid, without first securing such license, will be liable to the penalties prescribed by said act of Congress.

In witness whereof I have hereunto set my hand and caused the seal of the United States to be affixed.

Done in the District of Columbia this 25th day of February, in the year of our Lord 1918 and of the independence of the United States of America the one hundred and forty-second.

[SEAL.] WOODROW WILSON

By the President

ROBERT LANSING

Secretary of State

In the enforcement of the regulations prescribed in the President's proclamation, the Secretary of Agriculture has announced that he will be assisted by the following committee:

Charles W. Merrill, *chairman;* C. L. Alsberg, Karl F. Kellerman, A. E. Taylor, F. W. Brown, L. L. Summers.

RESEARCH INFORMATION COMMITTEE

The following statement is authorized by the Council of National Defense:

1—By joint action the Secretaries of War and Navy, with the approval of the Council of National Defense, have authorized and approved the organization, through the National Research Council, of a Research Information Committee in Washington with branch committees in Paris and London, which are intended to work in close coöperation with the officers of the Military and Naval Intelligence, and whose function shall be the securing, classifying, and disseminating of scientific, technical, and industrial research information, especially relating to war problems, and the interchange of such information between the allies in Europe and the United States.

ORGANIZATION OF COMMITTEES

2—The Washington committee consists of:

(*a*) A civilian member, representing the National Research Council, Dr. S. W. Stratton, chairman.

(*b*) The chief, Military Intelligence Section.

(*c*) The Director of Naval Intelligence.

3—The initial organization of the committee in London is:

(*a*) The scientific attaché representing the Research Information Committee; Dr. H. A. Bumstead, attaché.

(*b*) The military attaché, or an officer deputed to act for him.

(*c*) The naval attaché, or an officer deputed to act for him.

4—The initial organization of the committee in Paris is:

(*a*) The scientific attaché representing the Research Information Committee; Dr. W. F. Durand, attaché.

(*b*) The military attaché, or an officer deputed to act for him.

(*c*) The naval attaché, or an officer deputed to act for him.

FUNCTIONS OF FOREIGN COMMITTEES

5—The chief functions of the foreign committees thus organized are intended to be as follows:

(*a*) The development of contact with all important research laboratories or agencies, governmental or private; the compilation of problems and subjects under investigation; and the collection and compilation of the results attained.

(*b*) The classification, organization, and preparation of such information for transmission to the Research Information Committee in Washington.

(*c*) The maintenance of continuous contact with the work of the offices of military and naval attachés in order that all duplication of work or crossing of effort may be avoided, with the consequent waste of time and energy and the confusion resulting from crossed or duplicated effort.

(*d*) To serve as an immediate auxiliary to the offices of the military and naval attachés in the collection, analysis, and compilation of scientific, technical, and industrial research information.

(*e*) To serve as an agency at the immediate service of the commander-in-chief of the military or naval forces in Europe for the collection and analysis of scientific and technical research information, and as an auxiliary to such direct military and naval agencies as may be in use for the purpose.

(*f*) To serve as centers of distribution to the American Expeditionary Forces in France and to the American Naval Forces in European waters of scientific and technical research information, originating in the United States and transmitted through the Research Information Committee in Washington.

(*g*) To serve as centers of distribution to our allies in Europe of scientific, technical, and industrial research information originating in the United States and transmitted through the Research Information Committee in Washington.

(*h*) The maintenance of the necessary contact between the offices in Paris and London in order that provision may be made for the direct and prompt interchange of important scientific and technical information.

(*i*) To aid research workers or collectors of scientific, technical, and industrial information from the United States, when properly accredited from the Research Information Committee in Washington, in best achieving their several and particular purposes.

6—The headquarters of the Research Information Committee in Washington are in the offices of the National Research Council, 1023 Sixteenth Street; the branch committees are located at the American Embassies in London and Paris.

DYESTUFFS ASSOCIATION

At the meeting of manufacturers of and dealers in dyestuffs held in Rumford Hall, Chemists' Club, New York City, on March 6, 1918, to hear the report of the Organization Committee and to form a permanent organization, it was decided by a vote of 27 to 5 to confine the association strictly to manufacturers of dyes and intermediates.

The resolution presented to the meeting by the committee on organization read as follows:

INASMUCH as the interests of the American dyestuffs industry will be better served by having one association consisting of manufacturers only, and a separate association for dealers, now therefore be it

Resolved, That the organization committee recommend to the meeting on March 6, that there be formed an association of manufacturers of intermediates and dyes under the name of "Dyestuff Manufacturers' Association of America," or some similar name; and that there be formed a separate association consisting of dealers in dyestuffs and bearing an appropriate name.

The following were elected to the board of governors:

George H. Whayley	John Campbell Co.	New York
M. R. Poucher	E. I. du Pont de Nemours & Co.	Wilmington, Del.
Albert Blum	United Piece Dye Makers	Lodi, N. J.
August Merz	Heller & Merz Co.	Newark, N. J.
M. S. Orth	Marden, Orth & Hastings Cor.	New York
R. G. Jeffcott	Calco Chemical Co.	New York
Frank Hemingway	Frank Hemingway, Inc.	New York
L. A. Ault	Ault & Wiborg	Cincinnati
J. Merritt Matthews	Grasselli Chemical Co.	Cleveland
W. H. Cottingham	Sherwin-Williams Co.	Cleveland
Robert W. Kemp	Holliday, Kemp & Co.	New York
Robert P. Dicks	Dicks, Davis & Co.	New York
Elvin H. Killheffer	Newport Chemical Co.	Carrollton, Wis.
Samuel Isermann	Chemical Co. of America	New York
I. Stanley Stanislaus	Stanley Aniline Chem. Co.	Lock Haven, Pa.

Several of these will be selected as incorporators. Adjournment was taken subject to the call of the board of governors.

FOOD IN WAR TIME

A special emergency war course on Food in War Time is being given at the College of the City of New York under the chemistry department as Chemistry 29. One unit of college credit will be given those who have the necessary prerequisites and who complete all the required work, but those who wish to take the course without credit may enter as auditors. There is no tuition fee. A registration fee of one dollar for the entire course is charged. The lectures will be given in Doremus Lecture Theatre at 4 P. M. Dates, lectures, and lecture topics are as follows:

Series of Lectures by MISS LAURA CAUBLE, Consultant in Household Economy

MARCH 1. The Problem of Human Feeding. Food Requirements. (Exhibit.)
MARCH 5. Relative Food Values. The Choice of Foods. (Exhibit.)
MARCH 8. Making the Food Budget. Cost of Maintenance. (Exhibit.)
MARCH 12. The City's Markets. The Question of Distribution.
MARCH 15. The City's Source of Food Supply. New Foods. A Problem of Coöperation.

Series of Lectures by MR. ROBERT MCDOWELL ALLEN, Formerly Food and Drug Commissioner of Kentucky, Expert of the Ward Baking Company

MARCH 19. Cereals, World Production and Distribution.
MARCH 22. Bread Making in the Home and Bakery.
MARCH 26. Applied Science in Bread Making.
APRIL 9. Governmental Regulation—Sanitation and Conservation.
APRIL 12. Cereals in the Diet.

Series of Lectures by DR. LUCIUS P. BROWN, Department of Health, N. Y. City; Director of Bureau of Foods and Drugs

APRIL 16. Food Wastes After the Crop has Matured.
APRIL 19. Non-Essential Food Industries.
APRIL 23. Dehydration of Foods.
APRIL 26. The Work of the U. S. Department of Agriculture in War Time.
APRIL 30. Food Conservation for War Aid Purposes.
MAY 3. The U. S. Food Administration and Its Contacts with the Citizen.
MAY 7. Food Adulterations and Sanitation in War Time.

Series of Lectures by DR. H. C. SHERMAN, Professor of Food Chemistry, and MISS MARY G. MCCORMICK, Instructor in Nutrition, Columbia University

MAY 10. The Food Situation from the Standpoint of Nutrition.
MAY 14. Food as the Source of Human Energy.
MAY 17. Food as Material for Body Building.
MAY 21. Nutritional Characteristics of the Different Types of Food.
MAY 24. Relative Economy of the Different Types of Food.
MAY 28. The Importance of the Milk Supply.
MAY 31. The Opportunity of the Food Consumer.

MEETING WAR CONDITIONS AT RENSSELAER POLYTECHNIC INSTITUTE

The class of 1918 is to be graduated May first instead of the middle of June, and the class of 1919 on January 1, 1919. This plan necessitates the running of instructional work all summer, keeping the Institute going under full pressure for the upper classes without vacation interm'ssions. Unless modified by future changes, the work of the Freshman and Sophomore classes will continue as usual.

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

Success finally has crowned the prolonged efforts of representatives of the chemical industry to obtain a deferred classification for those chemists whose services are essential to the war industries. Prof. M. T. Bogert, chairman of the Committee on Chemistry for the National Research Council, and Dr. C. L. Parsons, Secretary of the AMERICAN CHEMICAL SOCIETY, with the efficient aid of other prominent chemists, were most active in securing this concession from the Secretary of War.

While the details of the reorganization of the War Industries Board have not been announced at this writing, it is stated authoritatively that it will have no bearing on the Chemical Section. The reorganization, however, is certain to have the important effect of defining the authority of the Chemical Section much more clearly than was the case previously. It is understood that L. L. Summers will continue as the administrative head of this section. He is being assisted in his administrative work by C. H. MacDowell. Mr. MacDowell also has direct charge of nitrates, alkalies, and chlorine. Dr. Samuel A. Tucker, of Columbia University, Dr. H. R. Moody, of the College of the City of New York, and J. M. Moorehead, of Chicago, have been added to the personnel of the section. Drs. Tucker and Moody are well known instructors in chemical subjects. Mr. Moorehead is a consulting chemical engineer. He will look after toluol and gas production for the War Industries Board.

No patent has been issued to Garabed Giragossian for his "free energy generator." A report to the effect that such a patent had been issued led to inquiry at the Patent Office. In reply J. T. Newton, the commissioner of patents, writes as follows:

"The Patent Office has not issued a patent to Garabed on his supposed invention. We have numerous applications for such things. In fact we get them almost daily, but as they are against demonstrated scientific principles, we refuse to grant patents thereon on the same ground, for example, that we refuse to grant patents for perpetual motion.

"I am sorry so much publicity has been given to this case, because it has a tendency to give a wrong impression of inventors as a class. They have done more for progress in America than has any other class and Garabed Giragossian is the exception and is not characteristic."

Exports of chemicals in January had a total value of $15,500,637. In January of 1917, the value of chemical exports was $17,102,702. Imports of chemicals in January of 1918 totalled $4,925,744. This compares with $4,046,080 in the corresponding month of 1917. Marked increases were shown in the amounts of chemicals sent to Japan, Brazil, British India and France. The principal decreases were shown in forwardings to the United Kingdom and to Mexico.

Some confusion having arisen as to the definition of the terms "ammonia, ammoniacal liquors or ammonium sulfate, from whatever source produced" as used in the proclamation of January 3, the Food Administration has interpreted it as meaning only the prime products of ammonia as produced in by-product coke oven plants, coal gas plants and nitrogen fixation plants. This

excludes druggists, wholesalers and dealers handling only secondary products. It also excludes persons using the prime products solely as ingredients in the manufacture of products not subject to license.

If it should become necessary, as seems quite probable, to restrict the use of ammonia, the Food Administration is making it very clear that plants with a low degree of efficiency will be the first to suffer. A great deal of waste has taken place, especially in the artificial ice industry, it is said, and many plants are reporting increased efficiency in the use of ammonia which is making possible the same output as in previous years with savings of ammonia running as high as 60 per cent.

Paint manufacturers and dealers at a meeting with officials of the Council of National Defense entered into a voluntary agreement to reduce house paints to 32 shades, after July 1. At present, more than 100 shades of house paint are being manufactured. To conserve tin, several sizes of containers are to be eliminated. The reduction in the number of shades has been carried even further. Enamels, for instance, will be restricted to eight shades; floor paint to eight; roof and barn paint to two; shingle stains to twelve; carriage paint to eight; marine varnishes to four.

Certain manufacturers of fertilizers have been charged by the Federal Trade Commission with using unfair methods of competition. Two large companies are said to have purchased raw materials at prices higher than were justified by conditions. This had the effect it is alleged of pushing prices to a point where they were prohibitive to small competitors. This and other charges will be the subject of a hearing in Washington on April 10.

To expedite traffic and to keep close account of the car supply, the Committee on Fertilizers of the Chemical Alliance has named transportation sub-committees in the railroad centers of the fertilizer-producing territory. The Committee on Fertilizers is one of the most active organizations doing war work in Washington and is rendering a very efficient service to the industry, all fertilizer manufacturers who come to Washington agree.

To meet very general objection to the sulfuric acid questionnaire prepared by the War Industries Board, new blanks are being sent out to the industry. The War Industries Board questionnaire called for so much clerical work each week that it is being replaced by the simpler questionnaire. The new inquiry asks only for production for the previous month, stocks on hand at the beginning and the end of each month, shipments, and total delivery on all contracts for the United States and the allied governments. In addition, manufacturers who are receiving raw materials from the government are asked to state their requirements for the ensuing three months.

Horace Bowker, Henry Howard, E. R. Grasselli, Charles H. McDowell, A. G. Rosengarten, D. W. Jayne, Charles G. Wilson, W. D. Huntington, F. A. Lidbury, J. D. Cameron Bradley and E. T. Connolly attended the meeting of the Board of Directors of the Chemical Alliance which was held in Washington on February 20.

C. H. Conner, of New York, is in charge of the wood chemical division of the Raw Materials Committee of the War Industries Board.

Weekly reports showing the production of by-product coke and the factors which prevent this industry from operating at maximum capacity have just been started by the Geological Survey. During the limited time covered by the new reports the industry has been operated at about 75 per cent of capacity. The chief limiting factor is inability to secure coal, which is chargeable almost entirely to car shortage.

UNVEILING OF THE PORTRAIT OF HERMAN FRASCH

On Sunday, the 3rd of March, it was the pleasure of the trustees of the Chemists' Club of New York to entertain Mrs. Herman Frasch and a party of her friends at luncheon. The occasion was the presentation by the guest of honor of a remarkably life-like and well-painted portrait of the late Herman Frasch. His daughter, Mrs. Whiton, and Mr. Hubert Vos, who painted the portrait, were among the company. In the absence of President Whitaker in Washington, Vice President Gustave W. Thompson presided. When coffee was served the following address was made by Mr. Ellwood Hendrick, of the committee appointed by the trustees to arrange for the ceremony:

There are two attitudes of mind in which to meet in memory of one who has gone ahead of us upon the long journey: we may congregate in dolor and address ourselves to regret at our loss in his passing, or we may, and I think with greater loyalty, rejoice in our good fortune and be glad that ours was the privilege to enjoy the benediction of his friendship. Let us to-day follow the path of the Greater Loyalty.

This is a large club and our members are of various rank and circumstance; indeed we are of many sorts and conditions of men. Some of us live out our little lives and hardly cast a ripple upon the surface of our days. A few do big things. "The moving finger writes, and having writ,...." there stands emblazoned a message for all mankind to see. Of such was Herman Frasch.

The emblazoned messages soon become so familiar that we take them as matters of course. The men who write them are usually modest. The feature of great men that is most often observed is that they are not peculiar at all but are, rather, remarkably like other men. They have the gift of vision, the art to do and the energy to persevere; and these are not showy qualities. As they complete their tasks, the world mechanically takes a step forward. Very frequently this happens so quietly that we need an historical perspective to find the origins of progress.

As a member of the club Mr. Frasch was especially interested in the efforts to make things run smoothly. In the council of good fellowship he would offer very sane and human views of such situations as arose, with which others were certain to agree and, as likely as not, re-propose his own ideas to him. He didn't mind; his main interest was to get things done.

In the course of time he grew rich, and this is a burden which few of us can bear without deterioration. It did not injure him. To members of the club, most of whom are in modest circumstances, he never showed a trace of rich man's vanity. Now very successful men are often difficult and wayward and even childish in their demands, and although we are happily free from them in the club, they abound in profusion throughout the land. The best answer as to the cause of their offenses is that they are short a generation of habits of grace in living and thinking. No one ever suggested that Herman Frasch lacked any needful generation of this sort. Wherever his forebears lived they must have been richly endowed with sympathy. This will explain the quality of his friendship for the club and his relations to it. They were never ostentatious, but they could always be counted on in time of need and when the clouds hung low.

One of his most distinctive qualities offers no side for any consideration save that of deep regret that he is not living today. That was his clean-cut, straightforward attitude toward affairs. He believed in this country. He was one hundred per cent American, despite his foreign birth. He was one of us.

When the scientific history of the great war is written, many instances that are now but slightly considered will loom large in the records. Let us note one of them. After the Germans had been turned at the Marne they entrenched themselves and proceeded with their repeated efforts to break through the allied lines in the West. The British had hardly any high explosives and the French barely enough for their own use. The United States undertook to supply them but a difficulty arose: Spanish

pyrites could not be brought over in adequate quantity to provide sulfuric acid to make them. The greatest pyrites mine in the country had been flooded—as likely as not by one of von Bernstorff's agents. Without high explosives the allied line would surely have weakened, and owing to the machinations of German agents the manufacture of munitions in this country almost came to a stop. At this point the results of the genius of the American, Herman Frasch, and the altruistic attitude of the great company which he founded came into play. By releasing their vast store of sulfur at a nominal price for the making of munitions the march of Prussian madness was stopped and the awful fate of Belgium and Picardy and Champagne was averted for Brittany and Normandy and even England itself. When we think of the countless thousands of men and women and little children thus saved from the atrocities of the German hordes, we may well be proud that one of our number was of such potent influence as an instrument of mercy!

Every one of us has his world within himself. What we touch and smell and see and hear will often make it or mar it for us. A kindly glance, the pressure of a hand, a word of encouragement: these things have their moments of fate. We shall now have, thanks to the abundant generosity of Mrs. Frasch, the likeness of our friend and fellow member for companionship. Thanks to the subtle art of Mr. Vos, it speaks. And thanks to his own good fellowship, his integrity of purpose and his resolution for the right, the voice is kindly, full of pleasant memories to those of us who knew him, and full of encouragement to those of us who are young.

. . . . . .

The party then entered the Social Room where the portrait was unveiled by Mrs. Frasch and formally accepted for the club by Vice President Thompson.

PERSONALS

Lieut. A. W. Davison has been transferred from Washington to Niagara Falls, New York, where he is supervising chemical plant construction and experimental operation at the Oldbury Electrochemical Company.

Mr. W. S. Allen, for many years chief chemist of the Laurel Hill plant of the General Chemical Company, has been transferred to New York. Mr. J. B. Barnett is the new chemist in charge at the Laboratory.

Dr. Paul H. M.-P. Brinton, professor of analytical chemistry in the University of Arizona, has been commissioned Captain in the Ordnance Reserve.

Mr. Pope Yeatman, consulting engineer of New York, has been placed in charge of the non-ferrous metals department of the War Industries Board, succeeding Eugene Meyer, Jr.

Mr. Nicholas Kozeloff has been appointed bacteriologist of the Louisiana Sugar Station to succeed Mr. W. L. Owen.

The U. S. Bureau of Mines has broadened the scope of its station at Urbana, Ill., to include work in coal and metal mining and the metallurgical industries of the Middle West. The present safety work will be continued and all work will be conducted under a coöperative agreement with the mining department of the University of Illinois. The bureau staff is under the superintendence of E. A. Holbrook, supervising mining engineer and metallurgist. Other members are W. B. Plank, in charge of safety, and F. K. Ovitz, chemist.

M. Henri Jequier, metallurgist of the Société Meniére et Metallurgique de Penarroya, and Dr. Auguste Hollard, consulting engineer, are on a visit to this country. The Penarroya Company, which has its headquarters in Paris, and mines and works in Spain, is the largest smelter and refiner of lead in Europe.

Dr. Yogoro Kato, professor at the Tokyo College of Technology and Director of the Nakamura Chemical Research Institute in Tokyo, who is on a professional visit to this country, attended the recent annual meeting of the American Institute of Mining Engineers in New York.

The Patent Office Society announces that a composite committee has been created by the National Research Council to make a preliminary study of the problems of the U. S. Patent Office. This committee is understood to comprise the following members: Leo H. Baekeland, Wm. F. Durand, Thos. Ewing, Frederick P. Fish, Robert A. Millikan, E. J. Prindle, Michael I. Pupin and S. W. Stratton. The action of the National Research Council in forming such a committee is understood to be in conformity with the wishes of the Commissioner of Patents J. T. Newton and Secretary of the Interior F. K. Lane. The special committee of the Patent Office Society urges all interested to forward any patent reform suggestions to Dr. Wm. F. Durand, National Research Council, Washington, D. C. It is not expected that patent reform can claim primary consideration during the continuance of the war, but it is felt that the time is ripe for at least a study of conditions.

Dr. B. Johnsen, formerly of the Forest Laboratories, Montreal, Canada, as chemical engineer in pulp and paper, is now research chemist for the Hammermill Paper Company, Erie, Pa.

Colonel W. R. Lang, professor of chemistry and director of chemical laboratories, University of Toronto, has left for Halifax to take up staff duties in his new appointment in the Halifax Military District, under General F. L. Lessard.

The March meeting of the Delaware Section was held on March 8 in Wilmington. Following an informal dinner, Prof. Edward Hart spoke on "The Manufacture of Nitric Acid." The following officers have been elected: *Chairman*, Lammot du Pont; *Vice Chairman*, J. G. Melendy; *Secretary*, R. P. Calvert; *Treasurer*, D. S. Ashbrook; *Councillors*, C. M. Stine and Firman Thompson.

Mr. Henry C. Howard, Jr., treasurer and chief chemist of the Charles A. Newhall Company, Seattle, Washington, has joined the 30th Engineers and is now stationed at Ft. Myer, Va. Mr. Howard has specialized in electrochemistry and has recently developed a process for the manufacturing of potassium perchlorate, the potassium salts being derived from kelp. The process is now being operated on a commercial scale in Seattle.

Dr. E. H. Leslie has resigned from his position as chief chemist of the Petroleum Corporation of Los Angeles and has assumed new duties as technical adviser to the Sales Department of the U. S. Industrial Alcohol Company and the U. S. Industrial Chemical Company. He will be located in their main offices at 27 William Street, New York City.

Mr. John Clifford English, well known in Philadelphia and New York as a chemist, physicist and expert in acoustics, died suddenly at San Antonio, Texas, where he had gone to regain his health.

Dr. S. A. Mahood, formerly instructor in organic chemistry at Cornell University, is now research chemist in the U. S. Forest Products Laboratory, Madison, Wisconsin.

Mr. W. H. Whitcomb, formerly professor of chemistry at Miami University, Oxford, Ohio, is now with the United States Rubber Company engaged in laboratory development work.

Mr. T. F. Chin, of Pekin, China, principal technical expert of the Chinese Ministry of War, is in this country with the Chinese mission to make purchases for the outfitting of an extensive chemical laboratory at Pekin for his government.

Mr. V. T. Stewart has been given charge of the new laboratory at Silver Lake, N. J., which will serve all the plants of Thos. A. Edison located at that point. He was previously engaged in research work on primary batteries for one of these plants.

Mr. Frank L. McCartney, formerly with Sharp and Dohme, but during the past two years manager of the Albodon Company, has been appointed Captain, Sanitary Corps, National Army, and will be stationed at the Medical Supply Depot, New York City. He is ex-chairman of the New York Board of Trade and Transportation, Drug Trade Section, and is president of the New York Branch of the American Pharmaceutical Association. He has been granted leave of absence by the Albodon Company for the duration of the war.

Dr. W. F. Faragher has resigned his position as research chemist for the Alden Speare's Sons Co. to become senior fellow at the Mellon Institute of Pittsburgh.

Dr. Fred W. Upson, for the past four years professor of agricultural chemistry in the Nebraska College of Agriculture, will on June 1 become head of the department of chemistry in the University of Nebraska. A chemical laboratory which is modern in every respect will be ready for occupancy at that time. The work of the departments of chemistry will be combined under the direction of Dr. Upson.

Dr. George L. Clark, who left a professorship at the University of Arizona to take the Ph.D. at the University of Chicago in January 1918, is engaged in research at the American University Experiment Station, Washington, D. C.

Prof. D. M. Folsom, of the department of mineralogy of Stanford University, has been appointed Fuel Administrator of the Western States. His jurisdiction will cover Idaho, Montana, Utah, Arizona, New Mexico, Nevada, Oregon, Washington, California and Alaska.

Mr. Sydney J. Jennings, vice president of the U. S. Smelting, Refining and Mining Company, has been elected president of the American Institute of Mining Engineers to succeed Philip M. Moore, of St. Louis.

Prof. G. H. Clevenger has resigned as research professor of metallurgy at Stanford University and is now engaged in directing coöperative experimental work which is being done by the United States Bureau of Mines, Netherlands East Indies Government, Research Corporation of New York, and others.

Mr. Arthur F. Brown, formerly with Swan-Meyers Company, is now located with the Griswold Worsted Company, Darby, Pa.

Dr. John Johnston has been appointed Secretary of the National Research Council. Dr. Johnston will devote his activities largely to the development of an industrial research section, the purpose of which is to assist in the organization of research by industries, a work similar to that now being carried out under government auspices in Great Britain and some of the British Dominions by the committee of the Privy Council for scientific and industrial research.

Word was received late in February announcing the death of Thomas Tyrer, one of England's most prominent pharmaceutical chemists, at the age of seventy-six. He was one of the patriarchs of the Society of Chemical Industry, at one time its president, and at the time of his death was Hon. Treasurer of that organization. He was a fellow of the Institute of Chemistry, of the Chemical Society and of the Statistical Society. He served as president of the British Pharmaceutical Conference, with which body he was closely identified throughout his life. Mr. Tyrer was well known in the United States and was a member of the American Chemical Society. His last visit to this country was in 1895. It was as a result of his unremitting labors that alcohol for use in the arts became tax-free in the British Empire.

Major Samuel C. Prescott, of the Sanitary Corps, National Army, who is professor of biology at the Massachusetts Institute of Technology, is about to make an extended tour through the cantonments of the South and West.

Professor Elmer P. Kohler, of the chemistry department of Harvard University, has been called to Washington, D. C. He will be stationed at the American University Experiment Station of the Bureau of Mines as assistant to the Director in charge of research problems. Professor Kohler's work at Cambridge will be carried on by Professor Ferris J. Moore, of the Massachusetts Institute of Technology, and by Dr. G. Albert Hill, of the Harvard chemical department. As a consequence of Professor Kohler's call the Harvard University detachment of the Chemical Service Corps has been transferred to Washington. Included in the detachment are the following members of the Northeastern Section: Lieut. Lee I. Smith, Sergeant Roy L. Gunter and Private Alexander D. MacDonald.

Dr. William M. Burton has been awarded the 1918 Willard Gibbs gold medal by the Chicago Section of the A. C. S. Dr. Burton was born in Cleveland, Ohio, November 17, 1865, and received his early education in the public schools of that city. In 1886 he was graduated from Western Reserve University with the degree of A.B. He then went to Johns Hopkins where he took his Ph.D. in chemistry in 1889. Dr. Burton then entered the employ of the Standard Oil Company of Ohio as chemist. In 1890 he went to the Standard Oil Company of Indiana, where he has been successively chemist, assistant superintendent and general superintendent of the company's refinery at Whiting, Ind., and now is vice president of the company, in charge of all manufacturing activities. In 1913 Dr. Burton brought out a practical pressure still process for converting high boiling point products of petroleum into products of low boiling point, thereby largely increasing the supply of gasoline and other naphtha products.

Lieut. Ellery K. Files of the Gas Defense Service has been transferred from Washington to be instructor of the National Army camp at Yaphank, L. I.

Mr. James Brown, formerly professor of chemistry at Butler College, has entered the commercial field and is now located in New York City.

Mr. Grover B. Purkey, assistant foreman in the chemical department of Eli Lilly & Company, died February 2. Mr. Purkey was born at Morocco, Indiana, and was a graduate of Purdue University.

Dr. Martha Tracy, of the Philadelphia Section, has been appointed Dean of the Woman's Medical College of Pennsylvania.

The Bureau of Standards has announced the appointment of Mr. Samuel S. Wyer, a consulting engineer of Columbus, Ohio, and Mr. Willard F. Hine, chief gas engineer of the Public Service Commission of the First District, New York State, as consulting engineers on the staff of the Bureau of Standards. These engineers will assist the Bureau in conferences and special investigations from time to time in order that the Bureau's regular staff may be augmented for particular and important work. These two appointments are the first which have been made by the Bureau under its new program of appointing permanent specialists in different fields to assist it as advisers and consultants in its investigations.

Dr. Francis G. Benedict, director of the nutrition laboratory of the Carnegie Institute, Brookline, Mass., has received a gold medal from the National Institute of Social Sciences, in recognition of his "notable service to mankind." The medal was presented at the recent fifth annual dinner of the National Institute in New York City.

Dr. Arthur H. Elliott, emeritus chief chemist of the New York Consolidated Gas Company and emeritus professor of chemistry and physics in the College of Pharmacy, died on March 2, at the age of seventy years.

Mr. H. E. Ives, of the United Gas Improvement Company of Philadelphia, Pa., has entered the Science and Research Division of the Signal Corps, and may be reached at 1023 Sixteenth Street, Washington, D. C.

Lieut. Col. Allerton S. Cushman, U. S. A., now connected with the Frankford Arsenal, will speak before the Philadelphia Section of the A. C. S. on "Chemistry and Its Applications to the Manufacture of Military Primers" on April 18, 1918.

Dr. Charles L. Reese, of E. I. du Pont de Nemours and Co., will deliver an illustrated lecture on "Explosives" before the Franklin Institute, Philadelphia, on April 4.

Mr. Samuel Batterman has entered the government service. He is in the Division of Forestry.

Mr. A. P. Peterson, formerly with the Western Electric Co., is now Second Lieutenant, U. S. R., 26th infantry, A. E. F.

Dr. Julius Stieglitz, Mr. A. V. H. Mory and Mr. William Hoskins were the delegates of the A. C. S. to the Congress of National Service, which was held in Chicago, February 21, 22 and 23. The Congress was under the auspices of the National Security League.

Lieut. Harold J. Brownlee, Company C, 110th Regular Engineers, has been promoted to Acting Captain. He is located at Camp Doniphan, Fort Sill, Okla.

The National Aniline and Chemical Company held its annual meeting on February 18. Stockholders voted to increase the number of directors and the following names were added to the Board: L. C. Jones, Clinton S. Lutkins, R. C. Taggesell and Orlando F. Weber. The other directors re-elected are J. F. Schoellkopf, J. F. Schoellkopf, Jr., C. P. Hugo Schoellkopf of the Schoellkopf Aniline and Chemical Works, Inc.; W. Beckers, Eugene Meyer, Jr., Charles J. Thurnauer, of the W. Beckers Aniline and Chemical Works, Inc., I. F. Stone of the National Aniline and Chemical Company; Henry Wigglesworth, J. M. Goetchius of the General Chemical Company; T. M. Rianhard, W. H. McIlravy of the Barrett Company; H. H. S. Handy and E. L. Pierce of the Semet-Solvay Company.

At the adjourned meeting of the board of directors held on March 12, the following officers were elected for the ensuing year: *President and Chairman of the Board*, William J. Matheson; *Vice Presidents*, William Beckers, Robert Alfred Shaw, I. F. Stone and C. L. Jones; *Treasurer*, Henry I. Moody; *Assistant Treasurers*, G. W. Yates and T. S. Baines; *Secretary*, William T. Miller; *Assistant Secretary*, W. E. Rowley; *Chairman of the Executive Committee*, Henry Wigglesworth.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE[1]	PATENT	APPLICANTS
1906	837,017	Carl Auer von Welsbach, Vienna, Austria-Hungary	.....	Pyrophoric alloy	New Process Metals Co., New York
1910	976,760	Carl Auer von Welsbach, Vienna, Austria-Hungary	Treibacher Chemische Werke Gesellschaft, M. B. H. of Treibach, Austria-Hungary	Pyrophoric mass	New Process Metals Co., New York
1915	1,123,843	Philipp Burger, Berlin, Germany	.....	Depolarizer for galvanic cells	French Battery & Carbon Co., Madison, Wis.
1903	724,789	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Blue dye and process of making same	National Aniline & Chemical Co., 244 Madison Ave., New York
1904	753,659	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigschafen-on-the-Rhine, Germany	Anthracene derivative and process of making same	National Aniline & Chemical Co., 244 Madison Ave., New York
1903	739,145	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigschafen-on-the-Rhine, Germany	Anthracene dye	National Aniline & Chemical Co., 244 Madison Ave., New York
1914	1,104,943	Rudolf Uhlenhuth, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Process of producing amino-anthraquinones	National Aniline & Chemical Co., 244 Madison Ave., New York
1915	1,145,934	Adolf Steindorff and Robert Welde, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Finely divided vat dyestuffs and process of making same	National Aniline & Chemical Co., 244 Madison Ave., New York
1907	844,914	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigschafen-on-the-Rhine, Germany	Process of making an anthracene dye	National Aniline & Chemical Co., 244 Madison Ave., New York
1901	682,523	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigschafen, Germany	Blue dye and process of making same	National Aniline & Chemical Co., 244 Madison Ave., New York
1903	739,579	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigschafen-on-the-Rhine, Germany	Blue coloring-matter	National Aniline & Chemical Co., 244 Madison Ave., New York
1914	13,848 *Reissue*	Georg Korndörfer and Baptist Reuter, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Derivatives of diaminodioxy-arsenobenzene and process of making same	Farbwerke-Hoechst Co., New York, N. Y.
1913	1,075,171	Albrecht Thiele & George Wichmann, Berlin, Germany	Chemische Fabrik auf Actien (vorm. E. Schering), Berlin, Germany	Process for the manufacture of 2-phenylquinolin-4-carboxylic acid	The Abbott Laboratories, Inc., Chicago, Ill.
1914	1,101,111	Arthur Zitscher	.....	.....	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,034,853	Adolf Winther, August Leopold Laska and Arthur Zitscher	.....	.....	E. I. du Pont de Nemours & Co., Wilmington, Del.
1912	1,042,356	August Leopold Laska, Arthur Zitscher, and Felix Kunert	.....	.....	E. I. du Pont de Nemours & Co., Wilmington, Del
1916	1,206,232	August Leopold Laska	.....	.....	E. I. du Pont de Nemours & Co., Wilmington, Del
1915	1,150,863	Richard Just and Fritz Eckard	.....	.....	E. I. du Pont de Nemours & Co., Wilmington, Del.
1916	1,193,566	Felix Kunert, Offenbach-on-the-Main, Germany	Chemische Fabrik, Griesheim-Elektron, Frankfort-on-the-Main, Germany	Compounds for use in the production of dyestuffs	E. I. du Pont de Nemours & Co., Wilmington, Del.
1910	976,760	Carl Auer von Welsbach, Vienna, Austria-Hungary	Treibacher Chemische Werke Gesellschaft, M. B. H., Treibach, Austria-Hungary	Pyrophoric mass	Welsbach Company, Gloucester City, N. J.
1915	1,127,027	Felix Kunert & Edwin Acker, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany	Process of producing dyestuffs on the fiber by means of the one-bath method	E. I. du Pont de Nemours & Co., Wilmington, Del.

[1] This column in the March issue was incorrectly headed "Assignor."

The Aetna Explosives and Chemical Company is to build a plant at Huntington, Pa., which will be adapted for the manufacture of dyes and chemicals after the close of the war, when the orders for smokeless powder are expected to decrease. The buildings will cost about $500,000.

Mr. Alexander T. Vogelsang, First Assistant Secretary of the Interior, recently called a conference of all government officials in the department interested in oil development. Many members of Congress were invited. The purpose of the assemblage was to discuss the plans for the development of the oil shale lands of Colorado, Wyoming and adjacent states, and to outline a program of legislation.

Acting for the United States Government the Atlas Powder Company has started the construction of a $6,000,000 ammonium nitrate plant in Maryland.

The Board of Directors of the Chemical Alliance, Inc., have appointed a Philadelphia subcommittee, as follows: J. S. Coale of I. P. Thomas and Sons Co., Raymond W. Tunnel of F. W. Tunnel & Co., Inc., Theodore J. Taylor of the American Agricultural and Chemical Company. Mr. Frank Groves of the Groves Fertilizer Works has been added to the Cincinnati committee. Local committees for other points are now under consideration. Manufacturers at points where local subcommittees have been appointed are urgently requested to confer with such committees on all local transportation matters.

Another medical discovery ranking with phenolsulfonephthalein has been announced by Johns Hopkins University. It is the application of a product called benzyl acetate or benzyl benzoate as a local anti-spasmodic and a substitute for opium, or any one of its derivatives, or cocaine, heroin, and other narcotic alkaloids. The substance itself is not new, but it is the discovery of its peculiar properties in causing a relaxation of the muscles and producing the same effect as any of the narcotics mentioned, but without their ill results, that constitutes its importance. The discovery was made by Dr. David I. Macht, lecturer on pharmacology and instructor in medicine at the Medical School.

According to a statement made by Secretary Lane, development of American mines would supply 2,000,000 tons of minerals now imported and allow vessels now engaged in this work to carry additional food and supplies to the overseas forces. He believes that American mines can supply all these essential war minerals if given proper assistance by the Federal Government. He has asked Congress to make a special appropriation so that a large force of metallurgists can set to work immediately on necessary changes in practice to permit the use of lower grade manganese ores. He says new mines will be opened as permanent industries and new operators will be informed as to the best practices. Secretary Lane cites the urgent need for nitrates, sulfuric acid from pyrites and sulfur, manganese, flake graphite, tin, mercury, potash, tungsten, chromite, magnesite and mica.

The United States Government will finance the erection and operation in Canada of a plant, which will cost in the neighborhood of $2,000,000, for the manufacture of acetic acid on a large scale. Announcement to this effect was made at the annual meeting of the Shawinigan Water and Power Company, held in Montreal recently. It is understood that work will be started immediately on the new plant, which will be a duplicate of the plant owned and operated by the Shawinigan Water and Power Company through its subsidiary, the Canadian Electro Products Company. As the new plant will be financed by the United States Government, and its affairs will be separate from those of the Canadian Electro Products Company, it is probable that a new subsidiary company will be incorporated immediately.

The Bureau of Standards has purchased eight acres of land west of Connecticut Avenue, Washington, D. C., and has let contracts for a new engineering laboratory, 175 by 350 feet, and four stories in height. The new building and its equipment will cost in the neighborhood of $1,000,000 and will increase the capacity of the Bureau by 50 per cent. The Pittsburgh laboratory of the Bureau, including the work on glass and ceramics, will be transferred to Washington. It is expected that the new building will be ready for occupancy during the coming summer.

An announcement by the U. S. Food Administration states that during 1918 the Government should have for munitions alone many million pounds of ammonia more than it is possible to make by working all existing plants producing ammonia in this country to their maximum capacity. In view of this, a request for coöperation in the saving of ammonia was sent to 15,000 ice-making and cold storage firms.

The Ironton Portland Cement Company is erecting a potash recovery plant. The dust from 2000 barrels of cement will be handled daily. When it was ascertained that the dust escaping from Portland cement plants carried a fair percentage of potash, experiments were undertaken by the Western Precipitation Company. A year's trial has resulted in a greater income from potash than from cement.

According to the *Textile World Journal* paper is being used extensively in Germany in the manufacture of various articles of wearing apparel, and recently at Chemnitz an exhibition of such goods and paper yarns was held. The German weavers, on account of the lack of yarns of other material, are making increasing use of paper. It is expected that the paper yarns will soon be requisitioned by the Government for the needs of the army. The consumption is so great that the mills cannot satisfy the demands.

The stock of the Schutte and Koerting Company has been transferred to the Alien Property Custodian of the United States and on February 23, at his instance, the Board of Directors was reconstructed as follows: E. Pusey Passmore, governor of the Federal Reserve Bank, Philadelphia; Ralph J. Baker, assistant general counsel of the Alien Property Custodian; D. W. Hildreth, treasurer of Schutte and Koerting Co.; T. H. Johnston of Schutte and Koerting Co.; Chas. S. Calwell, president of the Corn Exchange National Bank, Philadelphia. The new board elected the following officers: *President*, Chas. S. Calwell; *Treasurer*, D. W. Hildreth; *Secretary*, Ralph J. Baker.

According to information received from K. P. McElroy who handled the patent and case, Judge Geiger in the federal court at Milwaukee has rendered decision holding that the patent 824,906 granted H. O. Chute for process of making wood alcohol is valid and infringed by the Wisconsin Chemical Co. at Hackley, Wis. The patent claims the process of making wood alcohol from pyroligneous liquor by distilling the crude acid through a continuous column or "beer" still to produce a distillate of about 24 per cent alcohol from which the oils separate readily and this alcohol is treated with excess of alkali and redistilled in continuous column stills, producing perfectly miscible alcohol of greater than 82 per cent strength. The process and apparatus was introduced by the patentee at Ashland, Wis., in 1905, and later in the year the Cleveland Cliffs Co. bought apparatus and license for their plants at Marquette and Gladstone. Later it was used at Manistique, Newberry and Antrim, Mich. In 1907 the Lake Superior Iron and Chemical Co. bought license for its use at Ashland, Newberry, Manistique, and Elk Rapids. Suit was brought against the Antrim Chemical Co. and compromised by their purchasing a license. About 1200 cords of wood were worked daily under this patent process. The Wisconsin Chemical Co. at Hackley put in a plant and used the process, and suit was begun against them in 1909 with the final determination of the validity of the patent as indicated by the above decision.

The New Jersey State Board of Public Utility Commissions has extended for thirty days the order of January 26 last, allowing the Public Service Gas Company to lower its gas standard. This action was brought about by the urgent request from the production division of the Army Ordnance Department of the United States Government to recover as much toluol as possible for the manufacture of explosives.

Considerable interest has been aroused in the non-combustible substitute for celluloid which has been invented by a professor in a Japanese university, and for the manufacture of which a company has been organized in Japan. The factory buildings are now in course of construction and it is planned to begin in April of this year, or soon after, the manufacture of waterproof cloth, composition tiles and insulators. As soon as the machinery, which has been ordered in the United States, arrives, the manufacture of imitation leather, linoleum, stained glass, marble, lacquers and varnishes will be started. Patent rights have been obtained for the process in Japan and have been applied for in Great Britain, France and the United States. Of the twenty-one patents applied for in this country, eleven have actually been granted under date of November 6, 1917, and bear serial numbers 1,245,818 and 1,245,975 to 1,245,984, inclusive. Copies of these patents may be obtained from the U. S. Patent Office, Washington, D. C.

One molybdenum mill is completed and two are about to start operations in Summit County, Colorado. The mill at Climax, Colorado, is turning out a high-grade molybdenite concentrate, said to be solely for Government use. One mill at Camp Urad, near Empire, Colorado, will have a daily output of 250 tons of the ore.

A company has been organized in Sweden for the utilization of the enormous peat deposits by the Wielandt process of distillation, by which a coke is produced. By-products include ammonium sulfate, wood alcohol, acetic acid, tar, motor fuels, lubricating oils, creosote, hard and soft paraffin, and pitch.

According to the *Journal of Commerce*, scarcity of phosphate rock has become so acute that several sulfuric acid plants will be forced to close, owing to their inability to store acid which ordinarily is mixed immediately on manufacture with the phosphate. Another serious side to the phosphate rock situation is the fact that fertilizer shipments are being delayed.

The Newago Portland Cement Company, Newago, Mich., has contracted with the Western Precipitation Company of Los Angeles for the necessary equipment to recover potash by the Cottrell process from the fumes of its cement plant. The Newago plant uses limestone and shale from quarries in northern Michigan, and has an output of about 70,000 barrels of cement per month. The mill uses what is known as the wet process of manufacturing cement. The best feature of this new industry is that it is certain to be permanent. The initial cost of installation of equipment is high, but the operating cost is trifling.

The Government will shortly take over the Dow Chemical Company's plants at Midland and Mount Pleasant, Michigan, and will advance $2,000,000 for enlargement and new equipment in order to adequately supply the chemicals needed in the manufacture of munitions. Mr. Dow will continue in the management, but otherwise the plants will be conducted as Government industries.

One of the first American owned and controlled companies to receive a license for the manufacture of drugs formerly made in Germany was the Rector Chemical Company, 2 Rector Street, New York, which holds license No. 5 for the manufacture of "Procaine," the drug introduced by the Germans as "Novocain." The German patent is set forth in the license. The manufacturing process has been approved by the Federal Trade Commission, which will have supervision of samples, tests and the price charged. The Farbwerke-Hoechst Company also holds a license for making "Procaine," but neither that company nor H. A. Metz has any interest in the Rector Chemical Company. A published statement that Mr. Metz owned the stock of the Rector Company was an error, it being the Farbwerke-Hoechst Company, only, in which Mr. Metz is interested. The two companies are competitors in the manufacture of "Procaine." The name is a contraction of pro-cocaine, the drug being a substitute for cocaine, as explained by Dr. Julius Stieglitz in an article in the *Journal of the American Medical Association* of February 23, who announces that the Rector Chemical Company has had the assistance of Professor Bailey of the University of Texas in perfecting their manufacturing processes.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

GEOLOGICAL SURVEY

Geologic Structure in the Cushing Oil and Gas Field, Oklahoma, and Its Relation to the Oil, Gas, and Water. C. H. Beal. Bulletin 658. 61 pp. The geologic work done in the field has disclosed the following principal facts: (1) The folding of the formations in the Cushing field usually becomes greater with increase of depth, and there are many marked differences in structure among the Layton, Wheeler, and Bartlesville sands and the surface beds. (2) The interval between the Layton and Bartlesville sands is generally greater around the edges of the anticlines than on their crests. (3) The distribution of the bodies of oil, gas, and water indicates that the source of the oil lies west of the Cushing field. (4) In general, the oil area in an elongated dome, where folding is simple, extends farther down on the long axes of the anticline or dome than on the steeper sides. (5) The water surfaces on which the oil and gas rest in the different sands are not level but are inclined away from the centers of the anticlinal folds.

Tin Resources of the Kings Mountain District, North Carolina and South Carolina. A. Keith and D. B. Sterrett. Bulletin 660-D, from Contributions to Economic Geology, 1917, Part 1. 24 pp. Published December 10, 1917. "The presence of cassiterite, oxide of tin, at many places in the Kings Mountain and Lincolnton quadrangles, at one place near Gaffney, in the Gaffney quadrangle, and at one locality in the Gastonia quadrangle, has led to much prospecting and to attempts at mining. In at least one place—the Ross mine, near Gaffney—placer mining was temporarily done at considerable profit. Several prospects have also been opened in the Lincolnton and Gastonia quadrangles north and northeast of the Kings Mountain quadrangle. Practically all the work on cassiterite-bearing veins has been done at a loss, but this work has not been sufficiently conclusive to prove or disprove the value of some of the deposits."

Louisiana Clays Including Results of Tests Made in the Laboratory of the Bureau of Standards at Pittsburgh. G. C. Matson. Bulletin 660-E, from Contributions to Economic Geology, 1917, Part 1. 12 pp. Published November 26, 1917.

The Antimonial Silver-Lead Veins of the Arabia District, Nevada. A. Knopf. Bulletin 660-H, from Contributions to Economic Geology, 1917, Part 1. 7 pp. Published January 7, 1918. "The Arabia district, in Humboldt County, Nev., is an old mining camp which, long idle after its first period of activity in the late sixties, has again become active under the stimulus of the present high prices of lead, antimony, and silver."

Mining Developments and Water-Power Investigations in Southeastern Alaska. T. Chapin, H. M. Eakin and G. H. Canfield. Bulletin 662-B, from Mineral Resources of Alaska, 1916-B. 92 pp.

The Gold Placers of the Tolovana District, Alaska. J. B. Mertie, Jr. Bulletin 662-D, from Mineral Resources of Alaska, 1916-D. 57 pp.

Gold Placers of the Anvik-Andreafski Region, Alaska. G. L. Harrington. Bulletin 662-F, from Mineral Resources of Alaska, 1916-F. 17 pp.

Lode Deposits and Gold Placers near the Nenana Coal Field, Alaska. R. M. Overbeck and A. G. Maddren. Bulletin 662-G, from Mineral Resources of Alaska, 1916-G. 52 pp.

Lode Mining in the Fairbanks District, Alaska. J. B. Mertie, Jr. Bulletin 662-H, from Mineral Resources of Alaska, 1916-H. 22 pp.

Bibliography of North American Geology for 1916, with Subject Index. J. M. Nickles. Bulletin 665. 100 pp. The bibliography of North American geology, including paleontology, petrology, and mineralogy, for the year 1916 follows the plan and arrangement of its immediate predecessors. It includes publications bearing on the geology of the continent of North America and adjoining islands; also Panama and the Hawaiian Islands. Papers by American writers on the geology of other parts of the world are not included. Textbooks and papers, general in character, by American authors are included; those by foreign authors are excluded unless they appear in American publications.

Zinc Carbonate and Related Copper Carbonate Ores at Ophir, Utah. G. F. Loughlin. Bulletin 690-A, from Contributions to Economic Geology, 1918, Part 1. 14 pp. Published December 24, 1917. From the processes of deposition here described it is to be expected that bodies of lamellar zinc carbonate like those at Ophir will prove to be of high grade, owing to the complete removal of limestone, but of small dimensions and confined to the immediate vicinity of fractures and open bedding planes. Such small bodies are not likely to lead to larger bodies of massive ore, unless they lie near to groundwater level, or to some impervious stratum or fault that impounded the waters containing the oxidized compounds of zinc.

In districts where mixed sulfide deposits in limestone contain both copper and zinc in considerable quantity the resulting carbonate ores of both metals are to be expected in the oxidized zone, the copper carbonate immediately below the position of the original sulfide body or its siliceous casing, and the zinc carbonate below the copper carbonate. The details of these relations, as well as the richness and size of the carbonate bodies, depend on such local factors as the purity and permeability of the limestone replaced and the relative openness of bedding planes and fractures, which must be determined for each deposit or group of deposits.

The Helderberg Limestone of Central Pennsylvania. J. B. Reeside, Jr. Professional Paper 108-K, from Shorter Contributions to General Geology, 1917. 41 pp. Published December 13, 1917.

Chemical Analyses of Igneous Rocks. H. S. Washington. Professional Paper 99. 1182 pp. Paper, $1.75. This is a revision and expansion of Professional Paper 14. It contains more than a thousand large pages of tabulations of rock analyses. These are arranged according to the character of the rock and form probably the most complete summary of analyses ever prepared. The report can be obtained from the Superintendent of Documents at $1.75 per copy.

BUREAU OF CENSUS

Cast-Iron Pipe. Census of Manufactures 1914. Separate. 7 pp. This and the following separates are each one of a series of bulletins being issued by the Bureau, presenting statistics of industries concerning which inquiries were made at the quin-

quennial census of manufactures in 1914. Statistics are presented in three sections: Summary and analysis, giving general data compiled for industry; special statistics relating to materials, products, and methods of manufacture, and State tables, giving comparative summary, by States, for 1904, 1909 and 1914, and detailed statistics for industry, by States, 1914

Iron and Steel. Census of Manufactures, 1914, Separate. 68 pp.

Brass, Bronze and Copper Products. Census of Manufactures, 1914. Separate. 11 pp.

Canning and Preserving. Census of Manufactures, 1914. Separate. 31 pp.

Manufacture of Buttons. Census of Manufactures, 1914. Separate. 9 pp.

Miscellaneous Textiles. Census of Manufactures, 1914. Separate. 27 pp.

Silk Industry. Census of Manufactures, 1914. Separate. 24 pp.

BUREAU OF MINES

Seventh Annual Report of the Director. For the fiscal year ended June 30, 1917. 106 pp. Paper, 15 cents.

Directions for Sampling Coal for Shipment or Delivery. G. S. Pope. Technical Paper 133. 15 pp. Paper, 5 cents. "In the field work of the Bureau of Mines need has arisen for a circular giving brief directions for sampling coal at points in the field where the conditions for sampling are not fixed, and usually no such facilities are at hand for methodically collecting and preparing samples as are available at power plants that regularly receive and sample coal. Frequently there is need of sampling a special shipment of coal as it is loaded into railroad cars at the mine or as it is unloaded from railroad cars into bins or ships, and at such times there is need of printed instructions regarding hand methods of sampling. This paper has been prepared to meet the need stated and is issued in the hope that it will be of service in the collection and preparation by hand of samples of coal in the field."

Gypsum Products: Their Preparation and Uses. R. W. Stone. Technical Paper 155. 64 pp. Paper, 20 cents.

This paper has been prepared by R. W. Stone, of the U. S. Geological Survey, from information collected by him in the course of a comprehensive investigation of the gypsum deposits in the United States for the Geological Survey. The distribution of the deposits, their extent, their stratigraphic relations, and the conditions under which they formed will be described in a Survey bulletin. This report discusses the methods of mining or quarrying gypsum, the equipment and operation of plants for reducing the crude rock to commercial plaster, and the various forms in which gypsum products are marketed.

Although a minor industry, the manufacture of gypsum possesses decided importance. In 1915 the total amount of calcined plaster produced in this country amounted to 1,613,720 short tons, valued at $5,946,018, and the total value of all gypsum products was approximately $7,000,000. Sixty-eight plants were engaged in the production of gypsum and the manufacture of gypsum products, and these plants represented a capital investment of probably not less than $20,000,000.

In view of the greater attention being given to fire resistance and other desirable features of construction, the use of gypsum products in buildings is bound to increase. Also, as manufacturing industries become more varied and refined, the use of gypsum products for other purposes than in buildings will become larger. For these reasons this paper is printed by the Bureau of Mines in the hope that it will aid the development and utilization of one of the country's mineral resources and will thereby promote the advancement of the general welfare.

Compressibility of Natural Gas and Its Constituents, with Analyses of Natural Gas from 31 Cities in the United States. G. A. Burrell and I. W. Robertson. Technical Paper 158. 16 pp. Paper, 5 cents. "As a continuation of the work described in a previous publication of the Bureau of Mines, which presented the compressibility of the natural gas used in Pittsburgh, Pa., at pressures ranging from atmospheric up to 35.5 atmospheres, this paper shows the compressibility of three of the hydrocarbon gases (methane, ethane, and propane) that comprise natural gas, of carbon dioxide (another constituent of natural gas), and of natural gas from nine different cities. In addition, it contains analyses of natural gas from 31 cities and presents a formula by which the compressibility of any natural gas can be determined from the analysis. Data regarding other analyses and the composition and characteristics of natural gas, are given in previous publications of the Bureau of Mines."

Methods for Increasing the Recovery from Oil Sands. J. O. Lewis. Bulletin 148. 120 pp. Paper, 15 cents. "In the face of a demand that is increasing faster than the production and that, in the consensus of opinions of well-informed authorities, is soon likely to outstrip the productive capacity, it is well to consider whether it is not possible to extract more oil from the known sources of supply. It is universally acknowledged that by the usual production methods much oil is left underground, the general opinion being that at least 50 per cent of the oil in a field remains unrecovered when the field is abandoned as exhausted. From the writer's own investigations he believes the average recovery is even less, and if any considerable portion of this oil being left underground could be made available it would have a tremendously favorable influence on the petroleum industry and all the industries dependent on it.

"In this publication are considered the principles involved in increasing recovery and methods of extracting more oil from the oil-bearing formations than by the usual ways of producing. These methods are: The use of gas or vacuum pumps, forcing compressed air or gas through the oil-bearing formations, displacing the oil by water, and better utilization of the natural pressures in the oil-bearing formations. Especial attention is being given to a process commonly known as the Smith-Dunn for forcing compressed air through oil-bearing formations because it is believed to hold most promise for the future."

DEPARTMENT OF AGRICULTURE

The Expansion and Contraction of Concrete and Concrete Roads. A. T. Goldbeck and F. H. Jackson, Jr. Contribution from the Office of Public Roads and Rural Engineering. Bulletin 532. 31 pp. Paper, 10 cents. Issued October 13.

Increased Yield of Turpentine and Rosin from Double Chipping. A. W. Schorger and R. L. Pettigrew. Bulletin 567. Contribution from the Forest Service. 9 pp. Paper, 5 cents. Issued October 2. Describes a method of securing more naval stores from the same tree, and is of interest to all naval-stores operators.

The Recovery of Potash as a By-Product in the Cement Industry. W. H. Ross, A. R. Merz and C. R. Wagner. Bulletin 572. Contributions from the Bureau of Soils. 23 pp. Paper, 5 cents. Issued October 5. A discussion of the possibility of recovering potash from waste in cement-producing plants and a description of the various processes used.

A Guide for Formulating a Milk Ordinance. Prepared in the Dairy Division of the Bureau of Animal Industry and the Bureau of Chemistry. Bulletin 585. Contribution from the Bureau of Animal Industry and the Bureau of Chemistry. 4 pp. Paper, 5 cents. Issued October 18. Of interest to town, city, and other officials interested in the improvement of the milk supply.

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Agricultural Bacteriology. H. W. CONN. 8vo. 357 pp. Price, $2.00. P. Blakiston's Son & Co., Philadelphia.

Analysis: Essentials of Volumetric Analysis. H. W. SCHIMPF. 3rd Ed. 8vo. 366 pp. Price, $1.60. John Wiley & Sons, Inc., New York.

Analysis: Qualitative Analysis Section of Chemistry by Experimentation. W. F. HOYT. 12mo. 160 pp. Price, $0.25. D. Van Nostrand & Co., New York.

Analysis: Quantitative Chemical Analysis. F. CLOWES AND J. B. COLEMAN. 11th Ed. 8vo. 604 pp. Price, 12s. 6d. J. & A. Churchill, London.

Analysis: Standard Methods of Chemical Analysis. W. W. SCOTT. 2nd Ed. 8vo. 898 pp. Price, $6.00. D. Van Nostrand Co., New York.

British Grasses and Their Employment in Agriculture. S. F. ARMSTRONG. 8vo. 199 pp. Price, $2.00. C. P. Putnam's Sons, New York.

Chemistry: Travaux pratiques de chimie général. G. LEPERCQ. 8vo. 83 pp. M. Girard et E. Brière, Paris.

Coking: Modern Coking Practice. J. E. CHRISTOPHER. 8vo. 124 pp. Price, 7s. 6d. Crosby Lockwood & Son, London.

Dyes and Dyeing. C. E. PELLEW. 12mo. 274 pp. Price, $2.00. Robert M. McBride, New York.

Earthenware: Notes on the Manufacture of Earthenware. E. A. SANDEMAN. 12mo. 375 pp. Price, $3.00. D. Van Nostrand Co., New York.

Electrochemistry: L'Electrochimie et l'Electrometallurgie. A. LEVASSEUR. 8vo. 267 pp. Price, 9 fr. H. Dunod et E. Pinat, Paris.

Fans, Heaters and Air Washers. B. F. STURTEVANT CO. 4to. 959 pp. Price, $7.50. The Author, Boston.

Food: Its Composition, Preparation and Effects. J. H. TILDEN. 12mo. 306 pp. Price, $3.50. The Author, Denver, Col.

Forging: A Manual of Practical Instruction. J. JERNBERG. 8vo. 131 pp. Price, $1.00. American Technical Society, Chicago.

Fresh Water Biology. H. B. WARD AND G. C. WHIPPLE. 8vo. 1111 pp. Price, $6.00. John Wiley & Sons, Inc., New York.

Fuels: The Calorific Power of Fuels. HERMAN POOLE. 3rd Ed. 8vo. 267 pp. Price, $3.00. John Wiley & Sons, Inc., New York.

Gas Chemists' Handbook. 8vo. 354 pp. Price, $3.50. American Gas Institute, New York.

Gas-Engine Handbook. E. W. ROBERTS. 12mo. 315 pp. Price, $2.00. Gas Engine Pub. Co., Cincinnati.

Gas, Gasoline and Oil Engines. G. D. HISCOX. 22nd Ed. 8vo. 640 pp. Price, $2.50. Norman W. Henley Pub. Co., New York.

History of Commerce and Industry. C. HERRICK. 8vo. Price, $2.00. The Macmillan Co., New York.

Industrial Chemistry: L'Enseignement de la chimie industrielle en France. E. GRANDMOUGIN. 16mo. 185 pp. Price, 3fr.50. H. Dunod et E. Pinat, Paris.

Internal Combustion Engine Manual. F. W. STERLING. 4th Ed. 8vo. 168 pp. Price, $2.00. D. C. R. Beresford, Washington, D. C.

Iron Prices: Complete List of Base Prices, Differentials, and Extras on Iron, Steel and Non-Ferrous Products. PENTON PUBLISHING CO. 8vo. 42 pp. Price, $2.00. Penton Pub. Co., Cleveland.

Metals: A la recherche de deux métaux inconnus. MAX GERBER. 8vo. 32 pp. Price, 4fr. Moniteur scientifique Quesneville, Paris.

Microscopic Analysis of Cattle Foods. T. N. MORRIS. 12mo. 74 pp. Price, $0.60. G. P. Putnam's Sons, New York.

Oils and Fats: Aids to the Commercial Analysis of Oils, Fats and Their Commercial Products. G. F. PICKERING. 8vo. 141 pp. Price, 7s. 6d. Charles Griffin & Co., London.

Oils and Fats: Technical Handbook of Oils, Fats and Waxes. P. J. FRYER, AND F. E. WESTON. 8vo. 279 pp. Price, $3.00. G. P. Putnam's Sons, New York.

Organic Chemistry Including Certain Portions of Physical Chemistry. H. D. HASKINS. 12mo. 472 pp. Price, $2.00. John Wiley & Sons Inc., New York.

Sands: A Supplementary Memoir on British Resources of Sands and Rocks Used in Glass Manufacture. P. G. H. BOSWELL. 8vo. 92 pp. Price, $1.00. Longmans, Green & Co., New York.

Staining and Polishing. Including Varnishing and Other Methods of Finishing Wood. 8vo. 218 pp. Price, 3s. 6d. Evans Bros., London.

Steam Engines: Les Machines à vapeur. F. CORDIER. 18mo. 402 pp. Octave Doin et fils, Paris.

Steel and Its Heat Treatment. D. K. BULLENS. 2nd Ed. 8vo. 483 pp. Price, $4.00. John Wiley & Sons, Inc., New York.

Technical Mechanics, Statics and Dynamics. E. R. MAURER. 8vo. 381 pp. Price, $2.75. John Wiley & Sons, Inc., New York.

Thermodynamics: Notes on Thermodynamics. H. W. SPANGLER. 12mo. 77 pp. Price, $1.00. John Wiley & Sons, Inc., New York.

Transmission Gears. E. BUTLER. 8vo. 164 pp. Price, 8s. 6d. Charles Griffin & Co., London.

Wood: Seasoning of Wood. J. B. WAGNER. 8vo. 274 pp. Price, $3.00. D. Van Nostrand Co., New York.

RECENT JOURNAL ARTICLES

Absorption Refrigerating Machines. F. C. SPANGLER *Power*, Vol. 47 (1918), No. 8, pp. 274–277.

Acetylene: Characteristics and Properties of Acetylene. G. G. POND. *Journal of Acetylene Lighting*, Vol. 19 (1918), No. 9, pp. 295–297.

Acid Making: Theory and Practice of Acid Making. E. R. BAREER. *Paper*, Vol. 21 (1918), No. 23, pp. 24–28.

Bauxite Products. J. M. HILL. *Mining and Scientific Press*, Vol. 116 (1918), No. 8, pp. 267–268.

Blast Furnace: Description of Manchurian Blast Furnace. C. F. WANG. *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 3, pp. 109–111.

Bleaching: Notes on Bleaching Cotton. J. M. MATTHEWS. *Color Trade Journal*, Vol. 2 (1918), No. 2, pp. 53–58.

Burner-Gas Cooling. A. S. COSLER *Paper*, Vol. 21 (1918), No. 23, pp. 19–24.

By-Product Coke Oven and Its Products. W. H. BLAUVELT. *Transactions of the American Institute of Mining Engineers* (1918), No. 135, pp. 597–614.

Canvas Tubing for Mine Ventilation. L. D. FRINK. *Mining and Scientific Press*, Vol. 116 (1918), No. 7, pp. 223–227.

Cellulose: The Estimation of Cellulose in Wood. B. JOHNSEN AND R. W. HOVEY. *Paper*, Vol. 21 (1918), No. 23, pp. 36–52.

Colors: The Action of Carbonate of Lead, Sulfate of Lead and Zinc Oxide on Tinting Colors. G. B. HECKEL. *Paint and Varnish Record*, Vol. 14 (1918), No. 3, pp. 10–16.

Dextrine: The Development of the American Dextrine Industry. JOSEPH MORNINGSTAR. *Color Trade Journal*, Vol. 2 (1918), No. 2, pp. 67–69.

Dyestuffs of the Ancients. C. E. PELLEW. *Color Trade Journal*, Vol. 2 (1918), No. 2, pp. 50–52.

Engineering and Coöperation. I. N. HOLLIS. *Journal of the Cleveland Engineering Society*, Vol 10 (1918), No. 4, pp. 225–250.

Filtration: Plate- and Frame-Filtration. D. R. SPERRY. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 5, pp. 258–260.

Furnaces: High-Temperature Resistance Furnaces. W. E. RUDER. *Mining and Scientific Press*, Vol. 116 (1918), No. 9, pp. 301–303.

Glass: Some Common Problems in Melting and Working Glass. W. E. S. TURNER. *Journal of the Society of Glass Technology*, Vol. 1 (1917), No. 4, pp. 210–213.

Glass: The Use of Semi-Automatic Glass Making Machinery in America. R. E. MCCAULEY. *Journal of the Society of Glass Technology*, Vol. 1 (1917), No. 4, pp. 203–209.

Inorganic Chemical Synonyms. E. R. DARLING. *The Chemical Engineer*, Vol. 26 (1918), No. 3, pp. 107–112.

Leather: The Making of Artificial Leather. *DuPont Magazine*, Vol. 8 (1918), No. 2, pp. 8–10.

Lubrication: Notes on the Theory of Lubrication. LORD RALEIGH. *Philosophical Magazine*, Vol. 35 (1918), No. 205, pp. 1–12.

Manchuria Coal and Iron Deposits. C. F. WANG. *The Iron Trade Review*, Vol. 62 (1918), No. 7, pp. 433–435.

Manganese: Estimation of Manganese in Aluminum Alloys and Dust. J. E. CLENNELL. *Engineering and Mining Journal*, Vol. 105 (1918), No. 9, pp. 407–410.

Metallography of Aluminum. R. J. ANDERSON. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 4, pp. 172–178.

Mineral Blues. C. S. WEHRLY. *Color Trade Journal*, Vol. 2 (1918), No. 2, pp. 71–73.

Nickel and Brass Plating of Die Castings. R. J. HAZUCHA. *The Metal Industry*, Vol. 16 (1918), No. 2, p. 83.

Nickel Silver: Some Uses and Properties of Nickel Silver as Applied to the Optical Trade. G. C. HOLDER *The Metal Industry*, Vol. 16 (1918), No. 2, pp. 69–72.

Nitrocellulose from Wood Pulps. W. E. B. BAKER *Paper*, Vol. 21 (1918), No. 23, pp. 78–82.

Occluded Gases in Ferrous Alloys. G. ALLEMAN AND C. J. DARLINGTON. *Journal of the Franklin Institute*, Vol. 185 (1918), No. 2, pp. 161–198.

Paper: Practical Paper Making J. J. SULLIVAN *Pulp and Paper Magazine*, Vol. 16 (1918), No. 8, pp. 173–176.

Paper: A Review of Pulp and Paper Manufacturing in Canada. A. L. DAWE *Pulp and Paper Magazine*, Vol. 16 (1918), No. 9, pp. 207–209.

Porcelain: Experimental Investigation of Porcelain Mixes. C. J. GILCHRIST AND T. A. KLINEFELTER *The Electro Journal*, Vol. 15 (1918), No. 3, pp. 77–81.

Potash Recovery from Blast Furnace Dust. R. A. BERRY AND D. N. MCARTHUR *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 3, pp. 130–134.

MARKET REPORT—MARCH, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON MARCH 20, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lbs.	4.00	@	4.50
Aluminum Sulfate, high-grade	Lb.	2¾	@	3
Ammonium Carbonate, domestic	Lb.	11	@	11¾
Ammonium Chloride, white	Lb.	15½	@	16
Aqua Ammonia, 26°, drums	Lb	26	@	27
Arsenic, white	Lb.	16¾	@	17
Barium Chloride	Ton	65.00	@	85.00
Barium Nitrate	Lb.	9½	@	11
Barytes, prime white, foreign	Ton	40.00	@	45.00
Bleaching Powder, 35 per cent	100 Lbs.	2.25	@	2.50
Blue Vitriol	Lb.	9¼	@	9½
Boraz, crystals, in bags	Lb.	7¾	@	8¾
Boric Acid, powdered crystals	Lb.	13¼	@	15
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	85
Calcium Chloride, lump, 70 to 75% fused	Ton	25.00	@	30.00
Caustic Soda, 76 per cent	100 Lbs	4.25	@	4.50
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	15.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	1.75	@	3.00
Green Vitriol, bulk	100 Lbs.	1.15	@	1.25
Hydrochloric Acid, commercial, 20°	Lb.	2¼	@	2½
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	15	@	16
Lead Nitrate	Lb.	nominal		
Litharge, American	Lb.	9½	@	11
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	22
Magnesite, "Calcined"	Ton	40.00	@	65.00
Nitric Acid, 40°	Lb.	8½	@	9
Nitric Acid, 42°	Lb.	9	@	10
Phosphoric Acid, 48/50%	Lb.	8	@	10
Phosphorus, yellow	Lb.	1.60	@	1.70
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate, casks	Lb.	45	@	47
Potassium Bromide, granular	Lb.	1.35	@	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	45	@	55
Potassium Chlorate, crystals, spot	Lb.	36	@	40
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	83½	@	84
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	28	@	30
Potassium Permanganate, bulk	Lb.	4.00	@	4.10
Quicksilver, flask	75 Lbs.	120.00	@	125.00
Red Lead, American, dry	Lb.	10	@	10½
Salt Cake, glass makers'	Ton	20.00	@	25.00
Silver Nitrate	Oz.	56¼	@	57¼
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.65	@	2.70
Sodium Acetate	Lb.	21	@	22
Sodium Bicarbonate, domestic	100 Lbs.	2.50	@	3.00
Sodium Bichromate	Lb.	22	@	23
Sodium Chlorate	Lb.	24	@	25
Sodium Cyanide	Lb.	40	@	43
Sodium Fluoride, commercial	Lb.	17	@	18
Sodium Hyposulfite	100 Lbs.	2.40	@	2.75
Sodium Nitrate, 95 per cent, spot	100 Lbs.	nominal		
Sodium Silicate, liquid, 40° Bé	100 Lbs.	2.25		
Sodium Sulfide, 60%, fused in bbls	Lb.	5		
Sodium Bisulfite, powdered	Lb.	5½	@	6
Strontium Nitrate	Lb.	23		
Sulfur, flowers, sublimed	100 Lbs.	4.05	@	4.50
Sulfur, roll	100 Lbs.	3.70	@	4.10
Sulfuric Acid, chamber 66° Bé	Ton	45.00	@	50.00
Sulfuric Acid, oleum (fuming)	Ton	75.00	@	80.00
Talc, American white	Ton	15.00	@	18.00
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	23¾	@	24½
Tin Oxide	Lb.	75	@	80
White Lead, American, dry	Lb.	9	@	9½
Zinc Carbonate	Lb.	25	@	30
Zinc Chloride, commercial	Lb	12½	@	14
Zinc Oxide, American process XX	Lb	14	@	15

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	77	@	78
Acetic Acid, 56 per cent, in bbls	Lb.	13	@	14
Acetic Acid, glacial, 99½%, in carboys	Lb.	37	@	39
Acetone, drums	Lb.	nominal		
Alcohol, denatured, 180 proof	Gal.	70	@	75
Alcohol, sugar cane, 188 proof	Gal	4.90	@	5.00
Alcohol, wood, 95 per cent, refined	Gal.	1.35	@	1.37
Amyl Acetate	Gal.	5.50	@	5.75
Aniline Oil, drums extra	Lb.	26	@	28
Benzoic Acid, ex-toluol	Lb.	4.75	@	5.25
Benzol, pure	Gal	30	@	35
Camphor, refined in bulk, bbls	Lb.	98½	@	99
Carbolic Acid, U. S. P., crystals, drums	Lb.	53	@	57
Carbon Bisulfide	Lb.	7	@	8
Carbon Tetrachloride, drums, 100 gal	Lb.	15½	@	16
Chloroform	Lb.	63	@	65
Citric Acid, domestic, crystals	Lb.	75	@	78
Creosote, beechwood	Lb.	1.90	@	2.00
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	7½	@	8½
Dextrine, imported potato	Lb.	18	@	20
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	19½	@	20
Glycerine, dynamite, drums included	Lb.	66	@	67
Oxalic Acid, in casks	Lb.	45	@	46
Pyrogallic Acid, resublimed, bulk	Lb.	3.15	@	3.25
Salicylic Acid, U. S. P.	Lb.	1.00	@	1.05
Starch, cassava	Lb.	—		
Starch, corn (carloads, bags) pearl	100 Lbs.	6.30	@	6.45
Starch, potato, Japanese	Lb.	10½	@	11
Starch, rice	Lb.	8	@	10
Starch, sago flour	Lb.	6½	@	7½
Starch, wheat	Lb.	5	@	6
Tannic Acid, commercial	Lb.	55	@	60
Tartaric Acid, crystals	Lb.	75	@	77

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	59	@	63
Black Mineral Oil, 29 gravity	Gal.	21	@	22
Castor Oil, No. 3	Lb.	31	@	32
Ceresin, yellow	Lb.	17	@	18
Corn Oil, crude	100 Lbs.	18.65	@	18.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.40	@	20.50
Menhaden Oil, crude (southern)	Gal.	99½	@	1.00
Neat's-foot Oil, 20°	Gal.	2.87	@	3.05
Paraffin, crude, 118 to 120 m. p.	Lb.	10	@	10¼
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	6.50		
Rosin Oil, first run	Gal.	35	@	—
Shellac, T. N.	Lb.	62	@	64
Spermaceti, cake	Lb.	32	@	34
Sperm Oil, bleached winter, 38°	Gal.	nominal		
Spindle Oil, No. 200	Gal.	36	@	37
Stearic Acid, double-pressed	Lb.	23	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	33	@	34
Turpentine, spirits of	Gal.	43	@	43½

METALS

Aluminum, No. 1, ingots	Lb.	32.20		
Antimony, ordinary	Lb.	12¾	@	13
Bismuth, N. Y.	Lb.	3.30	@	3.35
Copper, electrolytic	Lb.	23½	@	—
Copper, lake	Lb.	23½	@	—
Lead, N. Y.	Lb.	7¼	@	7½
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	87¼	@	90
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	20.00	@	26.00
Zinc, N. Y.	Lb.	8¼	@	8¼

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.75		
Blood, dried, f. o. b. Chicago	Unit	6.50	@	6.55
Bone, 3 and 50, ground, raw	Ton	35.00	@	40.00
Calcium Cyanamid	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.00	&	10.00
Phosphate, acid, 16 per cent	Ton	16.00	@	17.00
Phosphate rock, f. o. b. mine	Ton	nominal		
Florida land pebble, 68 per cent	Ton	3.25	@	3.50
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	345.00	@	350.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.37½	@	6.40

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | MAY 1, 1918 | No. 5

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD | *Advertising Manager:* G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY, M. C. WHITAKER

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:

Four Days More 336

Platinum Scraps 336

Publicity Work to be Continued 338

The Chemists' Club 338

ORIGINAL PAPERS:

The Fertilizing Value of Activated Sludge. George G. Nasmith and G. P. McKay 339

Equilibria in Solutions Containing Mixtures of Salts. I—The System Water and the Sulfates and Chlorides of Sodium and Potassium. Walter C. Blasdale 344

The Separation of the Chlorides and Sulfates of Sodium and Potassium by Fractional Crystallization. Walter C. Blasdale 347

The Use of "Mine Run" Phosphates in the Manufacture of Soluble Phosphoric Acid. Wm. H. Waggaman and C. R. Wagner 353

The Concentration of Potash from Raw Materials Containing Only a Trace of This Element by Means of the Electric Precipitation of Flue Dust and Fume Cement Kilns. B. F. Erdahl 356

Toluol from Spruce Turpentine. A. S. Wheeler 359

Arsenic in Sulfured Food Products. W. D. Collins 360

Some Constituents of the American Grapefruit (*Citrus decumana*). Harper F. Zoller 364

LABORATORY AND PLANT:

An Inexpensive Ash Leaching Plant. W. D. Turner and B. G. Nichols 374

Antimony Sulfide as a Constituent in Military and Sporting Arms Primers. Allerton S. Cushman 376

ADDRESSES:

Food Chemistry in the Service of Human Nutrition. H. C. Sherman 383

Permanence as an Ideal of Research. S. R. Scholes. 390

THE DEDICATION OF GILMAN HALL, UNIVERSITY OF CALIFORNIA 391

CURRENT INDUSTRIAL NEWS:

Machinery for France; Exports from Gold Coast; English Pottery Industry; Soap Demand in Morocco; Ferro-Concrete Shipbuilding; Railway Material for Japan; Graphite for Boiler Scale; Swedish Gauges; South African Iron Ore; South African Diamonds; Shortage of Electrical Appliances; Margarine Industry in Holland; Electrolytic Zinc; Trade Developments in Sweden; Rubber Industry in Japan; Sorghum and Paper; Colloidal Nickel; Japanese Industrial Developments; Mineral Deposits in Malay States; Butter Substitute from Fish Oils; Cod Liver Oil from Newfoundland; Indian Oilseeds; Preservation of Pit Timber; Oil-Pressing Plant for India; Russian Asbestos Industry; Roumanian Petroleum; A Deoxidizing Alloy; Dye from Maple Leaves; Instruments and Tools for Venezeula; Swiss Electrochemical Industries; Oil-Break Switchgear; British Board of Trade 394

NOTES AND CORRESPONDENCE:

Preparation for Post-War Conditions in Great Britain; Note on "The Fertilizing Value of Activated Sludge" by Nasmith and McKay; Regulations Under the Potash Leasing Act; Notes on "Free Carbon" of Tar; The Growth of the Industrial Fellowship System; American Dyestuff Manufacturers' Association; Chemicals Division of National War Savings Committee Organized; American Ceramic Society; Technical Association of Pulp and Paper Industry; Calendar of Meetings; Synthetic Materials—Correction 399

WASHINGTON LETTER 403

PERSONAL NOTES 404

INDUSTRIAL NOTES 406

GOVERNMENT PUBLICATIONS 408

NEW PUBLICATIONS 415

MARKET REPORT 416

EDITORIALS

FOUR DAYS MORE

Not for the purpose of urging is this written, for that is unnecessary; nor to explain, for this has been capably done by those in charge of the promotion of the Third Liberty Loan; but only to remind the chemist who has not yet subscribed for his bonds that but four days remain in which he can aid in the provision of that "force to the limit" which President Wilson has declared the policy of this country from this time on until a just peace is declared.

LEND HIM A HAND! BUY LIBERTY BONDS!

PLATINUM SCRAPS

At the Kansas City Meeting of the AMERICAN CHEMICAL SOCIETY the following resolution was adopted:

"*Resolved*, That the attention of the National Council of Defense be called to the scarcity of platinum under existing conditions and to the great need of the metal, more particularly in the prosecution of the war. We hold that its use at this time in the production of articles of ornament is contrary to public welfare. Therefore, we recommend that an appeal be made to the women of the United States to discourage the use of platinum in jewelry and that all citizens be urged to avoid its use for jewelry, for photographic paper and for any other purpose whatever, save in scientific research and in the making of articles for industrial needs."

Since that time diametrically opposite campaigns have been waging, without a decisive victory yet assured on either side. The chemists have favored Government control of the entire stock of platinum, while the jewelers have fought strenuously to keep a supply available for their trade. In defense of their attitude, when the adoption of an amendment to the war tax bill placing a tax of two hundred and fifty per cent on the manufacture of platinum jewelry threatened, the Jewelers' Vigilance Committee pledged support in these words:

"Having in mind the present needs of American industries, educational institutions, and sciences for platinum and the possible future requirements of the Government, the Jewelers' Vigilance Committee, after giving the subject careful thought, at the request of the Secretary of Commerce, has adopted the following resolutions:

"WHEREAS, The Secretary of Commerce has requested the Platinum Committee of the Jewelers' Vigilance Committee to bring to the attention of the jewelry trade of the United States the advisability of conserving platinum in order that our Government may have larger supplies to draw upon for war purposes, and

"WHEREAS, The jewelry trade has already expressed its desire and determination to assist our Government to the extent of its ability in bringing the war to a successful termination, be it

"*Resolved*, That we pledge ourselves to discontinue and strongly recommend to all manufacturing and retail jewelers of the United States that they in a truly patriotic spirit discourage the manufacture, sale and use of platinum in all bulky and heavy pieces of jewelry. Be it further

"*Resolved*, That during the period of the war or until the present supplies of platinum shall be materially augmented, we pledge ourselves to discontinue and recommend that the jewelry trade discourage the use of all non-essential platinum findings or parts of jewelry, such as scarfpin stems, pin tongues, joints, catches, swivels, pin rings, ear backs, etc., where gold would satisfactorily serve. Be it further

"*Resolved*, That the jewelry trade encourage by all means in their power the use of gold in combination with platinum wherever proper artistic results may be obtained. Be it further

"*Resolved*, That copies of these resolutions be handed to the Secretary of Commerce, to the trade press, and be sent to all our trade organizations, and to the daily press, in order that they may have the widest possible dissemination."—*The Jewelers' Circular*, May 9, 1917.

and quoted Secretary of Commerce Redfield, as follows:

"This is wise, patriotic, and unselfish action for which the merchants and manufacturers are highly to be commended. It will take time to work out fully its beneficial effects to the country. It will disarm adverse criticism of the jewelry trade in this respect and lead to general coöperation with them. Such is the earnest desire of the Department. The jewelry business is a part and an important part of our commerce. It has acted fairly, its normal needs should be considered fairly. Platinum is required for many uses. Every such use has its just claim. None may urge an exclusive demand. All have a part in our common country, and the Government of that country seeks through the Department of Commerce to secure for all a due and proper share. To this end the considerate course taken by the jewelers will directly contribute."—*The Jewelers' Circular*, May 9, 1917.

Writing to Congressman Longworth, active in support of the tax measure, Meyer D. Rothschild, chairman of the Platinum Committee acting under the auspices of the Jewelers' Vigilance Committee, stated:

"*Seventh:* The Jewelers Committee who took up the question of conserving platinum with the Department of Commerce and other Government departments voluntarily agreed to cut out the use of this precious metal for heavier articles of jewelry and for jewelry findings and unnecessary parts, notwithstanding the fact that they were convinced, and so stated, that there was no shortage of platinum for war purposes.

"*Eighth:* The conferences with the Secretary of Commerce and Government officials brought out the fact that there was a persistent effort on the part of certain people to 'bear' the price of platinum and to that end wilful mis-statements of fact were being published and a regular press campaign undertaken to discourage the buying of platinum by patriotic women, with the avowed purpose of cheapening the price of platinum to chemists, who have always been able to get all the platinum they required at the market price, that is, at the same price that jewelers and others had to pay for it.

"The resolutions passed by the Daughters of the Revolution, and other like resolutions, can be readily traced to these misstatements of the actual requirements of platinum for war purposes. The arguments used are so close to those used by you on the floor of the House that a strong impression is created that the misinformation you received about platinum must have come from those sources."—*The Jewelers' Circular*, May 30, 1917.

At the Convention of the New York State Retail Jewelers' Association, Mr. Rothschild made the following statements:

"The selfish chemical interests which had started this attack on our industry with the avowed and shameless purpose of 'bearing' the price of platinum in order to get it cheaper, now began a misleading press campaign which the Platinum Committee met from day to day by press corrections and general statements of facts to the press and to jewelers. This campaign culminated in an attempt by Congressman Longworth to place a prohibitive war tax of 250 per cent on platinum jewelry, which the Platinum Committee was happily in a position to frustrate by the timely presentation of a letter from the Secretary of Commerce who had read on the floor of the House of Representatives, defeating the effort to tax platinum jewelry out of existence."—*The Jewelers' Circular*, May 30, 1917.

Coincidently, a vigorous advertising campaign was carried on by wholesale and retail jewelers in practically every city in the country, reference to which has already been made in these columns. The well directed efforts of the Women's National League for the Conservation of Platinum to create a sentiment against the use of platinum in jewelry gave renewed impetus to this advertising campaign.

Concerning the work of the Women's League, of which Mrs. Ellwood B. Spear, of Cambridge, Mass., is chairman, Secretary Charles L. Parsons writes:

"Platinum in my opinion should be 'tabooed' by all American women who wish to see their country successful in this war and successful after the war in keeping its lead in the industrial and scientific developments. The opal has been considered unlucky. Accordingly, it carried in the feminine mind little value as a gem. I believe that without ever using the phrase, the Women's League for Conservation of Platinum has already begun to instill into the minds of American women what really 'bad taste' it is to wear a metal that looks like lead in rings, bracelets, etc., simply on account of its high price. I also believe that the 'slacker wedding ring' made of platinum will soon be a thing of the past."

Then came the realization by the Government authorities of the dire necessity of increasing the supply of platinum for munitions manufacture and the consequent order taking control of the raw material.

In view of the resolutions of the Jewelers' Vigilance Committee quoted above, it is surprising to learn that in March 1918, when the manufacturers of jewelry were asked to offer to the Government at cost a considerable part of their supply of unworked platinum, a census of which had been taken, the response was only ten per cent of the amount on hand, whereas at least fifty per cent had been expected by the Government officials. The situation gave rise to apprehension on the part of the leaders

"* * * * that drastic action would possibly be taken by the Government in the near future to get the platinum which they believe the manufacturer should surrender."—*The Jewelers' Circular*, March 27, 1918.

Commenting upon the evident accumulation of platinum by certain manufacturers, *The Jewelers' Circular*, March 27, 1918, reports an interview with Mr. C. H. Conner of the War Industries Board, as follows:

"Mr. Conner also called attention to the fact that manufacturers might find themselves subject to serious loss inasmuch as when the Government does commandeer the platinum, the manufacturer who has bought since that time will not be protected against any loss, but will have to take for his platinum the Government price of $105, irrespective of what he has paid for it."

The following editorial discussion appeared in *The Jewelers' Circular* of April 3, 1918:

"The platinum situation in the jewelry trade is not satisfactory. The propaganda of the women fanatics asking the public to give up platinum jewelry has not been contradicted by the Government officials, who know it to be founded on erroneous statements, because these officials are 'sore' on the jewelers. The irritation arises from the fact that the jewelers' voluntary offer of platinum to the Government is very small. The smallness of the offer is due to two reasons: (1) the way that the so-called commandeering by order was handled and put into effect by the officials at Washington, and (2) the actions of certain manufacturers whose selfishness and lack of foresight have put the trade as a whole in a bad position with the very officials whose coöperation is needed at the present time to counteract the malicious propaganda that is hurting our retail trade.

"That approximately 5,000 ounces of platinum should be reported among the manufacturers in the jewelry trade as of February 1 and less than 500 ounces be offered to the Government when these manufacturers were called to give up caused officials to feel that the jewelers were not cooperating with the Government, but were selfishly looking to their own interests without thought of the Government's needs. Of course, they did not take into consideration that the census of platinum was taken of February 1 while the offer was made as of platinum on hand late in March; but another factor in their attitude was due to their knowledge of the speculation in platinum indulged in by a few manufacturers and the rush by others to put platinum into manufactured or half manufactured goods immediately after it became known that the Government would need the raw metal. This caused certain officials to believe that the manufacturing jewelers' pledges of loyalty were but 'lip service,' and without meaning. * * * *"

Here it is interesting to quote from the report of H. C. Larter, chairman of the Jewelers' Vigilance Committee at its meeting on April 2, 1918:

"We had hardly become organized when the agitation started by the chemists of the country to eliminate the use of platinum in the jewelry trade was promulgated. As you know, we promptly took this matter up, in defense of the entire jewelry trade, and at a large mass meeting a representative platinum committee was appointed, and at its head, Meyer D. Rothschild, who for nearly twelve months has successfully looked after the platinum situation in the interest of our trade, and at the same time has coöperated in every way possible with the Government.

"Unfortunately, for reasons beyond anyone's control—the most important one of which, however, is the breakdown of the Russian nation—the platinum situation is more confusing and perplexing than ever.

"While the platinum matter, insofar as its connection with the Government is concerned, is now out of the hands of this Platinum Committee, the Jewelers' Vigilance Committee is still interested in the adverse propaganda, started afresh with new vigor because of the acute situation now existing throughout the world in regard to this precious metal."—*The Jewelers' Circular*, April 10, 1918.

Realizing that "something had to be done to overcome the erroneous impression as to the jewelry trade held by Government officials," organizations of manufacturing jewelers in all sections of the country were appealed to by the Jewelers' War Service Committee to call special meetings "to increase the offer of platinum to the Government." Two meetings were held in New York City, at which 400 ounces additional were secured.

. . . . . .

In an article written for *The Keystone* (a leading jewelry circular), April 1918, James M. Hill, of the U. S. Geological Survey, states the relative supply and needs as follows:

"* * * * In 1915 there were approximately 44,000 ounces of platinum in contact acid plants; in 1917, about 60,000 ounces, and it is estimated that the industry must be further expanded during 1918 by at least fifty per cent to supply the sulfuric acid to make the munitions necessary to carry on the war.

"The platinum for the nitrogen fixation industry is used in the form of a very fine gauze, woven of pure platinum wire. The building of this industry has become necessary through the great expansion in the demand for nitrates to be used in explosives. The plants are being built under the control of the Government and it is not expedient to give details concerning the quantities of platinum required by them. It seems, however, safe to say that the quantity runs in the thousands, rather than in the hundreds of ounces.

"* * * * Yet it must always be remembered that platinum, the metal most resistant to all chemical reagents, is *par excellence* the chemist's metal for he can use it in nearly all steps of his work, while with substitutes he must constantly bear in mind the limitations of utensils made of other materials.

"* * * * In fact, it is believed that aside from the large amount of platinum metals in the form of manufactured jewelry, a large part of which is in private ownership, there is less than twenty-five per cent of the normal stock of unmanufactured platinum available for war needs.

"That these needs are very real cannot be questioned by any thinking man. The question of what can be done to meet these needs is very much alive and must be solved shortly or the war program of the United States is liable to suffer."

In the same issue of *The Keystone*, the Editor discusses the platinum situation with refreshing frankness, and in terms which evince a clear comprehen-

sion of the gravity of the situation and of the jewelers' responsibility therein.

"Let us not forget the urgency of the need for placing under United States control as large a portion of the world's platinum supply as possible. Crafty, forehanded Germany has been doing her utmost, since the war began, to increase her supply of the now doubly-precious and much-needed metal. Since the conclusion of her damnably insincere 'peace' contract with poor Russia, she is in a fair way, through seduction or force, to obtain access to the world's greatest source of the coveted material, and thus not only take care of her own very urgent need but also *deprive the United States and her Allies of further importations.*

"Hence, while the commandeering order recently issued by the United States Secretary of War does not requisition platinum jewelry nor in the least affect the sale of any already made up, the time may not be far distant when an appeal will be made or an order found necessary to call in even the finished product for use in essential purposes in prosecuting the war. What we have to suggest, therefore, is perhaps as much colored with prophecy as patriotism."

. . . . . .

The story here narrated through excerpts from the jewelers' publications constitutes no praiseworthy chapter in the history of our war making. It does furnish ample justification for the campaign inaugurated by the chemists at Kansas City. Plainly the handwriting is on the wall. Priority must be given to munitions manufacture and scientific research.

PUBLICITY WORK TO BE CONTINUED

The work of the Press and Publicity Committee of the AMERICAN CHEMICAL SOCIETY is to be continued. This policy was determined by the action of the Directors at their Spring Meeting on April 13, 1918, whereby "it was voted that an additional appropriation of $2,500, or so much thereof as may be necessary, be made to the Publicity Committee and that the Committee be continued."

This action has a twofold significance. In the first place, it is clearly indicative of an increase in the membership of the Society sufficiently large to dispel the possibility of a decreased income due to war conditions, for it was primarily upon this ground that the recommendations of the Committee were tabled at the December 1917 meeting of the Directors. (This action was discussed editorially in the January 1918 issue of THIS JOURNAL.) In the second place, it insures the continuance on an even more efficient scale of one of the most important activities of the Society. In justification of this appraisal of the Committee's work, there is reproduced a portion of the editorial above mentioned:

"We live in a democracy, and under such conditions sure foundations can be laid only in broad educational work from the bottom upward. Our people through their newspapers should have opportunity to learn more of chemistry treated in a popular way, and should be brought into a more sympathetic relationship with American chemists through the record of their achievements. Such work is preeminently the function of the AMERICAN CHEMICAL SOCIETY, an organization which has no propaganda to promote other than the welfare of this country through increased appreciation of chemistry."

As a result of the action of the Directors, the Committee is now formulating plans for the continuance of the work.

THE CHEMISTS' CLUB

At a meeting of the Trustees of The Chemists' Club on April 5, 1918, it was voted that the following communication and questionnaire should be sent to each member of the Club:

The Board of Trustees, in view of existing conditions at home and abroad, respectfully bring to the attention of all members of The Chemists' Club, resident and non-resident, the importance of complying with the following requests:

1st. That the German Language shall not be used in conversation in the Club.

2nd. That all disloyal criticism of the United States Government, or its allies in the present war, must be avoided in the Club.

3rd. That any member of the Club, resident or non-resident, of whatever descent, and whether an American citizen or not, whose sympathies favor the enemies of this country, or who cannot conscientiously comply with the foregoing requests or who cannot be sure of so conducting himself as to avoid giving offense to his fellow members by any display of hostility or disloyalty to the United States or its allies, is requested to resign.

The Trustees also ask you to fill out and return not later than May 1, 1918, in the accompanying addressed envelope, the enclosed card asking for certain data, to enable them accurately to answer inquiries from time to time made by the Government authorities.

April 15, 1918

FLOYD J. METZGER,
Acting Secretary

THE CHEMISTS' CLUB, NEW YORK

Name of Member . . . . . .

Address (Business) . . . . . (Home) . . . . . .

Business . . . . (Firm) . . . . . .

Birthplace (Self) . . . . . Year . . . . . .

Birthplace (Father) . . . . . Birthplace (Mother) . . . . . .

Citizen of United States Yes . . . . . No. . . . . .

If Naturalized When . . . Where . . .

Citizen of . . . . . .

Sons in Service In Army . . . . . In Navy . . . .

Other Members of Family in Service . . . . . .

This matter, we learn, had been under careful consideration at several previous meetings of the Trustees. The action taken officially establishes as a requisite of membership in the Club unswerving loyalty to the cause of this country and its allies, and will eliminate all enemy sympathizers, the number of whom is small, but whose presence, no matter how small the number, is completely incompatible with that spirit of home life which the term "club" implies.

ORIGINAL PAPERS

THE FERTILIZING VALUE OF ACTIVATED SLUDGE[1]

By George G. Nasmith and G. P. McKay

Received February 18, 1918

The most important problem remaining to be solved in the disposal of sewage is probably that of economically dewatering the sludge. Since the discovery of the activated sludge method, the necessity of devising a method of dewatering this new type of sludge has become even more urgent for the reason that activated sludge has marked fertilizing properties, as Bartow and Hatfield[2] have pointed out.

In the activated sludge method of sewage disposal, finely divided air is blown through the sewage. After some time the sludge which settles out is found to possess remarkable properties when agitated with fresh sewage by the same method of aeration. The sludge has become "activated" and when blown in contact with fresh sewage the organic matter present in the latter is rapidly oxidized, practically all the intestinal bacteria destroyed, nitrates elaborated, and a stable effluent formed.

"Activated" sludge, however, like ordinary sludge, contains 95 per cent of water, and still has to be dewatered before it can be satisfactorily handled.

The treatment of sewage by this method is very promising for if the fertilizing value of the sludge is high, the revenue therefrom would help to pay the cost of dewatering and disposing of the sludge. Furthermore, it is a question of conservation of the first magnitude, for if a fair proportion of the fertilizing value of the excreta from our cities and towns could be saved and turned back into the land it would be a great factor towards solving our fertilizer problem, particularly in conserving the supply of humus and nitrates, and increasing the fertility and productivity of the soil.

In December 1915 a small experimental activated sludge plant was started at the Toronto Main Sewage Disposal Works, Morley Avenue. Dr. Adams and Mr. J. Scott, who at first operated the plant during my absence in France, soon proved that Toronto sludge could be readily activated, and the plant has been in operation ever since. A good deal of preliminary data have been obtained for our own information in case the city of Toronto should ever decide to adopt the method on a large scale. Among other things, we have tested the value of activated sludge as a fertilizer.

Hatfield, in some experimental work to
value of activated sludge as a fertilizer,
r of experiments with the growth of
The activated sludge used by them
following analysis: Total Nitrogen = 6.3 per cent; P_2O_5 = 2.69 per cent.

By the use of one ton of this sludge per acre, equivalent to 120 lbs. of nitrogen, together with 5 tons of dolomite, 1/2 ton of bonemeal, and 500 lbs. of potassium sulfate per acre, they obtained a yield of 36 to 37 1/2 bu. of wheat per acre as against 13 1/2 bushels per acre where the equivalent amount of nitrogen had been added in the form of dried blood. The straw also amounted to over two tons per acre as against less than 3/4 of a ton of straw per acre where dried blood had been employed as fertilizer.

In further tests as to the value of sludge as a market garden fertilizer, these investigators used plots, each 2 ft. × 3 ft., which were treated with equivalent quantities of sludge and dried blood per acre. They obtained an increase in weight of 40 per cent in the lettuce and 150 per cent in the radishes, and the growth was much more rapid in the beds fertilized with activated sludge. They conclude from their experiments "that the nitrogen in 'activated sludge' is in a very available form, and that activated sludge is valuable as a fertilizer."

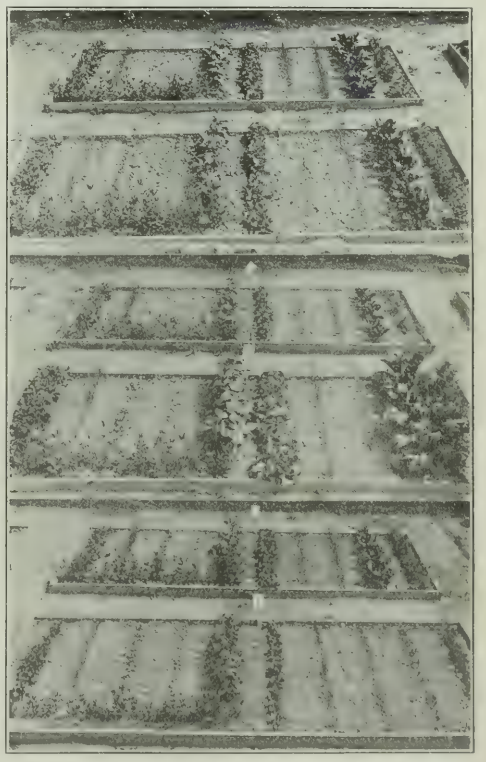


Fig. 1 Showing Growth on Experimental Plots, July 18, 1917

Bartow and Hatfield, in determining the amount of fertilizer to be employed, used as a basis the amount of nitrogen present. For instance, they used in their experiments the quantity of activated sludge and dried blood that would yield 120 lbs. of nitrogen per acre.

[1] See communication from P. Rudnick in Notes and Correspondence

[2] This Journal, 8 (1916), 17.

The amount of phosphate or other ingredients present in the sludge was not considered.

THE VALUE OF FERTILIZERS

Experience has proved that the value of fresh manure as a crop producer is from one-third to two-thirds more effective than rotted manure, because a certain proportion of the nitrogen and other in-

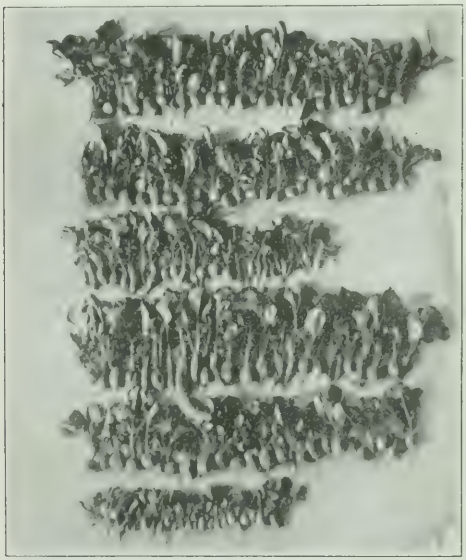


FIG. II—ILLUSTRATING TABLE I

gredients have been leached out of the latter and lost. Manure has a greater fertilizing value than would be estimated from the amount of nitrogen, phosphoric acid and potash present. This greater value is due to the large amount of humus present in the manure; humus is not found to any extent in the commercial fertilizers, which are commonly purchased on their nitrogen, phosphoric acid or potash content.

Humus is partly decomposed organic matter, such as decayed leaves. It is found in large quantities in all fertile soils and is probably the most valuable constituent present, because it is not only a source of nitrogen, but it helps to keep the soil moist, loose and well aerated, as well as to provide a medium for the propagation of soil organisms so essential to the growth of plant life.

The chemical constituents in a fertilizer are not the only ones upon which its fertilizing value must be determined. It would be possible to have the same amount of potash, nitrogen and phosphate in two different fertilizers and yet obtain entirely different results upon plant growth. The availability of the food material for the assimilation of the plant is a great factor. Thus ordinary septic sludge is not a good fertilizer for immediate growth of plants, results obtained the first year being poor. But the transformation of the septic sludge taking place in the soil frees the plant food material locked up in this sludge and renders it available, so that it becomes an excellent fertilizer the second year after it has been dug into the soil. The experiences of a number of amateurs in Toronto who have been using ordinary septic sludge for several years in their vegetable and rose gardens, have quite established this fact.

The truest test of fertilizers is not their content of nitrogen, phosphate or other chemical, but rather the availability of the chemicals present as food for growing crops and the actual increase in the yield brought about by the fertilizer. Here again the fertilizers must be differentiated according to their ability to produce immediate results. We must determine whether they are available through the growing season, whether they leave a residue of humus and other materials in the soil, and whether they bring about exhaustion of the mineral elements of the soil or not.

Activated sludge, when air-dried, is a dark brown, friable, perfectly inoffensive material with a slightly earthy odor like that of decayed leaves. It consists largely of humus, but contains much more nitrogen, phosphoric acid and potash than does ordinary barnyard manure. Furthermore, it is crowded with millions of the nitrifying type of organisms so essential to plant growth.

For the reasons given above as to the fertilizing value of manure, we have taken this for our standard of comparison and have not compared the fertilizing value of sludge with commercial fertilizers on a nitrogen, phosphoric acid or potash basis.

The real single, final test of any fertilizer or manure is the increase in the yield produced by it when compared with an equivalent amount of barnyard manure.

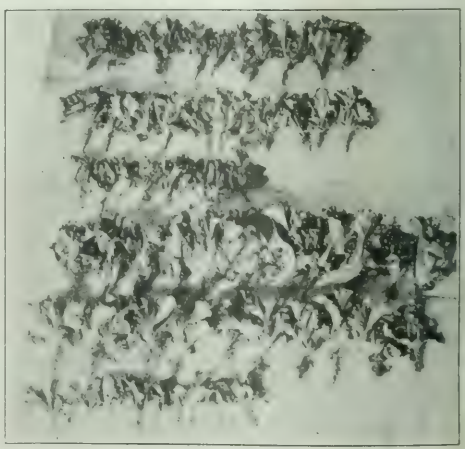


FIG. III—ILLUSTRATING TABLE 2

We selected for our plot experiments a site on very poor, humus-free clay soil, adjacent to our experimental plant. The surface was scraped to free it of any or-

ganic matter present, and four inches of water-washed sand were then thoroughly incorporated with the soil to a depth of ten inches. This was done to permit of aeration, to prevent the soil baking in the sun, and to make the soil friable.

Six beds, each 10 ft. × 4 ft., were then laid out and separated from the paths by boards placed edgewise in the ground.

One bed was kept as a control, and no fertilizer added to it. The second was treated with 27 lbs. of air-dried horse manure, and the other four each with 27 lbs. of air-dried sludge (equivalent to $14^1/_2$ tons to the acre). This is summarized below:

Bed	Air-dried Fertilizer	Quantity Used	Total Nitrogen Per cent	Total P_2O_5 Per cent
No. 1	None	0	0	0
No. 2	Manure	27 lbs.	1.90	1.00
No. 3	Activated sludge	27 lbs.	2.50	2.46
No. 4	Sludge from old bed	27 lbs.	1.10	0.85
No. 5	Humus—Brush filter	27 lbs.	1.30	1.20
No. 6	Sludge—tanks	27 lbs.	1.21	1.24

On May 18, 1917, the fertilizers were added and thoroughly incorporated with the soil, and on May 21, the seeds were planted in all the beds. Seeds were used except in the case of tomatoes and Spanish onions. A fairly thick planting was made so that plenty of seedlings would be available when thinning out, and a uniform number of strong seedlings of each variety could be left in each bed.

As each row of vegetables was pulled from the several beds at the same time, the complete plants, leaves and all, were placed in bags, labelled and brought to the laboratory. After the removal of adherent earth the product of each bed was weighed; the tops, in the case of root crops, were then taken off and weighed separately



FIG. IV—ILLUSTRATING TABLE 5

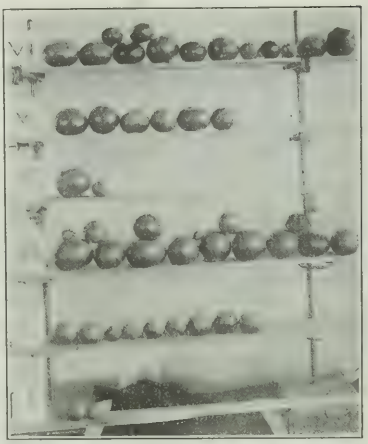


FIG. V—ILLUSTRATING TABLE 7

and the difference taken as the weight of the root. Notes were also made as to the quality of the crop.

Before weighing, the crops were spread out on the floor in their respective groups and photographed. The photographs, however, gave only a general idea of the difference in size of the various groups because of the fact that the camera had to be tilted, in consequence of which the rows closer to the camera appear larger and the rows farther away smaller than they should be.

The plan adopted worked very well in practice and gave, we think, fair comparative results.

Daily observations were made by the man who looked after the beds, and who was himself a gardener, as to appearance of the various vegetables, temperature, rainfall and cultivation. When he cultivated one bed he cultivated all the beds; if he watered one he watered all, and used the same amount of water, and when he pulled one variety he pulled that variety from all the beds.

In this way we tried to eliminate every factor which might give any advantage to one bed over another, and to remove every influence that might have had any bearing on the growth of the plants except the actual effect of the fertilizers themselves during the course of one season.

The following are synopses of the results obtained:

TABLE 1—EARLY RADISHES

	Control	Manure	Activated Sludge	Morley Ave. Sludge	N. Toronto Humus	N. Toronto Sludge
Weight, total—grams	92	455	757	317	582	752
Weight, roots—grams	59	350	490	200	417	518
Weight, tops—grams	33	105	267	117	165	234
Increase in roots over control—per cent	.	493	730	239	606	778
Yield per acre—tons	. .	5.04	7	. . .	. . .	. . .

TABLE 2—HEAD LETTUCE

Weight, total—grams	31	248	484	. . .	. . .	. . .
Increase over control—per cent	. .	667	1461	. . .	. . .	. .
Yield per acre—tons	. .	1.9	3.88	. . .	. . .	. . .

TABLE 3—LETTUCE, GRAND RAPIDS

Weight, total—grams	75	Missing	524	155	277	248
Increase over control—per cent	. .	Missing	598	106	269	228
Yield per acre—tons	. .	Missing	. . .	. . .	. . .	. . .

TABLE 4—BEANS

Weight, total—grams	256	296	525	487	377	531
Increase over control per cent	..	15.6	105	39.4	47.2	107
Yield per acre—tons	..	1 78	3 16	...	...	..

TABLE 5—BEETS

Weight, total—grams	79	1296	3437	1360	2012	2945
Weight, roots—grams	24	730	1737	437	891	1169
Increase over control per cent	..	2941	7137	1304	3612	4770
Yield per acre—tons	..	5 85	13 90	...	...	..

TABLE 6—LATE RADISHES

Weight, total—grams	32	75	315	472	285	738
Weight, roots—grams	18	43	179	283	197	452
Increase over control per cent	..	139	894	1470	1006	2410
Yield per acre—tons	..	..	..	...	...	...

TABLE 7—TOMATOES

Weight, total—grams	29	422	1684	164	533	1184
No. of tomatoes	2	9	15	2	6	13
Average weight of single tomato—grams	14½	47	110	82	89	91
Increase over control—per cent	..	1355	5603	466	1738	3983
Yield per acre—tons	..	5.07	19.9	...	...	...

TABLE 8—CARROTS

Weight, total—grams	885	1680	1535	1425	1560	2695
Increase over control—per cent	..	96	80	66	82	215
Yield per acre—tons	..	20	..	...	...	32.4

TABLE 9—ONIONS, SPANISH (16 BEST)

Weight, total—grams	41	96	280	142	68	327
Increase over control—per cent	..	134	583	246	64	700
Yield per acre—tons	..	1.2	3 4	...	...	3.9

TABLE 10—ONIONS, RED WEATHERFIELD (8 BEST)

Weight, total—grams	67	110	720	239	225	420
Increase over control per cent	..	64	974	256	235	527
Yield per acre—tons	..	1 3	8 7	...	..	5.1

TABLE 11—ONIONS, DANVERS YELLOW GLOBE (8 BEST)

Weight, total—grams	67	124	232	260	184	169
Increase over control per cent	..	85	246	288	174	152
Yield per acre—tons	..	1 5	2 8	...	..	..

NOTES ON TABLES 1 TO 11

TABLE 1—The radishes were planted May 21 and pulled July 5, approximately six weeks later. The same number of radishes was left in each bed.

The yields from the activated sludge and North Toronto sludge were about the same, but 40 per cent greater than that from the manured bed.

TABLES 2 AND 3—The two sets of lettuce, pulled July 19, clearly showed the superiority of activated sludge as a fertilizer. These beds yielded double the weight of lettuce produced by the beds fertilized with ordinary manure and other sludges. Activated sludge, therefore, is a particularly good fertilizer for lettuce.

TABLE 4—The beans, one of the legumes, were pulled August 7, and did not show so wide a variation in the different beds as did the radishes and lettuce. Still, the crops from the beds fertilized with activated sludge and with North Toronto sludge were 77 per cent heavier than from the bed fertilized with ordinary horse manure.

TABLE 5—The beets were pulled on August 16. During the period of growth the foliage on the beets in the activated sludge bed was much more luxuriant than that on the beets in any of the other plots. The yield of tops was double that from the beds fertilized with ordinary manure, and the yield of roots 138 per cent greater. The sludge from North Toronto was considerably behind in this case.

TABLE 6—The late radishes were not a success, though a large increase over the control was apparent in all cases; they were distorted in shape and in some cases rotted. The yield from the North Toronto sludge plot was greatest, but the sludge from the old beds, which had not been a successful fertilizer up to this time, made a good showing and indicated that aerobic action and nitrification of this sludge had taken place in the earth, rendering this fertilizer available as a plant food.

TABLE 7—The tomatoes were picked October 2. During the growing season the tomato plant in the activated sludge bed had been most vigorous; the tomatoes had also ripened first on the beds treated with activated sludge and North Toronto sludge. The activated sludge bed gave the greatest number and the greatest total weight of tomatoes. The activated sludge gave a yield of 300 per cent in excess over that of the manure bed, showing that activated sludge is an ideal fertilizer for tomatoes. The yield from the plot fertilized with North Toronto sludge was considerably behind the activated sludge, though away ahead of the manure plot.

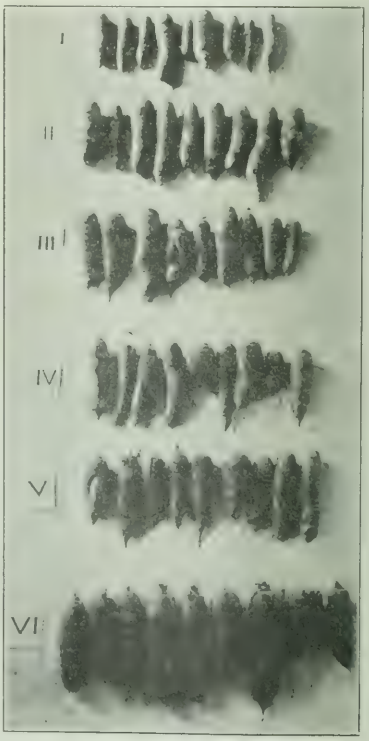


FIG. VI ILLUSTRATING TABLE 8

TABLE 8—The carrots were pulled on October 9. Except in the case of North Toronto sludge, which grew some huge carrots, the yields from the other beds were all much the same as that from the bed fertilized with ordinary manure.

TABLES 9, 10 AND 11—The onions were pulled October 9, and did not show phenomenal growth. Morley Avenue sludge gave a slightly better result than activated sludge in the case of Danvers Yellow Globe,

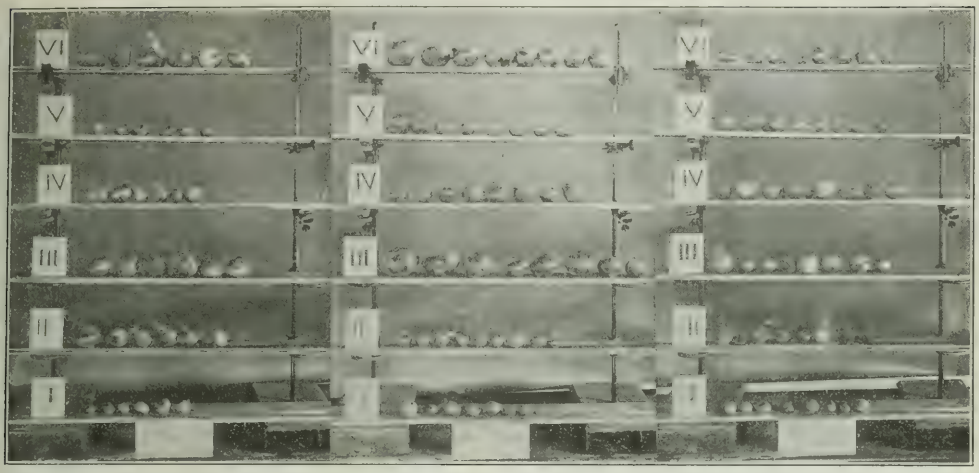


FIG VII—ILLUSTRATING TABLES 9, 10 AND 11

showing that this sludge had latent fertilizing value. Activated sludge was the best forcer in the case of Red Weatherfield onions, giving an increase in yield of 554 per cent over the manured crop.

The yield of Spanish onions was practically the same in the case of the beds fertilized with North Toronto sludge and activated sludge, but much greater than that from the manured plots.

In casting about for the reason why the sludge from the North Toronto sedimentation tanks gave us almost as good results as activated sludge, we went back over the method used in its preparation.

The sludge is pumped from the sedimentation tanks into drying beds. The water gradually flows away into the drains beneath, so that in from 2 to 4 weeks the sludge is dry enough to dig out. During this drying period it undergoes anaerobic action underneath the thick black crust which forms on the surface. Eventually, however, it dries sufficiently for aerobic action to take place in the spongy mass. The sludge is then dug out of the beds, carried away on small dump cars and deposited in long heaps, where it lies exposed to the sun and air until finally removed.

In all probability a series of nitrifying actions somewhat similar to those which occur in activating sludge occur accidentally in this method of drying North Toronto sludge, rendering it suitable for immediate assimilation by plants. It would seem very probable that any sludge dry enough to be spaded would, if thrown into shallow heaps or spread out in layers on the ground, be converted by oxidation and bacterial action from a form not readily assimilable by plants to one readily assimilable by them. The same action would occur when sludge is dug into the earth itself, and presumably more rapidly in a porous soil than in a heavy clay soil. This latter point seems to be evident from results obtained from the anaerobic sludge dug from the old Morley Avenue sludge beds. This sludge made a very poor showing early in the year, but later on in the season appeared to be more readily available for the growth of plant life.

CONCLUSIONS

From the foregoing tabulated results it is clearly evident that activated sludge is a most valuable fertilizer. When compared with the standard barnyard manure used by the farmer, our results show the following increases:

INCREASE IN YIELD DUE TO ACTIVATED SLUDGE OVER BARNYARD MANURE

	Per cent
Radishes	40.0
Lettuce	103.3
Beans	77.3
Beets	138.00
Late Radishes	316.0
Tomatoes	291.0
Carrots	No increase
Onions, Spanish	191.0
Weatherfield	554.0
Danvers Yellow Globe	87.1

From the results obtained by us it seems to be true that crops such as lettuce, where the foliage itself is eaten, or crops like beans, beets or tomatoes, which demand a heavy growth of plant and leaf if the yield of roots or fruit is to be heavy, can be stimulated into very heavy growth by the use of activated sludge. The increase in the yield of onions is also great.

For the growth of lettuce or tomatoes under glass, activated sludge should, therefore, prove to be a most valuable fertilizer. In the case of radishes, though the final weight was not materially greater, the radishes matured much more rapidly, which is just as valuable to the market gardener as if his crop were greater, for the quick growth is what is wanted. The same holds good of lettuce or beets in which the growth was much more rapid than it was with the other fertilizers tested. These points are now being tested by actual experiments under glass.

It should be noted that the amount of air-dried manure added, 14½ tons per acre, is about the maximum amount that could be used to advantage, and,

therefore, in all probability the maximum crops capable of being produced by the addition of manure had been produced.

If this is true then the increase in yield due to activated sludge over ordinary barnyard manure is very striking and at once places a high monetary value on this material, for the value of fertilizers must be directly proportional to the crop returns yielded by them.

DEPARTMENT OF PUBLIC HEALTH
DIVISION OF LABORATORIES
TORONTO, CANADA

EQUILIBRIA IN SOLUTIONS CONTAINING MIXTURES OF SALTS

I—THE SYSTEM WATER AND THE SULFATES AND CHLORIDES OF SODIUM AND POTASSIUM[1]

By WALTER C. BLASDALE

Received March 20, 1918

The various processes suggested for increasing the production of potassium-containing compounds involve the separation of that element from associated salts by fractional crystallization. The only satisfactory method of obtaining a clear understanding of the possibilities of making such separations is a study of the phase-rule diagrams representing the equilibria which exist in aqueous solutions between the salts to be separated. Unfortunately much of the data necessary for the preparation of such diagrams is lacking, and the present paper represents the first of a series which have been planned by members of the Department of Chemistry of the University of California for the purpose of supplying what is believed to be much-needed information. In carrying out the work here reported assistance in the large amount of analytical work involved has been rendered by students of the Department, and special acknowledgment should be made to Messrs. R. D. Elliott, A. H. Foster, D. Ehrenfeld and K. V. King.

PREVIOUS WORK ON THE SUBJECT

The system designated in the sub-title consists of four components, namely, water and any three of the four salts concerned, which constitute a "reciprocal salt pair." In addition to the four simple anhydrous salts the only solid phases to be considered are ice, the decahydrate of sodium sulfate, which will be called Glauber's salt, and the double sulfate of sodium and potassium generally known as glaserite. This name was first used by Penny to represent a compound corresponding to the formula $K_3Na(SO_4)_2$, but double sulfates containing somewhat different proportions of the constituent salts were subsequently reported by other investigators and different names applied to them. Van't Hoff[2] was able to show that it was possible to prepare a series of solid solutions in which the percentages of potassium sulfate varied between 78.6 and 61.8, which justifies treating all of these compounds as a single solid phase.

It was also shown by van't Hoff and Reicher[3] that it was possible to prepare a solution saturated with respect to glaserite, Glauber's salt, potassium chloride and sodium chloride at a temperature of 3.7°, and that therefore this temperature represents the "transition temperature" for the equilibrium

$$3KCl + 2Na_2SO_4.10H_2O \rightleftarrows K_3Na(SO_4)_2 + 3NaCl + 20\ H_2O,$$

in which all the formulae, except that of water, represent solid phases. A consequence of this fact is that one of the two pairs of salts (in this case potassium chloride and Glauber's salt) can exist as solid phases in equilibrium with solutions of the four salts at temperatures below 3.7° only, whereas the other pair, *i. e.*, glaserite and sodium chloride, can exist as solid phases in equilibrium with such solutions only above this temperature. If the temperature of the system is limited to the interval between 0° and 100°, which represents the limits of practical importance, so that ice is eliminated, nine different univariant systems in which three solid phases are present are theoretically possible. The univariant systems which can be actually realized experimentally were first studied by Meyerhoffer and Saunders,[1] who fixed the transition temperature discovered by van't Hoff at 4.4° instead of 3.7°, and worked out the phase-rule diagrams for the system at temperatures of 0°, 4.4°, 16° and 25°. In taking up the work at this point it was thought desirable to repeat the determinations upon which the diagrams for 0° and 25° were based, and to obtain data necessary for the preparation of similar diagrams at temperatures of 50°, 75° and 100°.

EXPERIMENTAL METHODS USED

Saturation of solutions with respect to the different salts was effected by stirring in an apparatus similar to that used by Meyerhoffer until its composition remained constant, which required from one to 4 days. The tubes for the determinations made at 0° were kept in a large thermostat capable of holding sufficient ice to last for 5 days. For saturation at the four other temperatures the necessary heat was supplied to the thermostats by electric lamps immersed in the water or oil of the bath; a large mercury regulator kept the temperature of the 25° and the 50° baths constant to within 0.2°, and of the 75° and 100° baths to within 1.0°.

The composition of the saturated solution was ascertained by removing portions of it in a weight pipette previously heated to the temperature of the bath, weighing and analyzing the solution. The chlorine ion was determined by titrating a fractional part of the solution with a standard solution of silver nitrate, the SO_4 ion by precipitating and weighing as $BaSO_4$, and the potassium ion by separating and weighing as K_2PtCl_6.

As it seemed probable that the control of any processes based on these diagrams could be most easily effected by means of a hydrometer the specific gravities of most of the solutions were also determined. The method consisted in removing and weighing, by means of a pipette which had been drawn out to a capillary at the mark on its stem, a definite volume of the solution,

[1] This work has been supported by the Council of Defense of the State of California.

[2] "Unters. u. Bildung der ozeanischen Salzablagerung," p. 220.

[3] *Z. physik. Chem.*, **3** (1889), 482.

[1] *Z. physik. Chem.* **28** (1899), 453.

measured at the temperature of the bath, and comparing the weight with that of the water delivered by the same pipette at a temperature of 20°. The results are probably accurate to within two units in the third decimal place. No corrections were made for changes in the capacity of the pipette due to varying temperature nor for variations in the volume delivered by it owing to changes in the viscosity of the solution.

THE DIAGRAM FOR 25°

The composition of the solutions saturated with one or more salts at this temperature expressed in grams of the various salts per 100 grams of water is given in Table I.[1] In order to represent these results graphically the corresponding values, when expressed in terms of mols of the various salts which have equal replacing power per 1000 mols of water, were calculated. These data are given in Table II; they are plotted in Fig. 1

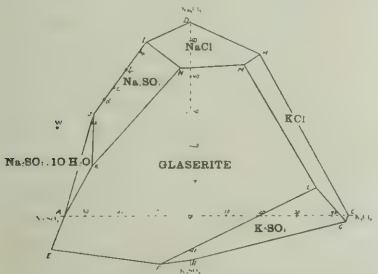


FIG. 1—THE EQUILIBRIUM DIAGRAM AT 25°

with respect to four axes, representing Na_2SO_4, K_2SO_4, K_2Cl_2 and Na_2Cl_2, respectively, and the various points are connected by straight lines, although it is probable

TABLE I—COMPOSITION, IN GRAMS PER 100 G. OF WATER, OF SOLUTIONS SATURATED AT 25°

	Saturated with	NaCl	KCl	Na_2SO_4	K_2SO_4	Sp. Gr.
A_1	Na_2SO_4	...	...	27.93	...	1.212
B_1	K_2SO_4	...	...	...	12.02	1.088
C_1	KCl	...	36.96	...	...	1.187
D_1	NaCl	35.63	...	...	...	1.199
E_1	Na_2SO_4 and glaserite	...	...	30.97	9.31	1.282
F_1	K_2SO_4 and glaserite	...	...	6.69	13.24	1.149
G_1	K_2SO_4 and KCl	...	36.63	...	1.53	1.190
H_1	KCl and NaCl	29.88	16.28	...	...	1.237
I_1	NaCl and Na_2SO_4	32.16	...	9.81	...	1.239
J_1	Na_2SO_4 and Glauber's salt	18.82	...	21.68	...	1.243
K_1	Na_2SO_4, Glauber's salt, glaserite	14.28	...	22.28	7.32	1.273
L_1	KCl, K_2SO_4, glaserite	6.78	29.38	...	2.23	1.200
M_1	KCl, NaCl, glaserite	27.96	16.37	3.51	...	1.250
N_1	NaCl, Na_2SO_4, glaserite	34.90	...	2.25	11.03	1.266

TABLE II—COMPOSITION, IN MOLS PER 1000 MOLS OF WATER, OF SOLUTIONS SATURATED AT 25°

	Saturated with	Na_2Cl_2	K_2Cl_2	Na_2SO_4	K_2SO_4	Sum
A_1	Na_2SO_4	...	...	35.41	...	35.41
B_1	K_2SO_4	...	...	...	12.46	12.46
C_1	KCl	...	44.62	...	...	44.62
D_1	NaCl	54.90	...	...	...	54.90
E_1	Na_2SO_4 and glaserite	...	...	39.27	9.63	48.90
F_1	K_2SO_4 and glaserite	...	...	8.48	13.69	22.17
G_1	K_2SO_4 and KCl	...	44.11	...	1.50	45.61
H_1	KCl and NaCl	46.04	19.66	...	...	65.70
I_1	NaCl and Na_2SO_4	49.56	...	12.44	...	62.00
J_1	Na_2SO_4 and Glauber's salt	29.00	...	27.5	...	56.50
K_1	Na_2SO_4, Glauber's salt, glaserite	21.92	...	28.25	7.57	57.74
L_1	KCl, K_2SO_4, glaserite	10.45	35.49	...	2.30	48.24
M_1	KCl, NaCl, glaserite	43.08	19.78	4.45	...	67.31
N_1	NaCl, Na_2SO_4, glaserite	53.75	...	2.85	11.40	68.00

that most of these are curved slightly. It should not be forgotten that this kind of a diagram actually represents the horizontal projection of a solid figure. Any point on it may represent a number of solutions of different composition, but if perpendiculars are erected at the limiting points and given lengths proportional to the total number of mols present in the saturated solutions to which these points correspond, and if the ends of these perpendiculars are properly connected, any point which appears on the planes which limit the resulting solid figure can have a single definite value only.

[1] In the tables in this article the subscripts of A, B, C, etc., indicate the figure on which the points are to be found.

The diagram agrees in all essential features with that given by Meyerhoffer, with the exception of the position of the point J representing the composition of a solution containing sodium chloride and sodium sulfate in equilibrium with solid sodium sulfate and Glauber's salt. His determination places the position of this point as W. That this is in error was clearly shown by duplicate determinations and also by determining the points *a*, *b*, *c* and *d* on the line IJ, and *e* on the line AJ, that is, the composition of solutions containing sodium chloride and sodium sulfate, and saturated with either sodium sulfate or Glauber's salt.

The diagram indicates the composition of all possible solutions which can be in equilibrium with the six different solid phases: *viz.*, glaserite, Glauber's salt, sodium chloride, sodium sulfate, potassium chloride and potassium sulfate. Since the composition of glaserite may vary between certain limits, the position of all points representing solutions saturated with respect to it may show slight variations. In determining the composition of such solutions care was taken to add only sufficient of the prepared salt to inoculate the solution, that is, to cause the greater part of the solid glaserite present to separate from the solution itself. This insured the presence of solid glaserite of a composition corresponding to the limiting value of the salt which could exist in the particular portion of the diagram concerned. No difficulty was experienced in inducing the salt to separate under favorable conditions, even without inoculation. It invariably appeared in the form of coarse, granular crystals sometimes 2 to 3 mm. in diameter, which showed under the microscope a well-defined hexagonal symmetry, and were uniaxial.

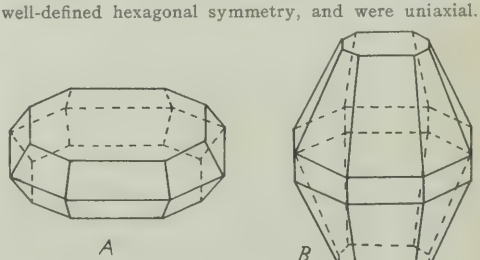


FIG. 2—CRYSTALS OF GLASERITE

The typical habit, which makes it easy to distinguish the salt from either potassium or sodium sulfates, is represented in Fig. 2, of which A represents a specimen prepared at 100° and B a specimen prepared at 50° from the two simple sulfates.

THE DIAGRAM FOR 0°

The data for this diagram are given in Tables III and IV. The graphical representation given in Fig. 3 differs from that given by Meyerhoffer in two funda-

mental respects. First, the position of the point I, representing the composition of solutions in equilibrium with solid sodium chloride and solid Glauber's salt, is located by Meyerhoffer at the point marked W. That the point I represents the correct composition of the solution was shown by the preparation of two different solutions whose analyses gave closely agreeing results.



FIG. 3—THE EQUILIBRIUM DIAGRAM AT 0°

The second difference relates to the location and size of the glaserite field. The Meyerhoffer diagram shows that the glaserite field includes the point F and extends over an interval between the points marked X and Y. It also makes the glaserite field extend between lines joining the points Y and L and the points X and O.

TABLE III—COMPOSITION, IN GRAMS PER 100 G. OF WATER, OF SOLUTIONS SATURATED AT 0°

Saturated with	NaCl	KCl	Na_2SO_4	K_2SO_4	Sp. Gr.
A_3 Na_2SO_4	...	...	4.62	...	1.043
B_3 K_2SO_4	...	...	...	7.23	1.063
C_3 KCl	...	28.20	...	...	1.153
D_3 NaCl	34.95	...	...	...	1.206
F_3 Glauber's salt and K_2SO_4	...	...	6.30	9.00	1.118
G_3 K_2SO_4 and KCl	...	27.88	...	1.21	...
H_3 NaCl and KCl	31.53	10.55	...	...	...
I_3 NaCl and Glauber's salt	34.48	...	1.70	...	1.185
L_3 K_2SO_4, KCl, glaserite	13.38	17.78	...	2.78	1.188
N_3 NaCl, Glauber's salt, KCl	32.08	7.81	...	3.62	1.240
O_3 KCl, Glauber's salt, glaserite	27.07	10.06	...	3.24	1.232
P_3 K_2SO_4, Glauber's salt, glaserite	7.46	13.24	4.73	...	...

TABLE IV—COMPOSITION, IN MOLS PER 1000 MOLS OF WATER, OF SOLUTIONS SATURATED AT 0°

Saturated with	Na_2Cl_2	K_2Cl_2	Na_2SO_4	K_2SO_4	Sum
A_3 Na_2SO_4	...	...	5.85	...	5.85
B_3 K_2SO_4	...	...	...	7.47	7.47
C_3 KCl	...	34.05	...	...	34.05
D_3 NaCl	53.84	...	...	...	53.84
F_3 Glauber's salt and K_2SO_4	...	...	7.99	9.30	17.29
G_3 K_2SO_4 and KCl	...	33.66	...	1.25	34.91
H_3 NaCl and KCl	48.58	12.75	...	...	61.33
I_3 NaCl and Glauber's salt	53.28	...	2.32	...	55.60
L_3 K_2SO_4, KCl, glaserite	19.41	21.48	2.87	...	43.76
N_3 NaCl, Glauber's salt, KCl	49.44	9.43	...	3.75	62.62
O_3 KCl, Glauber's salt, glaserite	41.71	12.15	...	3.35	57.21
P_3 K_2SO_4, Glauber's salt, glaserite	11.50	16.00	6.0	...	33.50

Several attempts to prepare a solution whose composition corresponded to that represented by the point X failed. All such attempts resulted in the formation of a solution whose composition was represented by the point F, when made either from Glauber's salt and glaserite or by the use of potassium sulfate and a large excess of Glauber's salt and inoculating with glaserite. Although glaserite seems to be unstable at this temperature in contact with any possible solution made from the constituent salts, it might be expected to exist as a solid phase in contact with solutions which also contain sodium and potassium chlorides, since the reaction by which it is formed involves the dehydration of Glauber's salt. No difficulty was experienced in showing that glaserite was stable in contact with solutions whose composition was represented by points slightly to the left of the line LO, and the locations of the points L and O, both of which represent solutions saturated with glaserite, were found to agree with those fixed by the work of Meyerhoffer. The determination of the third point which establishes the form and size of the glaserite field gave more difficulty. By starting with solutions containing varying amounts of sodium chloride and saturating with both Glauber's salt and potassium sulfate, solutions represented by the points *a*, *b*, *c* and *d*, evidently in the line FP, were obtained. By starting with solutions containing both sodium and potassium chlorides and saturating with Glauber's salt and glaserite, solutions represented by the points *e* and *f*, evidently on the line OP, were obtained, and by saturating a solution of sodium chloride with potassium sulfate and glaserite the point *g* was obtained. These make it possible to fix with apparent accuracy the position of the point P. The points *h* and *i* on the line OL were fixed by a similar method.

The other parts of the diagram differ but slightly from those found by Meyerhoffer. The complete diagram differs from that for 25° in the disappearance of sodium sulfate as a solid phase and the very much reduced area occupied by the glaserite field.

THE DIAGRAMS FOR 50°, 75° AND 100°

Since Glauber's salt loses its water of crystallization at 33°, even when in contact with a saturated solution of sodium sulfate, it cannot exist as a solid phase above this temperature in equilibrium with aqueous solutions of any of the salts here considered, and the only solid phases to be considered at temperatures of 50°, 75° and 100° are Na_2SO_4, K_2SO_4, KCl, NaCl and glaserite. The composition of the saturated solutions which determine the equilibrium diagrams for these temperatures are given in Tables V, VI, VII, VIII, IX and X, and the corresponding diagrams (Figs. 4, 5 and 6). If the diagram for 25° be compared with those for 50°, 75° and 100° it will be seen that the progressive changes in the positions of the points C, H, I, L, M and N are such as might be predicted from the changes in the solubilities of the four simple salts. The changes in the points E and F depend in part upon the specific properties of glaserite, but it is easy to correlate the change of E_1 to E_4 with the very great increase in the solubility of sodium sulfate between 25° and 50°, and the changes from E_4 to E_5 and E_6 with the slight decrease in the solubility of this salt between 50° and 75°. Similarly the successive changes from F_1 to F_4, F_5 and F_6 are correlated with the increase in the solubility of potassium sulfate between 25° and 100°. The striking feature of these diagrams is the great increase in the size of the fields representing the composition of solutions

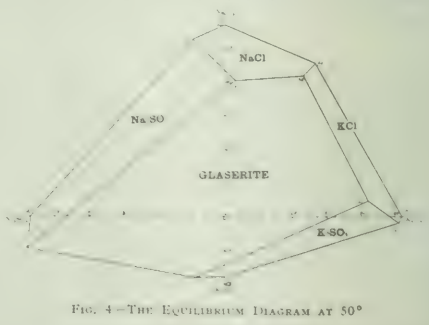


FIG. 4—THE EQUILIBRIUM DIAGRAM AT 50°

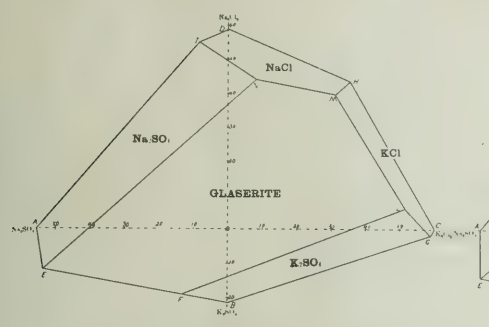


FIG. 5—THE EQUILIBRIUM DIAGRAM AT 75°

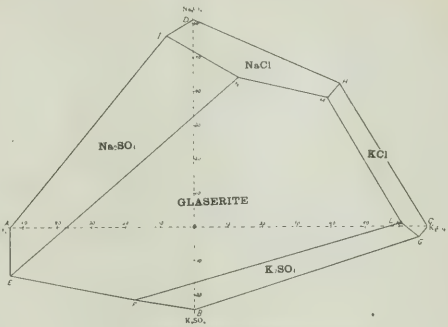


FIG. 6—THE EQUILIBRIUM DIAGRAM AT 100°

TABLE V—COMPOSITION, IN GRAMS PER 100 G. OF WATER, OF SOLUTIONS SATURATED AT 50°

	Saturated with	NaCl	KCl	Na_2SO_4	K_2SO_4	Sp. Gr.
A_5	Na_2SO_4	...	...	44.84	...	1.301
B_5	K_2SO_4	...	...	...	17.09	1.110
C_5	KCl	...	43.12	...	...	1.198
D_5	NaCl	36.50	...	...	...	1.188
E_5	Na_2SO_4 and glaserite	...	...	45.73	9.40	1.351
F_5	K_2SO_4 and glaserite	...	...	6.79	17.36	1.307
G_5	KCl and K_2SO_4	...	42.24	...	1.84	1.212
H_5	KCl and NaCl	29.09	22.03	...	...	1.246
I_5	NaCl and Na_2SO_4	33.70	...	7.34	...	1.223
L_5	K_2SO_4, KCl, glaserite	4.68	35.06	...	2.59	1.203
M_5	KCl, NaCl, glaserite	26.84	22.43	3.15	...	1.254
N_5	NaCl, Na_2SO_4, glaserite	40.15	14.58	11.74	...	1.248

TABLE VI—COMPOSITION, IN MOLS PER 1000 MOLS OF WATER, OF SOLUTIONS SATURATED AT 50°

	Saturated with	Na_2Cl_2	K_2Cl_2	Na_2SO_4	K_2SO_4	Sum
A_5	Na_2SO_4	...	...	56.86	...	56.86
B_5	K_2SO_4	...	...	...	17.60	17.60
C_5	KCl	...	52.10	...	...	52.10
D_5	NaCl	56.24	...	...	...	56.24
E_5	Na_2SO_4 and glaserite	...	...	58.00	9.72	67.72
F_5	K_2SO_4 and glaserite	...	...	8.61	17.95	26.56
G_5	KCl and K_2SO_4	...	51.03	...	1.90	52.93
H_5	KCl and NaCl	44.82	26.61	...	...	71.43
I_5	NaCl and Na_2SO_4	51.93	...	9.26	...	61.19
L_5	K_2SO_4, KCl, glaserite	7.21	42.36	...	2.67	52.24
M_5	KCl, NaCl, glaserite	41.36	27.01	4.00	...	72.37
N_5	NaCl, Na_2SO_4, glaserite	40.15	14.58	11.74	...	66.47

TABLE VII—COMPOSITION, IN GRAMS PER 100 G. OF WATER, OF SOLUTIONS SATURATED AT 75°

	Saturated with	NaCl	KCl	Na_2SO_4	K_2SO_4	Sp. Gr.
A_5	Na_2SO_4	...	...	43.41	...	1.286
B_5	K_2SO_4	...	...	...	20.80	1.120
C_5	KCl	...	49.70	...	...	1.204
D_5	NaCl	37.75	...	...	...	1.183
E_5	Na_2SO_4 and glaserite	...	...	42.06	11.77	1.332
F_5	K_2SO_4 and glaserite	...	...	10.09	18.60	1.183
G_5	KCl and K_2SO_4	...	48.75	...	2.12	...
H_5	KCl and NaCl	27.87	29.06	...	...	1.249
I_5	NaCl and Na_2SO_4	35.46	...	6.67	...	1.210
L_5	K_2SO_4, KCl, glaserite	5.71	42.58	...	2.83	1.223
M_5	KCl, NaCl, glaserite	25.45	29.38	3.33	...	1.257
N_5	NaCl, Na_2SO_4, glaserite	28.28	15.72	8.88	...	1.253

TABLE VIII—COMPOSITION, IN MOLS PER 1000 MOLS OF WATER, OF SOLUTIONS SATURATED AT 75°

	Saturated with	Na_2Cl_2	K_2Cl_2	Na_2SO_4	K_2SO_4	Sum
A_5	Na_2SO_4	...	...	55.03	...	55.03
B_5	K_2SO_4	...	...	...	21.50	21.50
C_5	KCl	...	60.02	...	...	60.02
D_5	NaCl	58.17	...	...	...	58.17
E_5	Na_2SO_4 and glaserite	...	...	53.34	12.17	65.51
F_5	K_2SO_4 and glaserite	...	...	12.80	19.23	32.03
G_5	KCl and K_2SO_4	...	58.90	...	2.19	61.09
H_5	KCl and NaCl	42.94	35.11	...	...	78.05
I_5	NaCl and Na_2SO_4	54.64	...	8.48	...	63.12
L_5	K_2SO_4, KCl, glaserite	8.80	51.45	...	2.93	63.18
M_5	KCl, NaCl, glaserite	39.23	35.50	4.23	...	78.96
N_5	NaCl, Na_2SO_4, glaserite	43.57	18.99	11.26	...	73.82

TABLE IX—COMPOSITION, IN GRAMS PER 100 G. OF WATER, OF SOLUTIONS SATURATED AT 100°

	Saturated with	NaCl	KCl	Na_2SO_4	K_2SO_4	Sp. Gr.
A_5	Na_2SO_4	...	...	41.68	...	1.264
B_5	K_2SO_4	...	...	...	23.44	1.134
C_5	KCl	...	56.20	...	...	1.217
D_5	NaCl	39.40	...	...	...	1.175
E_5	Na_2SO_4 and glaserite	...	...	41.70	13.62	1.326
F_5	K_2SO_4 and glaserite	...	...	13.57	20.51	1.213
G_5	K_2SO_4 and KCl	...	54.43	...	2.83	1.225
H_5	NaCl and KCl	27.39	35.16	...	...	1.253
I_5	NaCl and Na_2SO_4	36.56	...	6.41	...	1.204
L_5	K_2SO_4, KCl, glaserite	3.19	50.01	...	3.24	1.233
M_5	KCl, NaCl, glaserite	24.82	36.13	3.77	...	1.269
N_5	NaCl, Na_2SO_4, glaserite	35.84	10.18	...	11.00	1.256

TABLE X—COMPOSITION, IN MOLS PER 1000 MOLS OF WATER, OF SOLUTIONS SATURATED AT 100°

	Saturated with	Na_2Cl_2	K_2Cl_2	Na_2SO_4	K_2SO_4	Sum
A_5	Na_2SO_4	...	...	52.86	...	52.86
B_5	K_2SO_4	...	...	...	24.07	24.07
C_5	KCl	...	67.90	...	...	67.90
D_5	NaCl	60.81	...	...	...	60.81
E_5	Na_2SO_4 and glaserite	...	...	52.88	14.08	66.96
F_5	K_2SO_4 and glaserite	...	...	17.21	21.21	38.42
G_5	K_2SO_4 and KCl	...	65.76	...	2.93	68.69
H_5	NaCl and KCl	42.20	42.48	...	...	84.68
I_5	NaCl and Na_2SO_4	56.33	...	8.12	...	64.45
L_5	K_2SO_4, KCl, glaserite	4.91	60.41	...	3.24	68.56
M_5	KCl, NaCl, glaserite	38.25	43.65	4.78	...	86.68
N_5	NaCl, Na_2SO_4, glaserite	55.22	12.31	...	11.37	78.90

with which solid glaserite is in equilibrium. Some further details of these diagrams will be described in the following paper.

UNIVERSITY OF CALIFORNIA
BERKELEY

THE SEPARATION OF THE CHLORIDES AND SULFATES OF SODIUM AND POTASSIUM BY FRACTIONAL CRYSTALLIZATION

By WALTER C. BLASDALE

Received March 20, 1918

Relatively little use has been made in the industries of data similar to that presented in the preceding article, although the possibility of doing so was indicated by van't Hoff[1] and has recently been discussed by Hildebrand[2] as applied to the utilization of the bittern of sea water. In this paper the data referred to will be utilized in suggesting and testing the efficiencies of methods for the separation of certain pairs of salts which yield a common ion, and for the recovery of potassium salts from two classes of materials which are of special importance to the states of the Pacific Coast. The first is the ash of kelp, which is already produced on a large scale in the state of California; the second includes certain natural brines found in the desert regions of California, Nevada and Utah. Many of the latter contain small amounts of carbonates, bicarbonates and borates which would make it necessary to modify to some extent any process based upon these data; others contain such large proportions of these substances as to make an entirely new set of data necessary.

I—SEPARATION OF POTASSIUM CHLORIDE FROM SODIUM CHLORIDE

The behavior upon evaporation of solutions containing different proportions of these salts can be easily

[1] "Zur Bildung der ozeanischen Salzablagerung," **1908**.

[2] THIS JOURNAL, **10** (1918), 96.

followed by means of a diagram based upon the data given in the preceding article. In this diagram (Fig. I) the weight of sodium chloride in the solution per 100 parts of water is measured along the vertical axis, that of potassium chloride along the horizontal axis.

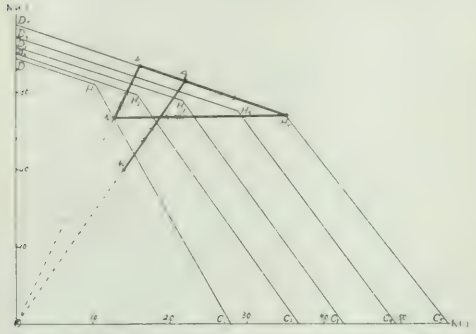


FIG. I THE SEPARATION OF POTASSIUM CHLORIDE FROM SODIUM CHLORIDE

The points D_1, D_2, D_3, D_4 and D_5 represent the composition of solutions saturated with sodium chloride at 0°, 25°, 50°, 75° and 100°, respectively, the points C_1, C_2, C_3, C_4 and C_5 that of solutions saturated with potassium chloride, and the points H_1, H_2, H_3, H_4 and H_5 that of solutions saturated with both salts. The lines D_1H_1, etc., represent the composition of solutions saturated with sodium chloride in the presence of varying amounts of potassium chloride in solution and the lines C_1H_1, etc., that of solutions saturated with potassium chloride which contain varying amounts of sodium chloride. It is assumed that all of these lines are straight, and although no actual measurements have been made, it is probable that they are curves which differ but slightly from straight lines.

A solution which contains 20 g. of sodium and 14 g. of potassium chloride per 100 of water is properly represented by the point p on the diagram. Since this point lies within the space included by the broken line $C_1 H_1 D_1$ it is unsaturated, even at 0°, with respect to both salts. When such a solution is evaporated the proportion of the two salts to each other does not change, and the process of evaporation corresponds to movement of the point p in the direction Op. If the evaporation is made at 100° the solution will become saturated with sodium chloride at the point of intersection of the two lines Op and D_5H_5. The composition of the solution at this point can be ascertained graphically, that is, by measurement of its position with respect to the axes of reference, or by formulating the equations representing the two intersecting lines (namely, $x = 1.4449y$ and $x = 50.4 - 0.3430y$) and solving for the unknown coördinates. The latter method gave the values 22.07 KCl and 31.86 NaCl per 100 H_2O. The amount of water which must be evaporated before this point is reached is easily calculated as follows:

Let it be assumed that we start with 134 g. of the solution referred to above. When r is reached the ratio of NaCl to H_2O must have changed from 20 : 100 to 31.8 : 100. If x represents the water which is evaporated, the following relation is true:

$$20 : 100 = y : 31.86 : 100$$

When solved for x we obtain 37.22 g.

If the evaporation is still continued, sodium chloride will continue to separate and the solution must change its composition in a manner represented by movement of the point q to H_5, at which point potassium chloride will begin to separate. If the sodium chloride which has separated is removed and the temperature reduced to zero, the solution becomes supersaturated with potassium chloride, but unsaturated with sodium chloride, and hence potassium chloride will separate out, and the composition of the solution will change to correspond to that represented by the point r. If the potassium chloride is now removed and the solution again evaporated at 100°, its composition changes to that represented by the point s, at which point sodium chloride will again separate. The result of these operations can be calculated by methods similar to that already used, to be as follows:

Composition of Solution	NaCl	KCl	H_2O	Substances eliminated
At the outset.....	20	14	100	
At the point q . . .	20	14	62.78	37.22 g. H_2O
At the point H_5 . . .	10.91	14	39.72	{ 9.09 g. NaCl { 23 g. H_2O
At the point r . . .	10.91	5.14	39.72	8.86 g. KCl
At the point s.....	10.91	5.14	31.83	7.89 g. H_2O

The series of changes representing movement of r to s, s to H_5, and H_5 to r, constitutes a cycle which can be repeated as long as any solution remains, or the residual solution can be added to a further quantity of fresh solution. Cooling to 25° rather than 0° would reduce the efficiency of the process but little and might prove to be more economical.

II—SEPARATION OF POTASSIUM CHLORIDE FROM POTASSIUM SULFATE

The possibility of separating these salts can be easily shown by reference to Fig. II which is based upon the data given in the preceding article. In this diagram the weight of KCl per 100 g. of water is plotted on the horizontal, that of K_2SO_4 on the vertical axis, and the lines B_1G_1, B_2G_2, etc., represent the solubility of potassium sulfate in the presence of varying amounts

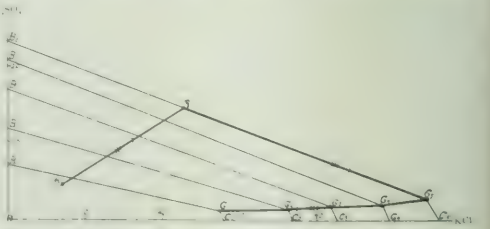


FIG. II THE SEPARATION OF POTASSIUM SULFATE FROM POTASSIUM CHLORIDE

of potassium chloride, while the lines C_1 G_1, etc., represent the solubility of potassium chloride in the presence of varying amounts of potassium sulfate. When a solution of the composition p is evaporated at 100°, K_2SO_4 will separate first at the point q and will continue to separate in pure form until the solution has the composition G_5 at which point potassium chloride will separate also. If the temperature is now reduced both

KCl and K_2SO_4 will separate, and the composition of the solution will change to correspond with that represented successively by the points G_4, G_3, G_2 and G_1. This is a consequence of the fact that the solubility of neither salt is increased by decreasing the temperature as with the KCl-NaCl mixtures. If the solution of composition G_1 or G_2 is again evaporated at 100° it will first become saturated with KCl at a point on the C_5G_5 line very near to G_5, and very little additional evaporation will suffice to saturate it with K_2SO_4 as well as KCl at the point G_5. The proportion of KCl which could be recovered in pure form by this part of the process would be too small to be of commercial significance, but the mixture obtained by continued evaporation at the point G_5 would contain only about 5 per cent of K_2SO_4, and might be used for many purposes without further purification. Hence in dealing with these mixtures it is possible to recover in pure form only that amount of K_2SO_4 which must be separated before the ratio of K_2SO_4 to KCl is changed to the ratio of 1 to 20.

III—THE SEPARATION OF POTASSIUM SULFATE FROM SODIUM SULFATE

The changes which take place during the evaporation of solutions containing the two sulfates can be predicted from Fig. III which is based upon the data given in the preceding article. The vertical axis represents grams of K_2SO_4, the horizontal, grams of Na_2SO_4, per 100 grams of water. The lines B_1F_1, etc., represent the composition of solutions saturated with K_2SO_4 in the presence of varying amounts of Na_2SO_4, the lines F_1E_2, F_2E_2, etc., solutions saturated with glaserite in the presence of varying amounts of K_2SO_4 and Na_2SO_4, the lines F_1A_1 and E_2A_2 solutions saturated with Glauber's salt in the presence of varying amounts of K_2SO_4 and E_3A_3, etc., solutions saturated with Na_2SO_4 in the presence of varying amounts of K_2SO_4. A study of the diagram suggests two possible cycles representing possible commercial methods.

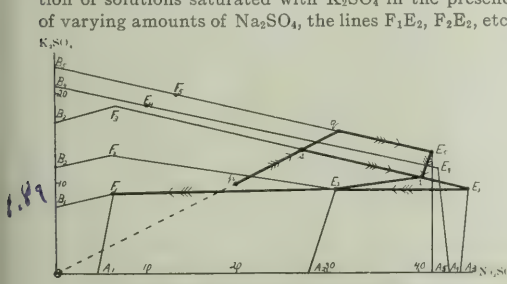


FIG. III—THE SEPARATION OF POTASSIUM SULFATE FROM SODIUM SULFATE

If a solution containing 20 g. Na_2SO_4, 10 g. K_2SO_4 and 100 g. of water, corresponding to the point p, is heated to 100° and evaporated at that temperature, glaserite will begin to separate at q, and the composition of the solution will change from q to E_5; if the temperature is then dropped to 50°, glaserite will separate along the line E_5r, parallel to the line representing the composition of solutions which contain K_2SO_4 and Na_2SO_4 in the same proportions as in glaserite, but no Na_2SO_4 will separate as such since the solution is not saturated with respect to this salt at 50° until it attains the composition E_5. If the temperature is now dropped to 25° a very little glaserite and much sodium sulfate will separate, and all of the latter will be in the form of Glauber's salt by the time the solution reaches the point E_2; if the temperature is dropped to 0° a little glaserite and much Glauber's salt will separate along E_2F_1, but at some stage in the process all the glaserite should change into potassium sulfate and Glauber's salt, although it is probable that this change will be slow and perhaps incomplete unless the glaserite separates as a fine precipitate, and unless it is agitated with the residual solution. In making use of this cycle it is evident that a potassium-rich mixture should be removed at r and a sodium-rich mixture at E_2 or F_1.

The second cycle suggested would involve evaporating at 50° instead of 100°, that is, from s to E_3 and removing the potassium-rich mixture, then cooling to 25° or 0° and removing the separated sodium-rich mixture. The comparative efficiencies of the two methods can be calculated, by the methods already discussed, to be as follows:

SUBSTANCES ELIMINATED BY PROCESS I

	H_2O	Na_2SO_4	K_2SO_4
Between p and q	37.5		
Between q and E_5	17.01	1.03	3.79
Between E_5 and r		0.39	1.43
Between r and E_2	8.60	7.16	1.36
Between E_2 and F_1	13.02	9.92	1.26
Left in Solution	23.86	1.50	2.16

SUBSTANCES ELIMINATED BY PROCESS II

	H_2O	Na_2SO_4	K_2SO_4
Between p and s	25.37		
Between s and E_3	33.34	1.22	4.49
Between E_3 and E_4	10.86	9.42	3.12
Between E_2 and F_1	11.43	8.18	0.69
Left in Solution	18.80	1.19	1.70

These figures show that the total amount of K_2SO_4 recovered by Process I in a concentrated form is somewhat greater than that recovered by Process II, also that the proportion of K_2SO_4 lost with the sodium-rich mixture is less in Process I than in Process II. It is also probable that under most conditions evaporation at 100° would be more economical than at 50°. The treatment of the residual solution by either of the two processes would be more efficient than the treatment of the original solution. The effect of cooling to 25° only would be to decrease greatly the proportion of K_2SO_4 to Na_2SO_4 in the residual solution and to increase the amount of water which would have to be removed by evaporation in the treatment of this residual solution.

The separation of pure K_2SO_4 from the potassium-rich mixture would involve large wastes of either power or product, but it is probable that its K_2SO_4 content could be utilized as such without further concentration. It is doubtful whether the sodium-rich mixture (especially that obtained by cooling to 0°) could be profitably treated for the recovery of the potash which it contains, since it could not be concentrated to a greater degree than would be represented by solutions saturated with both sodium sulfate and glaserite, which at 100° would correspond to the point E_5.

IV—THE SEPARATION OF SODIUM SULFATE FROM SODIUM CHLORIDE

The diagram needed for the discussion of this separation is shown in Fig. IV. The horizontal axis repre-

sents grams of Na_2SO_4, the vertical axis grams of NaCl, per 100 g. of water. The lines D_1I_1, etc., represent solutions saturated with NaCl in the presence of varying amounts of Na_2SO_4, the lines I_2J_2, I_3A_3, I_4A_4 and I_5A_5 solutions saturated with Na_2SO_4 in the presence of NaCl, and I_1A_1 and J_2A_2 solutions saturated with

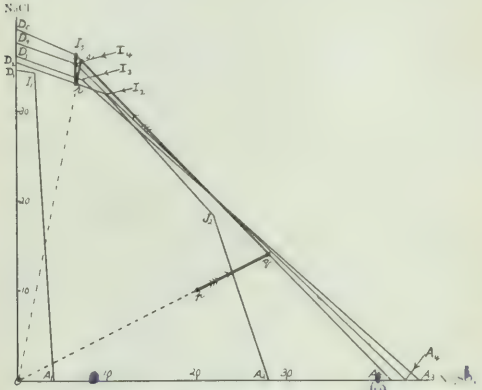


FIG. IV—THE SEPARATION OF SODIUM SULFATE FROM SODIUM CHLORIDE

Glauber's salt in the presence of Na_2SO_4 and NaCl. It will be assumed that a solution which consists of 20 g. Na_2SO_4, 10 g. NaCl and 100 g. H_2O is to be treated. The composition of this solution is represented by the point p. When evaporated at 100° pure Na_2SO_4 would separate from q to the crystallization end-point at I_5. If the separated sulfate is removed and the solution allowed to cool to 25°, pure NaCl would separate until the solution attains the composition r, or if allowed to cool to 0°, both NaCl and Glauber's salt would separate until it attains the composition I_1. If the former procedure is adopted the separated NaCl could be removed, the solution again evaporated at 100°, a further quantity of pure Na_2SO_4 recovered, and this cycle of changes repeated as in the separation of KCl from NaCl, but it is obvious that the amount of pure salt separated would be small, and in view of the cheapness of both salts not commercially feasible.

Cooling to 0° would give a residual solution containing a relatively small proportion of Na_2SO_4 and would also eliminate a large amount of water as water of crystallization. The efficiency of these processes could be calculated quantitatively, but an approximate idea can also be gained from a study of the diagram.

V—THE SEPARATION OF SALTS OF POTASSIUM FROM MIXTURES CONTAINING SULFATES AND CHLORIDES OF SODIUM AND POTASSIUM

PRELIMINARY DISCUSSION—In applying the method already used to the discussion of the more complex mixtures here considered it becomes necessary to make use of diagrams in which concentrations are expressed in molecular equivalents, since the salts actually present are in part ionized, and the manner in which the unionized basic elements and the acidic elements or groups are actually combined is both variable and difficult to ascertain. Hence the composition of all such solutions will be expressed in terms of the number of mols of Na_2Cl_2, K_2Cl_2, Na_2SO_4 and K_2SO_4 per 1000 mols of water. The composition of any of these solutions can be expressed in terms of any three of the four, and the three actually used will be chosen arbitrarily. By plotting the concentration with reference to two axes, intersecting at right angles, as explained in the previous paper, it is possible to prepare diagrams which properly represent the composition of any such solutions. A clearer idea of the uses of such diagrams can be gained from a study of Fig. V which represents the equilibrium conditions for the system here considered at 25°. The formulas which appear on the different areas represented on this diagram indicate the composition of all possible solutions which are saturated with respect to the salts represented by these formulas. The lines separating these fields represent the composition of solutions saturated with respect to the two salts of the adjacent field, and the points of intersection of these lines the composition of solutions saturated as to the two or three salts of the adjacent fields. It should be noted that each area represents the bounding surface of a solid figure, and that all points within the space enclosed by these surfaces represent unsaturated solutions. When such a solution is evaporated the change in its composition corresponds to the movement of the point representing it in a straight line away from the origin. The point at which this line intersects the surface of the solid figure indicates the salt with which the solution first becomes saturated and the composition of the solution at that point. If the process of evaporation be continued the salt continues to separate, and the composition of the solution changes in a manner represented by movement of the point of intersection along a line, which is on the intersected surface, in a direction away from the point representing saturation with respect to the salt concerned in water, that is, in the absence of

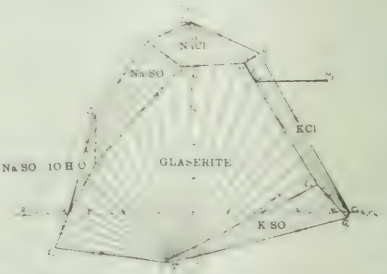


FIG. V—THE SEPARATION OF COMPLEX MIXTURES AT 25°

all other salts. These lines will not in general be straight lines, but in most cases the error involved in assuming them to be straight will not be large.

The points representing saturation with respect to $Na_2SO_4.10H_2O$, K_2SO_4, KCl and Na_2Cl_2 are A_2, B_2, C_2 and D_2, and the series of lines radiating from these points represent the "crystallization paths" of solutions from which these salts separate during evaporation. The point representing saturation with Na_2SO_4 is found by prolonging the line I_2J_2 until it intersects OA_2. The assumption is made here that if Na_2SO_4 could exist

at 25° in equilibrium with water, and if its solubility were changed by varying concentrations of NaCl beyond J_2 at the same rate as between I_2J_2, its solubility in pure water would correspond to the point R. The point representing saturation with pure glaserite is found by drawing from O a line representing solutions containing K_2SO_4 and Na_2SO_4 in the ratio of three to one (as in pure glaserite) and finding its intersection with the line E_2F_2. Here it is assumed that if pure glaserite could exist in equilibrium with water at 25°, and if its solubility were to be changed by varying proportions of K_2SO_4 and Na_2SO_4 uniformly along the line E_2F_2, the composition of the solution with which it was in equilibrium would be represented by the point S.

Having in this manner drawn crystallization paths on all six of the surfaces bounding the figure, it is readily possible to predict the crystallization paths after the lines separating these surfaces have been reached. It is obvious that solutions corresponding to points on the N_2M_2 line, which are to the right of the line joining D_2 and S must change to correspond with the point M_2, whereas those to the left of this line must change to correspond with the point N_2 when evaporated; that is, there are two "crystallization end-points," M_2 and N_2. Aside from the fact that the Glauber's salt field is eliminated, the crystallization paths on the 100° diagram (Fig. VI) differ from those of the 25° diagram mainly in the fact that there is only one "crystallization end-point," namely M_5. This is a result of the fact that both N_5 and M_5 are to the right of the line joining D_5 and S.

THE SEPARATION OF POTASH FROM THE ASH OF KELP—From a study of the analysis of the ash of a typical sample of *Macrocystis pyrifera*, which is the species of kelp most largely used in California, made by P. L. Hibbard,[1] it would appear to be readily possible by leaching with water at 100° to prepare from such an ash a solution containing 30 g. KCl, 10 g. NaCl, and 6 g. Na_2SO_4 per 100 g. of H_2O. The composition of this solution, expressed in mols of K_2Cl_2, Na_2Cl_2 and Na_2SO_4 per 1000 mols of water, can be calculated as follows:

$$\left.\begin{array}{l} 30 \div 149.12 = 0.2012 \\ 10 \div 116.92 = 0.0855 \\ 6 \div 142.06 = 0.0422 \\ 100 \div 18 = 5.555 \end{array}\right\} \times 180 = \left\{\begin{array}{l} 36.20 \text{ mols } K_2Cl_2 \\ 15.39 \text{ mols } Na_2Cl_2 \\ 7.60 \text{ mols } Na_2SO_4 \\ 1000. \text{ mols } H_2O \end{array}\right.$$

The composition of this solution corresponds to the point *p*, of Fig. VI, which represents the equilibrium diagram at 100°. It is obvious that, when evaporated, glaserite, then glaserite and potassium chloride, will separate until the composition of the solution corresponds to the point M_5. The total amount of H_2O, glaserite and K_2Cl_2 which separate during the evaporation can be calculated as follows:

Let x = H_2O, y = K_2Cl_2, z = glaserite separated.

Then the following relations representing changes in the composition of the solution as to K_2, SO_4, Cl_2 and Na_2 are obvious.

$$\begin{array}{lll} (1) & 36.20 - y - 1.5\,z & : 1000 - x = 43.65 : 1000 \\ (1) & 7.60 - 2\,z & : 1000 - x = 4.78 : 1000 \\ (3) & 51.59 - y & : 1000 - x = 81.90 : 1000 \\ (4) & 22.99 - 0.5\,z & : 1000 - x = 43.03 : 1000 \end{array}$$

When solved for x, y and z these equations give the following values in mols:

H_2O = 495.87, K_2Cl_2 = 10.30, glaserite = 2.59

[1] University of California Experiment Station, *Bulletin* 248, 142.

The residual solution could then be calculated to have the composition in mols:

504.13 H_2O, 22.01 K_2Cl_2, 2.41 Na_2SO_4, 19.28 Na_2Cl_2.

It is also of some interest to ascertain the amount of H_2O which must be evaporated before any glaserite separates, the water which separates with the pure

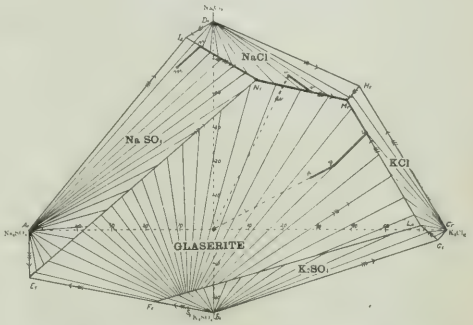


FIG. VI—THE SEPARATION OF COMPLEX MIXTURES AT 100°

glaserite, and the water and K_2Cl_2 which separate along the line L_5M_5. These calculations are somewhat long but the methods can be outlined as follows:

1—Calculate the ratio which the K_2Cl_2 separating along the line L_5M_5 bears to the H_2O and to the glaserite separating simultaneously, assuming the rate is a uniform one.

2—Calculate by means of these ratios the weights of H_2O and glaserite which would separate after the K_2Cl_2 begins to separate, from the total amount of K_2Cl_2 separated, and add the amounts of H_2O, K_2Cl_2, Na_2SO_4 and Na_2Cl_2 which they represent to the amounts of these salts present at M_5 to obtain the amounts present at the point *r*.

3—Subtract the glaserite lost between *r* and M_5 from that lost between *q* and M_5 to find that lost between *q* and *r* and add the amounts of K_2Cl_2, Na_2SO_4, and Na_2Cl_2, which it represents, to the amounts of these salts present at *r* to find the amounts present at *q*.

4—Determine the intersection of O*p* with the crystallization path passing through *r* to get the coördinates of the point *q* and from them the amount of water present at *q*.

5—Subtract the sum of the amounts of water lost between *q* and *r* and between *r* and M_5 from that lost between *p* and M_5 to get that lost between *p* and *q*.

The results of these calculations gave when expressed in mols:

Loss between *p* and *q* = 182.0 H_2O

Loss between *q* and *r* = 151.16 H_2O + 2.955 glaserite

Loss between *r* and M_5 = 162.71 H_2O + 0.25 glaserite + 10.3 K_2Cl_2.

If the solution is now cooled to 25° it will become greatly supersaturated with respect to K_2Cl_2 as is shown by the position of M_5 on the 25° diagram (Fig. V). After the excess of KCl has separated its composition will be represented by some point on the plane $C_2H_2M_2L_2G_2$. The determination of the position of this point can be made by the following procedure:

1—Calculate the total amount of K_2Cl_2, glaserite and H_2O which must separate in passing from M_5 to M_2.

2—Calculate the ratio which the amount of glaserite separating along the line L_2M_2 bears to the amount of K_2Cl_2 and of water separating simultaneously, assuming that the rates are uniform.

3—Calculate, by the use of these ratios, the weights of H_2O

and K_2Cl_2, which separate after the glaserite begins to separate at the point t, from the total amount of glaserite separated and add the amounts found to the amounts of these substances present at M_2 to get the composition of the solution at t.

4—Subtract the H_2O and K_2Cl_2 lost between t and M_2 from the amounts lost between M_2 and M_5 and add to the amounts present at M_2 to find the amounts present at s.

5—Determine the point of intersection of the crystallization path tL_2 with the horizontal line M_5 s, and from the coördinates of this point determine the K_2Cl_2 present at the point s.

6—Subtract the sum of the amounts of K_2Cl_2 lost between t and M_2 and between s and t from that between M_5 and M_2 to find the amount lost between M_5 and s.

The results of these calculations can be summarized as follows:

Loss between M_4 and s = 10.28 KCl;
Loss between s and t = 1.25 KCl + 21.68 H_2O
Loss between t and M_2 = 1.20 KCl, 28.15 H_2O + 0.19 glaserite

It is not probable that these solutions could be evaporated at a temperature of 25° economically and the only reason for calculating the changes which take place in evaporating the solution from s to N_2 was to ascertain the composition of the solution at s, that is, at the point at which all the KCl which can be separated by cooling to 25°, has separated. The most rational procedure would be to evaporate the solution of composition s at 100° for the purpose of eliminating salts of sodium.

By again referring to Fig. VI it will become apparent that when this evaporation is made glaserite and NaCl must separate, but it is not possible to predict *a priori* which of the two will separate first. By using methods similar to those already employed it can be shown that the solution will first become saturated with NaCl at the point u, that NaCl and H_2O will separate along uv and that H_2O, NaCl and glaserite will separate along vM_5. These changes can be summarized as follows:

Loss between s and u = 75.53 H_2O
Loss between u and v = 101.64 H_2O, 6.09 Na_2Cl_2
Loss between v and M_5 = 79.33 H_2O, 4.66 Na_2Cl_2, 0.61 glaserite

This completes a cycle of changes similar to that described in the separation of KCl from NaCl, but one which is less efficient than the former since some potash is necessarily included with the sodium salts separated at 100°.

A comprehensive idea of the entire process as outlined may be gained by summarizing the changes during the three important stages in terms of the weights of separated salts expressed in grams.

Composition of solution at outset 100 H_2O, 40 KCl, 10 NaCl, 6 Na_2SO_4
Separated during evaporation to M_2 49.59 H_2O, 8.83 KCl + 5.36 glaserite
Separated during cooling to t 8.81 KCl
Separated during evaporation to M_5 75.67 H_2O, 6.98 NaCl, 0.79 glaserite
Left in residual solution 24.74 H_2O, 8.98 KCl, 6.13 NaCl, 0.94 Na_2SO_4

THE SEPARATION OF POTASH FROM A DESERT BRINE.—A sample of brine from a hole near the center of Death Valley which was analyzed by A. R. Merz[1] will serve as an illustration for the application of the data of the preceding article to this class of substances. The result of the analysis, expressed in grams per 100 cc. of solution, was 3.06 KCl, 25.97 NaCl, 9.71 Na_2SO_4 and 1.28 g. of undetermined salts. Although the specific gravity is not given, a solution of this composition should give a value not far from 1.24 and the composition of the solution in grams per 100 g. of H_2O can be calculated to be 3.64 KCl, 30.92 NaCl and 11.56 Na_2SO_4. Calculated to mols per 1000 mols of water these values become

4.40 K_2Cl_2, 47.60 Na_2Cl_2, 14.65 Na_2SO_4, 1000 H_2O.

A solution of this composition would be represented by the point m on Fig. VI, and when evaporated at 100° sodium sulfate must separate first, then a mixture of sodium sulfate and sodium chloride, and finally glaserite and sodium chloride corresponding roughly to movement from m to n, from n to N_5, and from N_5 to M_5. The change from m to N_5 can be calculated to involve the elimination of 814.2 mols of H_2O, 39.45 of Na_2Cl_2, and 12.45 of Na_2SO_4; the change from N_5 to M_5 of 115.5 H_2O, 6.79 Na_2Cl_2 and 0.886 glaserite. This would leave 70.3 mols of H_2O, 3.27 of Na_2Cl_2, 3.08 of K_2Cl_2 and 0.34 of Na_2SO_4, which solutions could then be treated by the cyclic process already described in dealing with the ash of kelp.

The chief objection to this method of procedure is the large amount of evaporation needed; this might be decreased by utilizing solar evaporation to some extent. If, for example, it were permitted to evaporate at 25° the solution would attain a composition corresponding to N_2 of Fig. V as the result of the elimination of 614 H_2O, 31.25 Na_2Cl_2 and 5.49 Na_2SO_4. Further evaporation at this temperature would not change the composition of the solution and it would be necessary to continue the evaporation at a higher temperature (preferably at 100°) in order to concentrate still further the potassium salts present.

A third possible method would involve cooling the brine to 0° for the purpose of eliminating much of the Na_2SO_4 and H_2O as Glauber's salt before evaporation. The composition of the original solution on the 0° diagram (Fig. 3 of the previous article) is represented by a point which shows that it is supersaturated at this temperature with Glauber's salt and sodium chloride. The composition of the solution after the excess of these salts has separated must be represented by a point on the line I_3N_3; it can be established by making use of the following considerations:

1—The original solution contains 4.4 K_2Cl_2, but (as shown later) the solution loses 138 mols of water with the separated Glauber's salt, hence the K_2Cl_2 content at the desired point must be $4.4 \div (1000 - 138) = 5.1$ per 1000 H_2O.

2—Since the K_2Cl_2 changes from 0 to 13.18 between I_3 and N_3, the desired point must be $5.1 \div 13.18$ times the distance $I_3 - N_3$ from I_3. This locates it at q, which required the presence of 48.5 Na_2Cl_2 and 0.97 Na_2SO_4.

3—The Glauber's salt which must separate in order to cause Na_2SO_4 to change from 14.65 : 1000 to 0.97 : 1000 can be found by trial to be 13.80. Similarly the Na_2Cl_2 which must separate in order to cause the Na_2Cl_2 to change from 47.6 : 1000 to 48.5 : 1000, in spite of the loss of 138 mols of water associated with the separated Glauber's salt, can be calculated to be 5.8.

This leaves a solution containing 41.8 Na_2Cl_2, 4.4 K_2Cl_2, 0.85 Na_2SO_4 and 862 H_2O which can be treated by methods similar to those used for the ash of kelp. Of the three methods suggested for the treatment of the brine the second gives promise of being the most economical.

The application of similar methods of treatment to

[1] THIS JOURNAL, 5 (1913), 23.

the waters of Owens, Searles, Mono and other desert lakes presents a more complex problem, owing to the fact that these waters contain large percentages of carbonates. It is not improbable that when the diagrams representing the equilibria, which must exist in solutions which contain carbonates as well as sulfates and chlorides of sodium and potassium, have been prepared it will be found possible to suggest methods by which the salts present in such waters can be profitably separated into commercial products. It is also possible that it may be found commercially feasible to precipitate most of the CO_3 ion, either as $NaHCO_3$ or $CaCO_3$, from certain of these waters and recover the potassium salts in the residual solution by the methods already described.

UNIVERSITY OF CALIFORNIA
BERKELEY

THE USE OF "MINE RUN" PHOSPHATES IN THE MANUFACTURE OF SOLUBLE PHOSPHORIC ACID

By Wm. H. Waggaman and C. R. Wagner[1]

Received February 21, 1918

The increasing price of acid phosphate makes it appear timely, if not absolutely essential, to look to other methods of producing available phosphoric acid which will not only release to the munitions industry part of the immense tonnage of sulfuric acid now manufactured at the fertilizer plants, but will also enable the farmer to continue to obtain phosphates at a cost which will justify their application to the soil.

The method which has received special attention in this Bureau is that based on the smelting in an electric furnace of a mixture of phosphate rock, sand and coke, whereby the phosphoric acid is volatilized and subsequently collected by means of the Cottrell precipitator. The equations showing this reaction may be represented thus:

$$Ca_3(PO_4)_2 + 3SiO_2 + 5C = 3CaSiO_3 + 2P + 5CO$$
$$2P + 5O_2 = P_2O_5$$

Ross, Carothers and Merz[2] showed that the Cottrell precipitator gave acid of such a high degree of concentration that the added cost of production by the electric furnace method could be overcome in part at least by the saving in freight charges over the lower grades of commercial phosphates.

In order to obtain more definite data on the cost of producing phosphoric acid by volatilization and electrical precipitation this Bureau conducted some work in coöperation with the R. B. Davis Company, of Hoboken, N. J., over a period of several months. In a recent report on this work Carothers[3] showed that phosphoric acid (P_2O_5) could be produced by this method at a cost of 3.37 cents per lb., exclusive of interest on investment, taxes and royalty. By using the phosphoric acid thus obtained, however, to treat another batch of phosphate rock, double superphosphate is formed, a product containing three times as much phosphoric acid as ordinary acid phosphate, and as Ross, Carothers and Merz[1] have pointed out, the making of double superphosphate brings down the price of phosphoric acid produced by the volatilization process very materially.

In order to compare the economic merits of the furnace process with that of the old established sulfuric acid method of making superphosphate, details of the cost of the two processes are given below in Tables I, II and III. In these estimates it is assumed that washed rock will contain an average of 34 per cent of phosphoric acid (P_2O_5) and that 90 per cent of this is recoverable by the furnace method of treatment. It is also assumed that the proportions of sand and coke necessary to smelt the high-grade rock from the different localities is practically the same.[2] The estimates on the cost of the furnace treatment are based on Carothers' figures[3] obtained at Hoboken, N. J., but they are modified on the assumption that the process is carried on at the mines. Allowances, therefore, have been made only for the difference in the cost of phosphate rock, sand and coke.

While the cost of labor and of power undoubtedly varies considerably in different parts of the country, a uniform charge has been made for these items throughout. In the case of the labor and repairs necessary in the manufacture of ordinary superphosphate a charge has been made which is 50 per cent higher than that prevailing in the South Atlantic States prior to the war.

Since Carothers gives no estimates on the cost of installing the furnace process, no interest, charges, taxes and insurance are included in the cost data for the acid phosphate process.

A comparison of the data given in Tables I and III show that under the present abnormal conditions the phosphoric acid in double superphosphate produced by using the acid volatilized in the electric furnace compares favorably in cost with that of ordinary acid phosphate. This is particularly true when we consider that in shipping such a concentrated product as double acid phosphate the freight rates per ton of phosphoric acid (P_2O_5) are considerably reduced. Based on the conditions existing prior to the war, this saving in freight charges should be more than counterbalanced at the end of the war by a considerable drop in the price of ordinary acid phosphate, due to the release of an immense tonnage of sulfuric acid no longer needed for the manufacture of munitions. So in order that the furnace method may permanently compete with the acid process of producing soluble phosphates, the cost of the former must be materially lowered.

There is, however, another and a very important factor to be considered in connection with the furnace method of producing phosphoric acid which makes this method worthy of more serious consideration. This factor is the immense saving to be effected in low-grade phosphates and phosphatic material wasted

[1] The writers wish to express their thanks to Prof. Milton Whitney, who suggested the work described in this paper.

[2] THIS JOURNAL, 9 (1917), 26.

[3] *Ibid.*, 10 (1918), 35.

[1] *Loc. cit.*

[2] While this assumption is not strictly correct, due to the varying composition of the different types of rock, it serves all practical purposes.

[3] Carothers' figures are based on a plant of 4000 kw. capacity producing 2347 tons P_2O_5 annually

TABLE I—ESTIMATED COST (AT THE MINES) OF PRODUCING ONE TON OF AVAILABLE PHOSPHORIC ACID (P_2O_5) BY TREATING HIGH-GRADE PHOSPHATE ROCK WITH SULFURIC ACID

	Florida Hard Rock Phosphate			Florida Pebble Phosphate			Tennessee Brown Rock Phosphate		
Items	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars
Phosphate Rock	3.18	3.50	11.13	3.18	2.50	7.95	3.18	2.75	8.75
Sulfuric Acid (50° Bé.)	3.44	9.90(a)	34.06	3.44	9.90(a)	34.06	3.44	9.90(a)	34.06
Labor and Repairs	..	1.30(b)	8.61	..	1.30(b)	8.61		1.30(b)	8.61
TOTAL COST			53.80	..		50.62			51.42

(a) Cost per ton including interest, taxes and insurance.
(b) Cost per ton of material handled.

TABLE II—ESTIMATED COST (AT THE MINES) OF PRODUCING ONE TON OF PHOSPHORIC ACID (P_2O_5) BY THE ELECTRIC FURNACE METHOD FROM VARIOUS GRADES OF WASHED PHOSPHATE ROCK

	Florida Hard Rock Phosphate			Florida Pebble Phosphate			Tennessee Brown Rock Phosphate		
Items	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Quantity Tons	Cost per Ton Dollars	Total Cost Dollars
Phosphate Rock	3.32	3.50	11.62	3.32	2.50	8.30	3.32	2.75	9.13
Sand	1.50	0.25	0.37	1.50	0.25	0.37	1.50	0.50	0.75
Coke	0.75	8.00	6.00	0.75	8.00	6.00	0.75	4.50	3.37
Operating Expenses:									
Electrodes	2.13								
Labor	4.45	Total							
Power	44.01								
TOTAL COST			68.58	..		65.26			63.84

TABLE III—ESTIMATED COST (AT THE MINES) OF PRODUCING ONE TON OF AVAILABLE PHOSPHORIC ACID (P_2O_5) IN THE FORM OF DOUBLE SUPERPHOSPHATE BY TREATING HIGH-GRADE PHOSPHATE ROCK WITH PHOSPHORIC ACID OBTAINED BY VOLATILIZATION IN THE ELECTRIC FURNACE

	Florida Hard Rock Phosphate			Florida Pebble Phosphate			Tennessee Brown Rock Phosphate		
Items	Quantity Ton	Cost per Ton Dollars	Total Cost Dollars	Quantity Ton	Cost per Ton Dollars	Total Cost Dollars	Quantity Ton	Cost per Ton Dollars	Total Cost Dollars
Phosphate Rock	0.98	3.50	3.43	0.98	2.50	2.45	0.98	2.75	2.69
P_2O_5 in Form of 58° Bé. Acid	0.67(a)	68.58	45.95	0.67	65.26	43.72	0.67	63.84	42.77
Labor and Power	..	1.30(b)	2.68	..	1.30(a)	2.68		1.30(a)	2.68
Drying	..	0.25(b)	0.52	..	0.25(a)	0.52		0.25(a)	0.52
TOTAL COST	..	...	52.58	..	...	49.37		...	48.66

(a) Equivalent to 1.08 tons of 58° Bé. acid
(b) Cost per ton of material handled.

in the present system of mining and preparing a high-grade rock for the market.

Since the fertilizer manufacturer finds it impracticable to acidulate rock containing more than 3 to 4 per cent of the combined oxides of iron and aluminum, the phosphate miners have installed elaborate washing plants in order to turn out a product high in phosphoric acid and low in these objectionable impurities.

In the mining and concentration of Florida phosphate, all material passing screens of $^3/_{16}$-in. mesh is discarded and washed out through a flume upon a dump or waste heap. Of the total material mined in these fields an average of not more than 15 per cent is saved as marketable rock having a phosphate of lime content ranging from 68 to 78 per cent. The 85 per cent of detritus which is washed away contains the equivalent of from 32 to 33 per cent of phosphate of lime and represents an annual loss in phosphoric acid fully twice as great as that marketed.

In the electric smelting of phosphate rock the presence of sufficient silica to produce silicates of calcium is necessary in order to set free the phosphoric acid contained in the rock. When using high-grade phosphates this necessitates the addition of a considerable quantity of sand in order to obtain the proper silica-lime ratio. Obviously, it would be very much more practical from an economic standpoint to use, if possible, phosphatic material already containing sufficient silica and alumina for smelting purposes than to separate these materials by an expensive washing process only to put them back again when the material is charged to the furnace.

With this idea in view the writers undertook a number of experiments to test the feasibility of smelting "mine run" material in the electric furnace, thus avoiding the expense and losses entailed in handling and washing the rock.

For this work samples of "mine run" material were obtained from each of the following three localities:

1—Hard rock phosphate and matrix from Newberry, Florida.

2—Pebble phosphate and matrix from Ft. Meade, Florida.

3—Tennessee brown rock phosphate from old dumps near Mt. Pleasant, Tennessee.

The analyses of these samples of phosphatic material are given in Table IV:

TABLE IV—ANALYSES OF AIR-DRIED SAMPLES OF "MINE RUN" AND WASTE MATERIAL FROM FLORIDA AND TENNESSEE

Constituent	Florida Hard Rock and Matrix Per cent	Florida Pebble Phosphate and Matrix Per cent	Tennessee Brown Phosphate Waste Per cent
CO_2	2.22	1.53	1.49
SiO_2	14.37	45.99	14.23
P_2O_5	30.69	15.38	29.85
$Al_2O_3 + Fe_2O_3$	5.03	7.50	7.72
CaO	42.07	22.79	40.42
F	3.68	1.58	2.71
TOTAL	98.06	94.77	96.42

Since the most practical ratio of lime to silica for use in the smelting of phosphate rock is approximately 1 to 1.44 it will be seen from the analyses given in Table IV that all of these "mine run" samples require additions of either sand or phosphate rock in order to produce a charge suitable for furnace treatment. It is the opinion of the writers, however, that none of the samples is representative of the field from which it came, the Florida hard rock and matrix and the Tennessee waste material being higher, and the

Florida pebble[1] sample lower in phosphoric acid than the average "mine run" material from these fields.

In order to obtain a charge of the desired composition the phosphatic material from the pebble region of Florida was reënforced with a washed rock containing 32 per cent of P_2O_5 and 7 per cent of SiO_2. The Florida hard rock and matrix and the material from the Tennessee dump heaps were mixed with a high-grade, white sand and sufficient coke was added in each instance to bring about the necessary reduction in the smelting operation. Approximately 500 lbs. of charge were made up in each instance, and smelted in the electric furnace for 3 hrs., the phosphoric acid volatilized being collected by means of the Cottrell precipitator. Since the charge used was relatively small and the period of run was comparatively short, no attempt was made to determine the quantity of P_2O_5 volatilized from the weight of acid collected, but at the end of 3 hrs. the furnace was tapped and the amount of phosphoric acid (P_2O_5) still remaining in the slag was determined by analysis. The amount volatilized was thus obtained by difference.

The figures showing the efficiency of this furnace treatment as applied to "mine run" rock are given in Table V.

TABLE V—QUANTITY OF PHOSPHORIC ACID (P_2O_5) VOLATILIZED FROM A CHARGE MADE UP OF "MINE RUN" PHOSPHATES WHEN SMELTED IN THE ELECTRIC FURNACE FOR 3 HRS.

Phosphatic Material Used in Charge	P_2O_5 in Charge Exclusive of Coke, CO_2 and F Per cent	P_2O_5 in Slag by Analysis Per cent	Percentage of Total P_2O_5 Remaining in Slag after Smelting	Amount of P_2O_5 Volatilized Per cent
Hard Rock and Matrix	22.0	0.50	1.8	98.2
Land Pebble and Matrix	19.1	0.66	3.0	97.0
Tennessee Waste Material	21.3	0.67	2.7	97.3

While the figures given in Table V show a higher volatilization of P_2O_5 from the "mine run" material than from the high-grade rock used in the commercial operations at Hoboken, N. J., such results would probably not be obtained in an actual run over a protracted period of time when conditions would not always be favorable. No data were obtained which would admit of a comparison between the power consumed on the "mine run" samples and that required for a charge made up with high-grade washed rock, but it seems unlikely that there would be much difference in these figures. In fact the lowering of the melting point of the former charge due to its higher content of iron and aluminum oxides should more than counterbalance the extra number of thermal units required to raise the temperature of the increased quantity of slag.

In calculating the figures given in Tables VI and VII, showing the cost of producing phosphoric acid (P_2O_5) from "mine run" material by means of the electric furnace, a 90 per cent recovery is assumed in order to make the figures comparable with those of Carothers[1] on high-grade washed rock.

By comparing the figures given in Table VII with those of Table III, it will be seen that the cost of producing one ton of P_2O_5 by smelting "mine run" phosphate in the electric furnace would be materially lower than that of treating high-grade phosphates which have undergone an expensive mechanical washing and screening process to prepare them for the market. If the sample from the pebble regions of Florida had been of better grade—and from the writer's knowledge of the Florida deposits, it seems that most of the "mine run" rock will require no reënforcement with higher grade phosphate rock—the cost of producing one ton of P_2O_5 from "mine run" material in the various fields would be from $3.75 to $6.50 less than from high-grade phosphates.

Although it would be necessary to wash and screen sufficient phosphate rock for treatment with the phosphoric acid obtained by the volatilization process, the use of the electric furnace at the phosphate mines would save the vast bulk of phosphate now discharged upon the waste heaps and thus greatly prolong the life of the phosphate mines. Whether or not this factor would counterbalance the lower cost (under normal conditions) of producing soluble phosphate by treatment with sulfuric acid would probably have to be definitely determined by actual experience.

TABLE VI—ESTIMATED COST (AT THE MINES) OF PRODUCING ONE TON OF PHOSPHORIC ACID (P_2O_5) BY THE ELECTRIC FURNACE METHOD FROM "MINE RUN" PHOSPHATES

Items	Florida Hard Rock and Matrix Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Florida Pebble and Matrix Quantity Tons	Cost per Ton Dollars	Total Cost Dollars	Tennessee Brown Phosphate Waste Quantity Tons	Cost per Ton Dollars	Total Cost Dollars
Phosphate and Matrix	3.62	0.50	1.81	4.89	0.50	2.45	3.73	0.75	2.80
Washed Pebble for Reënforcing	...	...	...	1.12	2.50	2.80	...	...	...
Sand	1.64	0.25	0.41	...	...	...	1.64	0.50	0.82
Coke	0.75	8.00	6.00	0.75	8.00	6.00	0.75	4.50	3.37
Operating Expenses	..	..	50.59	..	..	50.59	..	..	50.59
TOTAL COST	..	..	58.81	..	..	61.84	..	..	57.58

TABLE VII—ESTIMATED COST (AT THE MINES) OF PRODUCING ONE TON OF AVAILABLE PHOSPHORIC ACID (P_2O_5) IN THE FORM OF DOUBLE SUPERPHOSPHATE BY TREATING HIGH-GRADE PHOSPHATE ROCK WITH PHOSPHORIC ACID FROM "MINE RUN" MATERIAL

Items	Florida Hard Rock Phosphate Quantity Ton	Cost per Ton Dollars	Total Cost Dollars	Florida Pebble Phosphate Quantity Ton	Cost per Ton Dollars	Total Cost Dollars	Tennessee Brown Rock Phosphate Quantity Ton	Cost per Ton Dollars	Total Cost Dollars
Phosphate Rock	0.98	3.50	3.43	0.98	2.50	2.45	0.98	2.75	2.69
P_2O_5 in the Form of 58° Bé. Acid	0.67(a)	58.81	39.40	0.67	61.84	41.43	0.67	57.58	38.58
Labor and Power	..	1.30(b)	2.68	..	1.30(b)	2.68	..	1.30(b)	2.68
Drying	..	0.25(b)	0.52	..	0.25(b)	0.52	..	0.25(b)	0.52
TOTAL COST	..	...	46.03	..	...	47.08	..	...	44.47

(a) Equivalent to 1.08 tons of 58° Bé. acid.
(b) Cost per ton of material handled.

[1] More representative samples of pebble phosphate and matrix showed a composition more nearly corresponding to the proper furnace charge, but there were not sufficient quantities of these materials to smelt in the furnace

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS, WASHINGTON, D. C.

[1] *Loc. cit.*

THE CONCENTRATION OF POTASH FROM RAW MATERIALS CONTAINING ONLY A TRACE OF THIS ELEMENT BY MEANS OF THE ELECTRIC PRECIPITATION OF FLUE DUST AND FUME CEMENT KILNS

By B. F. Erdahl

Received June 25, 1917

With a view of securing more definite information regarding the concentration of potash from flue dust and fume cement kilns, a series of experiments was made during the past 6 mo. at a cement plant using limestone and blast-furnace slag as raw materials and powdered coal for fuel.

During the period of experiments outlined herein an electric precipitation system was installed; 4 precipitators were put in operation successively, one applied to each kiln. The plant has 4 kilns 150 ft. long and 10 ft. in diameter. The precipitation system was installed primarily to abate the dust nuisance and recover the dust for clinker. It occurred to the writer that the system at the same time might serve as a concentrator of potash volatilized from the kilns.

In order to find the potash content of the limestone, the slag, the coal ash resulting from the fuel, the clinker and the precipitated dust, a series of analyses was made of weekly average samples during the past 6 mo.

From these analyses it was found that the potash content of the limestone and clinker remained constant; the potash content of the slag varied from 0.28 per cent to 0.69 per cent, of the coal ash from 1.20 per cent to 1.52 per cent; the potash in the precipitated dust increased with each addition of a new treater to the system of kilns.

The latter fact suggested the idea that the precipitator system may serve as a concentrator of volatilized potash.

The amount of potash going in with the raw material during a week was figured from the registered dumps of the raw material scales and the amount of potash produced from the coal ash was figured from the amount of coal used to burn the number of barrels of clinker corresponding to the raw material passing through.

A fairly representative week showed the following results:

Limestone contained 0.06 per cent K_2O, existing most likely as insoluble feldspar, $KAlSiO_4$.
Slag contained 0.69 per cent K_2O, existing mainly as soluble K_2CO_3 and K_2SO_4, the former derived from the coke ash, the latter precipitated from K_2CO_3 by vapors of SO_2 and H_2O in the blast furnace.
Coal ash contained 1.20 per cent K_2O, existing as soluble K_2CO_3.
Clinker contained 0.14 per cent K_2O.

With these percentages for the week in question were calculated the number of pounds K_2O going in with the raw material and coal and the amount of K_2O coming out with the clinker, the difference giving us the number of pounds volatilized potash for the week, thus:

Limestone carried in	3084.30 lbs	K_2O
Slag carried in	5408.89 lbs	K_2O
Coal ash carried in	1756.00 lbs	K_2O
Total	10249.19 lbs	K_2O
Clinker carried out	1008.30 lbs	K_2O
Volatilized	25240.89 lbs	K_2O

Expressed in percentage = 70.26 per cent K_2O volatilized

The writer has considered the difference between the amount of potash fed to the kilns with the raw material and coal and the amount leaving the kilns with the clinker as volatilized potash. Strictly speaking, some of the potash, however, goes over as non-volatilized with the dust blown from the kilns by the draught before the mixture reaches the volatilizing zone. The dust thus carried over is not any richer in potash than the corresponding mixture and the amount of potash in it is in relation to the total potash content in the mixture as the regular stack loss is to the whole raw material charge. The non-volatilized potash, therefore, represents a small amount compared with the volatilized and as a distinction between them will not influence the subsequent calculations, it is omitted.

The highest efficiency as to volatilization of potash is dependent on many factors. The writer's personal experience based on analyses of clinker, clinkerdust, clinker balls and rings under varying kiln conditions seems to point out as the main factors for producing the highest possible percentage of volatilized potash:

1—A kiln temperature of 2550° F. or higher.

2—A neutral or slightly over-limed mixture, facilitating the formation of a small nut sized clinker which in turn would make easier the liberation of potash possibly enclosed in the clinker.

3—A low percentage of sulfur in the slag and the coal, decreasing the formation of SO_2 which in turn would tend to precipitate less of the more difficultly volatilizing K_2SO_4, leaving the greater part of the potash as K_2CO_3.

From the preceding data it will be seen that some potash, in spite of normal kiln conditions, will remain in the clinker, but at the same time it must be remembered as an important fact that *this loss is practically constant.* This leads to another conclusion, namely, that *the potash once volatilized is easily volatilized again.* The writer had occasion to verify this through the successive erection of the four treaters. The potash content of the dust returning to the kilns increased with the addition of precipitators and as the result the charge to the kilns became richer in potash but the potash content of the clinker remained constant. It is, therefore, evident that a precipitation system returning all the dust from the flue gases, assuming 100 per cent efficiency, would conserve all the potash volatilized. At the clinker end the potash cannot escape over and above a certain constant amount mentioned above because of the volatilization temperature in the clinkering zone; at the stack end the potash will be returned by the electric precipitator; practically the efficiency is not absolute; normally a recovery of approximately 96 per cent is obtained; the dust escaping is richer in potash than the average dust precipitated; this material is not coal ash but conforms to the general analysis of dust returned to the system with the exception of its potash content. The fact that this escaping dust is richer in potash than the precipitated seems to be a consequence of operating an electrical precipitation installation. The heavier dust is easily collected, while the recovery of fine fume presents a more difficult problem. As the potash volatilized in the kilns is largely present in the form of fine fume it naturally follows that the escaping ma-

terial will be richer in potash than the material collected.

In order to discover the laws governing the accumulation taking place, a dump of the raw material scales was taken as a unit for the purpose of calculation. A dump at the plant where and during the week these investigations were conducted was a representative one and consisted of 1500 lbs. of limestone and 1314 lbs. of slag, while the fuel necessary to burn this to a clinker produced 42.7 lbs. ash.

Accordingly a dump represents:

From limestone	0.90 lb. K_2O
From slag	9.07 lbs. K_2O
From coal ash	0.51 lb. K_2O
TOTAL	10.48 lbs. K_2O

As the volatilized potash escapes back through the kilns with the speed of the gases and cools off below its condensation point some of it strikes and adheres to the walls of the back end of the kilns and the walls of the kiln housings and gas coolers, while some will solidify in small particles and intermingle with the dust. The former part will deposit while the latter part will act as dust and later be returned to the kilns. It is, therefore, convenient to distinguish between the deposits and the circulating dust, as they are following different laws as to accumulation.

In deposits closest to the clinkering zone the K_2SO_4 naturally will be prevalent, while there are indications that the potash in the circulating dust is mainly K_2CO_3. It is hard to tell how much of the volatilized potash will deposit and how much will be left in the circulating dust. The writer has assumed that $^3/_{10}$ will deposit. This, however, is an arbitrary figure used for the purpose of determining the law of this potash accumulation.

Regarding the dust escaping through the electric field or stack loss, it amounted to approximately 1500 lbs. in 24 hrs. for each precipitator or to 36,000 lbs. for the week the investigation was made, during which time the precipitators recovered approximately 96 per cent of the dust passing through them. A representative average sample of this escaping dust is for practical reasons extremely hard to get. The best sample the writer could obtain analyzed 1.20 per cent K_2O, but this result is most likely too low. Conceding this, the potash content of the escaping dust will show a lower limit in the subsequent calculations than really will exist. This circumstance, however, will not change the principle in the laws of potash accumulation, so the above result will be used in calculations below. Accordingly, the stack loss for the week in question amounted to 432 lbs. K_2O. In other words, of 25,240.89 lbs. volatilized K_2O, 432 lbs., or, expressed in percentage, 1.7115 per cent, were lost through the stacks in spite of the precipitators.

With these preliminary data at our disposal we will follow the volatilized potash in its circuit through the precipitation system and elicit the laws of accumulation.

In order to make clear the distribution of the potash and its recirculation the results at the different stages are tabulated below.

It will be necessary to recollect that the potash once volatilized is all volatilized again; that 29.74 per cent of the total potash in a unit of 10.48 lbs. K_2O remain in the clinker; that $^3/_{10}$ of the volatilized potash are assumed depositing in the back end of the kilns, the kiln housings and the gas coolers; that 1.7115 per cent of the volatilized potash is lost through the stacks.

CYCLE No.	Amount of K_2O Fed to the Kilns with the Charge. Lbs.	Amount of K_2O Remaining in the Clinker. Lbs.	Volatilized K_2O Leaving Clinkering Zone. Lbs.	Deposits in Back End of Kilns, Housings, Gas Coolers. Lbs.	Amount of K_2O Entering the Precipitators. Lbs.	Loss of K_2O through the Electric Field (Stack Loss). Lbs	Amount of K_2O in Dust Returning to the Kilns. Lbs.
1	10.48	3.1168	7.3632	2.2090	5.1542	0.1260	5.0282
2	5.0282 + 10.48	3.1168	12.3914	3.7174	8.6740	0.2121	8.4619
3	8.4619 + 10.48	3.1168	15.8251	4.7475	11.0776	0.2708	10.8068
4	10.8068 + 10.48	3.1168	18.1700	5.4510	12.7190	0.3110	12.4080

Gathering from this table the results on the increase of potash in the returning dust and in the deposits in the back end of the kilns, the kiln housings and the gas coolers and further the results on the loss through the stacks we have:

	Returning Dust Lbs.	Deposits Lbs.	Stack Loss Lb.
Cycle No 1	5.0282	2.2090	0.1260
Cycle No. 2	8.4619	3.7174	0.2121
Cycle No. 3	10.8068	4.7475	0.2708
Cycle No. 4	12.4080	5.4510	0.3110

According to the results for the returning dust we find an increase of 3.4337 from Cycle 1 to Cycle 2, 2.3449 from Cycle 2 to Cycle 3 and 1.6012 from Cycle 3 to Cycle 4. The total of these increases carried into infinity—or what may be considered infinity for all practical purposes—will form a series like this:

$$\Sigma = 3.4337 + 2.3449 + 1.6012 + \ldots\ldots \infty$$

This series is *a converging geometric progression* in which the coefficient between the terms is approximately $\frac{1000}{1465}$. Without any appreciable error we may for use in our calculations call the coefficient $\frac{100}{147}$.

In studying the series we will observe that the increase is getting smaller all the time and is approaching *a limit*. The reason for this is the separating out of the deposits and the stack loss. In order to find the limit of the increase we may put down the following equation:

$$\Sigma = \frac{AM^n - A}{M - 1} = \frac{3.4337\left(\frac{100}{147}\right)^{\infty} - 3.4337}{\frac{100}{147} - 1} = 10.7394$$

Starting out in the progression with 3.4337 while the total available increase is 10.7394, it is evident the returning dust—with the amount assumed depositing and the figured stack loss—will increase only 3.1276 times its original amount.

When the last treater in our system started up, the returning dust contained 1.47 per cent K_2O. The laws of the progression above may be applied to this, using $\frac{100}{147}$ as coefficient, or we may simply multiply the percentage by 3.1276, thus:

$$\Sigma = \frac{1.47\left(\frac{100}{147}\right)^{\infty} - 1.47}{\frac{100}{147} - 1} = 1.47 \times 3.1276 = 4.60$$

Accordingly, the limit of the potash content in the returning dust should be 4.60 per cent, but it must be remembered that the increase is mainly governed by the amount deposited. As previously stated, $^3/_{10}$ is only an arbitrary figure, so the returning dust may run higher or lower in potash, according to the size of this figure; but nevertheless we will on the whole get the benefit of the volatilized potash one way or the other, with the exception, of course, of the stack loss.

The writer used this way of calculating under the successive erection of precipitators.

When 2 precipitators had been in operation for a reasonable length of time the limit of the increase, taking into consideration the extra loss through the stacks not connected up, was figured to be 0.58 per cent K_2O and analysis strikingly corroborated this; when 3 precipitators had been in use for a fair length of time the limit with the same consideration as above was figured to be 1.47 per cent K_2O and again analysis strikingly corroborated the figured result; finally when 4 precipitators had been in operation for a reasonable length of time the limit was figured as above to be 4.60 per cent K_2O—analysis again giving corroborating result. For depositing figures in these, three cases were used, respectively $^1/_{10}$, $^2/_{10}$ and $^3/_{10}$.

The deposits in the back end of the kilns, the kiln housings and gas coolers follow a different law as to accumulation from that of the circulating dust. Studying the cycles we see that 2.2090 lbs. K_2O are deposited during Cycle 1 and note they *stay* there; during Cycle 2, 3.7174 lbs. are brought in and so on.

Accordingly the series for the deposits will be:

$$\Sigma = 2.2090 + 3.7174 + 4.7475 + 5.4510 + \ldots\ldots \infty$$

forming *a progression, the total of which goes beyond limits*. The amount deposited each time, however, is approaching a limit. There is an increase of 1.5084 between Cycles 1 and 2, 1.0301 between Cycles 2 and 3, and 0.7035 between Cycles 3 and 4. In order to find the highest possible amount to be deposited at one time we may use the series:

$$\Sigma = 1.5084 + 1.0301 + 0.7035 + \ldots\ldots\ldots\ldots \infty$$

Here again the coefficient is $\frac{100}{147}$, approximately, for reasons previously mentioned, and accordingly we have:

$$\Sigma = \frac{1.5084\left(\frac{100}{147}\right)^{\infty} - 1.5084}{\frac{100}{147} - 1} = 4.7177$$

As we started out in the progression with 1.5084, we will observe that the highest available deposits for one cycle will be 3.1276 times the original amount and consequently we have:

$$\Sigma = \frac{2.2090\left(\frac{100}{147}\right)^{\infty} - 2.2090}{\frac{100}{147} - 1} = 2.2090 \times 3.1276 = 6.9090$$

The series for the deposits will therefore look thus:

$$\Sigma = 2.2090 + 3.7174 + 4.7475 + 5.4510 + \ldots . 6.9090 = \infty$$

This theoretically means that the deposits will go on until the system is clogged up. When that will take place practically is just a matter of conjecture as our depositing figure, $^3/_{10}$, is an arbitrary one and may be considerably smaller. Also some of the deposited cakes may loosen from the walls and drop into the conveyers for the returning dust and in that case, what we lose in deposits we will get back in the circulating dust.

The work on locating and analyzing deposits is still in progress. Up to date they have been found to be richer in potash than the circulating dust. Deposits containing 6 per cent K_2O have been found at the entrance of the gas coolers.

Regarding the stack loss it will be seen from the cycles that it also will increase. In order to find the largest amount going out we note the increase in loss from Cycle 1 to Cycle 2 to be 0.0861, from Cycle 2 to Cycle 3, 0.0587, and from Cycle 3 to Cycle 4, 0.0402.

The series for the stack loss will accordingly be:

$$\Sigma = 0.0861 + 0.0587 + 0.0402 + \ldots\ldots \infty$$

This is also *a converging geometric progression* in which the coefficient is $\frac{100}{147}$, approximately, for reasons stated previously.

Consequently we have as before:

$$\Sigma = \frac{0.0861\left(\frac{100}{147}\right)^{\infty} - 0.0861}{\frac{100}{147} - 1} = 0.2693$$

Starting out in the progression with 0.0861 while the highest loss is 0.2693, it follows that the highest possible loss of potash through the stacks will be 3.1276 times the original amount.

For a sample taken before the last precipitator was connected up the writer found 1.20 per cent K_2O in the dust escaping from the stacks. This value is conceded too low, as previously mentioned, but being the only figure at hand it will be used in our final calculation and accordingly we have as before:

$$\Sigma = \frac{1.20\left(\frac{100}{147}\right)^{\infty} - 1.20}{\frac{100}{147} - 1} \qquad 1.20 \times 3.1276 = 3.75$$

In view of this we may look for a loss of K_2O passing through the stacks in spite of the precipitators, a loss steadily increasing up to a certain *limit*. This limit probably should be the same as the limit for the returning dust. Some time after the last precipitator started up, but before the limit could have been reached, the writer found a sample of escaping stack dust to analyze 3.65 per cent K_2O.

This potash in the dust and deposits exists mainly as soluble K_2CO_3 and K_2SO_4, making the dust and deposits suitable fertilizing material.

SUMMARY

I—Under normal kiln conditions about 30 per cent of the potash in the raw material and the fuel will remain in the clinker while 70 per cent will be volatilized.

II—There will occur an accumulation of volatilized potash in the back end of the kilns, the kiln housings and the gas coolers which in time may clog up the system.

III—Under normal precipitator conditions the circulating dust will increase in potash up to a certain limit, the increase being governed by the amount deposited and the efficiency of the precipitators and following the laws of a converging geometric progression.

IV—In spite of fairly ideal precipitator conditions there will occur a loss of potash through the stacks, a loss steadily increasing up to a certain limit and also governed by the amount deposited and the efficiency of the precipitators and following the laws of a converging geometric progression.

UNIVERSAL PORTLAND CEMENT COMPANY
DULUTH, MINNESOTA

TOLUOL FROM SPRUCE TURPENTINE

By A. S. WHEELER

Received March 25, 1918

The heavy demand for trinitrotoluol is taxing the resources of the country in toluol, and any new source for the latter requires careful investigation in the hope of increasing the supply. It has been suggested that spruce turpentine, a waste product of the sulfite process of making sprucewood paper pulp, might serve as an important source of toluol. Spruce turpentine is remarkable in that it consists largely of one aromatic hydrocarbon, cymol (cymene). It has been attracting interest in several quarters in recent years. The French chemists Boedtker and Halse[1] subjected the crude turpentine and also pure cymol to the Friedel-Crafts reaction with benzol and obtained high yields of toluol and cumol. On account of the importance of the reaction I have attempted to repeat their best experiment in order to confirm their findings and offer in this paper a preliminary report, giving the results of the first two experiments.

Boedtker and Halse reported on four experiments as follows: (1) 150 g. crude 90 per cent cymol (spruce turpentine itself), 1 kg. benzol and 30 g. aluminium chloride boiled 6 hrs. on the water bath. Products: 52 g. toluol, 75 g. cumol. (2) 100 g. cymol, pure, 1 kg. benzol and 20 g. aluminium chloride boiled 6 hrs. Products: 41 g. toluol, 85 g. cumol. (3) 100 g. cymol, pure, 1 kg. benzol and 10 g. aluminium chloride boiled 8 hrs. Products: 31 g. toluol, 67 g. cumol. (4) 90 g. cymol, pure, 900 g. benzol and 4.5 g. aluminium chloride boiled 10 hrs. Products: 44 g. toluol (80 per cent), 68 g. cumol (85 per cent yield). (The figure, 80 per cent, is an error. A recalculation shows that this ought to be 71 per cent, the theoretical yield being 61.8 g.) A Vigreux column was used in the distillations but no statement is made as to the number of fractionations and no figures are given for the boiling points of the fractions. Further, it is not known what the authors mean by pure cymol. A number of boiling points have been given for this compound but Schorger[2] seems to have prepared a pure product. This was due to the observation that concentrated sulfuric acid removes impurities which have defied a variety of active agents. As late as 1916, Bogert and Tuttle[1] worked with an impure cymol.

In the two preliminary experiments reported below the purification of the cymol was not carried to the extreme limit. The Champion Fiber Company, of Canton, North Carolina, is generously furnishing the spruce turpentine for this investigation. The first experiment was carried through by the author. The second, or parallel, experiment was carried through from the beginning to the end by Mr. E. P. Wood, a senior student in chemistry and I wish to thank him here for his careful work.

The spruce turpentine was purified by first subjecting it to distillation in superheated steam, the vapor being carried through hot 10 per cent caustic soda and then condensed in the usual way. The crude turpentine was pale red, but the condensed oil was brilliant and water-white. The caustic soda assumed a reddish color. Seventy per cent of the oil passed over into the receiver but a newer shipment is giving a larger yield as high as 87 per cent. If caustic soda is not used the distillate is lemon-yellow in color. The oil was separated from the water and shaken several times with 0.5 per cent potassium permanganate, then 20 times with one-sixth its volume of concentrated sulfuric acid. The first addition of sulfuric acid assumed a very dark color, later washings a red color and finally a pale yellow color. Schorger states that pure cymol gives no color with this acid. The oil was then shaken with water several times, dried with calcium chloride and finally boiled with metallic sodium. It was distilled with a Glinsky still head and the main portion, boiling at 177–177.5°, was employed in the reaction. The benzol was a sample of Baker's C. P. It was dried over calcium chloride and boiled with metallic sodium. The aluminium chloride was freshly prepared by passing dry hydrochloric acid gas over hot aluminium filings.

EXPERIMENT I

90 g. cymol, 900 g. benzol and 4.5 g. aluminium chloride were boiled together on a water bath for 10 hrs. The solution became dark red. The fractionations of the product were carried out with a 3-section Young still head, with results as follows:

Fraction No.	Temperature Interval	Volume Cc.	Fraction No.	Temperature Interval	Volume Cc.
1.....	79– 80°	380	7.....	113–141°	15
2.....	80– 81°	242	8.....	141–151°	11
3.....	81– 83°	184	9.....	151–154°	47
4.....	83– 95°	167	10.....	155–200°	6
5.....	95–110°	18	11.....	200°+	3 (*a*)
6.....	110–131°	27	(*a*) Fluorescent.		

The second distillation was begun with Fraction No. 4 and gave the following results:

Fraction No.	Temperature Interval	Volume Cc.	Fraction No.	Temperature Interval	Volume Cc.
1.....	80– 83°	80	8.....	115–120°	6
2.....	83– 95°	50	9.....	120–131°	6
3.....	95–100°	3	10.....	131–151°	19
4.....	100–105°	2	11.....	151–154°	43
5.....	105–109°	4	12.....	154–156°	4
6.....	109–113°	15	13.....	156–170°	4
7.....	113–115°	11	14.....	170°+	2

Accumulations occur at the vicinity of the boiling points of toluol, 110°, and cumol, 153°.

[1] *Bull. soc. chim.*, [4] **19** (1916), 444.
[2] *J. Am. Chem. Soc.*, **39** (1917), 2671.
[1] *J. Am. Chem. Soc.*, **38** (1916), 1352.

A sample of No. 6, 109–113°, was easily and smoothly converted into trinitrotoluol (TNT), according to the method recommended by Hoffmann.[1] The crude product, washed with hot water, melted at 76–78°. After one recrystallization from a mixture of alcohol (9 parts) and benzol (1 part), pale yellow needles, melting sharply at 80–80.5°, were obtained in excellent yield.

EXPERIMENT II

88.5 g. cymol, 885 g. benzol and 4.5 g. aluminium chloride were boiled together on a water bath for 10 hrs. A 3-section Young still head was used in the first fractionation and a 5-section Young still head in the second.

Fraction No.	Temperature Interval	Volume Cc.	Fraction No.	Temperature Interval	Volume Cc.
1.....	79– 81°	501	7.....	141–151°	11
2.....	81– 83°	299	8.....	151–154°	37
3.....	83– 95°	151	9.....	154–170°	15
4.....	95–110°	21	10.....	170–180°	3
5.....	110–131°	16	11.....	180–200°	2
6.....	131–141°	16	12.....	200°+	3

For the second distillation, Fraction No. 2 was started with.

Fraction No.	Temperature Interval	Volume Cc.	Fraction No.	Temperature Interval	Volume Cc.
1.....	80– 81°	249	7.....	115–120°	4
2.....	81– 83°	126	8.....	120–131°	7
3.....	83– 95°	62	9.....	131–141°	4
4.....	95–108°	6	10.....	141–149°	7
5.....	108–112°	22	11.....	149–154°	52
6.....	112–115°	8	12.....	154°+	4

The accumulations again show toluol and cumol. The amounts are less in both experiments than those claimed by Boedtker and Halse. They gave no statement as to the purity of their products so that question is in doubt. On our part some necessary step may still be lacking for maximum yields. The investigation is being actively pursued. Boedtker and Halse introduced in each of their experiments two variants so that it cannot be said which variant changed the results. It will be noted that 17 molecules of benzol were used for one molecule of cymol. It is hoped to materially reduce this proportion. The mechanism of the reaction will be studied in order to determine whether the cymol furnishes the methyl or the tolyl group for the toluol. It is noted that the published work on the nitration of cymol and of cumol is of an unsatisfactory character and these reactions are being reëxamined.

CONCLUSIONS

Spruce turpentine yields toluol when subjected to the combined action of benzol and aluminium chloride.

The other product, cumol, is not a waste product since it may be oxidized directly to benzoic acid. This will save a like amount of toluol now used to make benzoic acid.

UNIVERSITY OF NORTH CAROLINA
CHAPEL HILL, N. C.

ARSENIC IN SULFURED FOOD PRODUCTS

By W. D. Collins

Received January 10, 1918

INTRODUCTION

It has been recognized for a long time that appreciable quantities of arsenic might be taken up by food products through treatment with sulfur dioxide fumes obtained by burning sulfur which contained arsenic.

The most notable case of contamination of food products with arsenic was the well-known instance of poisoning at Manchester, England, caused by arsenic in beer. The investigation that followed showed that the arsenic in the beer came from the use of glucose or brewers' sugar which was made from starch by the use of sulfuric acid which contained large amounts of arsenic. Analyses of some of the samples of sulfuric acid showed as much as 2 per cent of arsenic as As_2O_3. Samples of the glucose contained from 0.01 up to nearly 0.1 per cent of arsenic. Samples of the beer in question contained up to 1.0 or 1.5 grains of arsenic per gallon of beer, and some even as high as 3 grains per gallon. The average medicinal dose of arsenic mentioned in the *U. S. Pharmacopoeia* is 2 mg. or one-thirtieth of a grain. In the report of the English Commission which investigated these cases of arsenical poisoning, it was recommended that liquid food materials should be considered adulterated if they contained as much as 0.01 of a grain of arsenic per gallon, and that solid food materials should be considered deleterious if they contained as much as 0.01 grain of arsenic per pound. The results of the investigation showed that it was entirely possible to keep the arsenic below these limits in all the materials used in the production of the beer and in the other food materials which were investigated at that time, provided care was taken to keep the materials free from arsenic.

In connection with an investigation of the subject of arsenic in wines, Dr. H. D. Gibbs,[1] in 1905, suggested arsenical sulfur as one of the possible sources of arsenic. Several samples of the Japanese sulfur which he examined showed amounts of arsenic up to several hundred parts per million. Dr. W. W. Stockberger,[2] in a bulletin published in 1908, suggested that sulfur was probably the cause of the presence of appreciable amounts of arsenic in certain samples of sulfured hops. It appears to be recognized by the dealers in sulfur that it is desirable to use for bleaching hops and dried fruits sulfur which is free from arsenic. It is probable that certain users of sulfur have made some effort to obtain sulfur which contained no arsenic.

In 1914, as a result of objections made to some shipments of hops from the United States to foreign ports on account of the fact that the hops were said to contain more arsenic than was permissible, the Department of Agriculture investigated again the question of the source of arsenic in dried hops. Dr. Stockberger, of the Bureau of Plant Industry, visited the hop-growing districts and collected samples of unsulfured hops, sulfured hops and samples of the sulfur used. He also collected samples of sulfur used on the hops in the shipments which were rejected on account of excessive arsenic. Two samples of sulfur from this lot showed 329 and 356 parts of arsenic per million. The writer made a study of various methods for the determination of small quantities of arsenic in such

[1] Bureau of Mines, *Technical Paper* **146** (1916).

[1] *Am. Chem. J.*, **27** (1902).

[2] U. S. Dept. of Agr., Bureau of Plant Industry, *Bull.* **121** (1908), 41–46.

materials as hops and sulfur and after reaching a satisfactory method, as described below, determined the arsenic in samples of sun-dried hops, kiln-dried hops and sulfur.[1]

METHOD OF ANALYSIS

The use of the Gutzeit test for the quantitative determination of arsenic has been discussed by Sanger and Black,[2] Smith,[3] Allen and Palmer,[4] and recently by Beck and Merres[5] of the Kaiserlichen Gesundheitsamt who found Smith's method entirely reliable. Many references to the literature are given by these authors. On account of the difficulties found in applying the various methods described, it seems worth while to describe fully the details of the method found satisfactory for the examination of hops. It is mainly a selection of some of the procedures described by C. R. Smith.

OUTLINE OF METHOD

The method depends upon the action of arsine upon a salt of mercury. The arsine is produced by reduction of an arsenious compound by nascent hydrogen obtained with zinc and an acid. In the colorimetric method the arsine acts along a strip of paper impregnated with mercuric bromide, and the amount of arsenic is measured by the brown color produced. In the gravimetric method the arsine acts on mercuric chloride in solution and the mercurous chloride obtained on boiling is weighed.

PRECAUTIONS

To obtain consistent results in the colorimetric method where comparison is made with standard stains, it is essential that the rate of evolution of hydrogen and of arsine be the same in all cases for a given amount of arsenic. Smith recommends cooling the generator in making standard stains to obtain results comparable with those obtained with samples containing salts in solution. Allen and Palmer advise using more acid when salts are present. Smith's precipitation method seems more certain to give a uniform amount of salts in the generator. The arsenic is precipitated as ammonium magnesium arsenate together with ammonium magnesium phosphate by adding about 2 g. of a soluble phosphate to the solution of sample and then precipitating with magnesia mixture and ammonium hydroxide. This precipitate is large enough to mask small differences in the amounts of salts so that solutions for standard strips and for the samples will have practically the same conditions in the generator if the same amount of acid is used to dissolve the precipitate. In testing substances which will give a precipitate in ammoniacal solution with the ammonium magnesium phosphate, allowance must be made for the extra amount of salts which will be in the generator. In order that the rate of evolution of arsine may be the same in all cases, it is necessary that the arsenic be reduced to the arsenious condition before zinc is added. The choice of reducing agent and of acid depends upon the amount of arsenic present, and for the best results the proper combination must be selected.

When hydrochloric acid is used in the generator it is not easy to secure sufficiently slow evolution of gas to make a strongly colored stain if enough acid is used to complete the reduction of the arsenic. This difficulty is overcome by using sulfuric acid, but if potassium iodide and stannous chloride are used for reduction with sulfuric acid, it sometimes happens that reduction of sulfuric acid to hydrogen sulfide takes place and the determination is lost. It is possible, however, to fail to reduce all the arsenic to the arsenious state without the use of potassium iodide if much more than 0.1 mg. of arsenic, as As_2O_3, is present. For small quantities, reduction with stannous chloride (0.5 g.), with 1 g. sodium chloride and 10 cc. sulfuric acid in a volume of 75 cc., gives consistent results. For larger quantities which are to be determined gravimetrically, so that the rate of action need not be the same in every case, reduction by stannous chloride and potassium iodide in hydrochloric acid solution is best.

The surface area of the zinc will affect the rate of action. Care must be taken to use always the same number of pieces of zinc of the same size. The amount of iron in the zinc will affect the rate of solution and, therefore, the appearance of the stain.

The capacity of the apparatus and the amount of liquid used in the generator will affect the appearance of the stain.

For obtaining a test for a very small quantity of arsenic, as to distinguish between 0.5 and 1 microgram, it may be best to use a small generating bottle; but for quantitative measurement of amounts from 5 to 50 micrograms a larger generator gives more uniform results, though the time required is longer.

The temperature of the reaction affects not only the rate of evolution, but, as pointed out by Allen, the temperature determines the amount of moisture in the gas evolved and so affects the appearance of the stain. Differences of one or two degrees in temperature are not likely to have any measurable effect on the stains, but as much as 10° may have a decided effect.

APPARATUS

The accompanying diagram shows the form and dimensions of the apparatus used.

REAGENTS

THE SENSITIZED STRIPS OF DRAWING PAPER, 11 cm. long by 2.0 or 2.5 mm. wide, are prepared by soaking for one hour in a 5 per cent alcoholic solution of mercuric bromide. The excess solution is wiped off and the strips dried on glass rods.

ACIDS AND ZINC may be purchased practically free from arsenic.

SODIUM CHLORIDE is usually free from arsenic, but samples of reagent sodium chloride have been found to contain measurable amounts.

STANNOUS CHLORIDE is liable to contain traces of arsenic. This can be removed by heating the solution of the salt in hydrochloric acid with pieces of metallic

[1] The detailed results of the analyses are given in U. S. Dept. of Agr., *Bull.* **668**, "The Presence of Arsenic in Hops" W. W. Stockberger and W. D. Collins.

[2] *J. Soc. Chem. Ind.*, **26** (1906), 1115.

[3] U. S. Dept. of Agr., Bureau of Chemistry, *Circular* **102** (1912)

[4] *Orig. Com. 8th Inter. Cong. Appl. Chem.*, **1** (1912), 9–17.

[5] *Arb. kais. Gesundh.*, **50** (1916), 38–49.

tin and a piece of platinum wire or foil. Heating the solution for several hours will usually remove the arsenic. The solution is diluted, filtered, and made to such a volume that 1 cc. contains 0.5 g. stannous chloride.

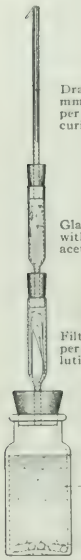


FIG. I—APPARATUS FOR THE GUTZEIT TEST AS MODIFIED BY C. R. SMITH

THE SODIUM OR AMMONIUM PHOSPHATES found in the laboratory may contain arsenic. The microcosmic salt used in examining hops was purified by making a concentrated solution strongly acidified with hydrochloric acid, adding mercuric chloride solution and passing in hydrogen sulfide gas to saturation. The solution was left about 24 hrs. with occasional stirring by a stream of hydrogen sulfide. The precipitated mercuric sulfide, which carried with it the arsenic as sulfide, was filtered out. The solution was boiled to remove hydrogen sulfide, and bromine water was added in slight excess. After filtering, if necessary, the volume was made such that 10 cc. contained 2 g. of the microcosmic salt.

MAGNESIA MIXTURE—The general laboratory stock of magnesium salts are liable to contain arsenic. This can be eliminated by treating a solution of the salt with hydrochloric acid and arsenic-free zinc. The reaction may be allowed to proceed for a day, with gentle heating. After filtration ammonium hydroxide and hydrochloric acid are added alternately till there is no precipitate when the solution contains an excess of ammonia. The volume is adjusted so that a convenient amount, 15 or 20 cc., will give an excess when used to precipitate 2 g. of the phosphate.

VESSELS—It is generally known that arsenic may be taken up from some glass vessels by solutions, especially when heated. It is advisable, therefore, to use porcelain, as far as possible, for heating solutions to be tested for arsenic. Tests of solutions of reagents soon after treatment to remove arsenic rarely gave any indications of the presence of arsenic, while after standing a month in flasks the same solutions often showed measurable amounts of arsenic, which may have been absorbed from the glass.

STANDARDS

With all precautions there will still be some irregularity in the length of stains due to variations in width of paper strip, in size and condition of pieces of zinc, in volume of solution, strength of acid, volume of air space above solution in generator, in size of tubes holding lead acetate paper and moistened glass wool, possibly also in the sensitiveness of the paper. All these possibilities of error are covered by Smith in the suggestion that at least three concordant stains should be obtained before a value is selected. In testing a number of samples of hops over several weeks' time, it was found advantageous to make a few standard stains each day with the day's lot of samples. Portions of standard arsenic solution were treated with bromine to oxidize the arsenic and the same so prepared was treated in exactly the same manner as the solutions prepared from the samples. At the end of the experiments a number of standard strips had been made covering all the range of values which had been found. The end of the brown stain on each side of a strip was marked to the nearest millimeter and the average of the lengths on both sides was taken as the length of stain corresponding to the amount of arsenic which was precipitated. The accompanying curve, which shows all the values obtained for standard stains, shows the relation between the length of stain and the amount of arsenic, and indicates the errors which may be made in single determinations.

C. R. SMITH'S COLORIMETRIC METHOD APPLIED TO HOPS

To determine arsenic in hops the samples were oxidized carefully in porcelain casseroles with concentrated nitric and sulfuric acids. After the vigorous action with nitric acid was over, sulfuric acid was added and oxidation completed by heating over a small flame with additions of small amounts of nitric acid till fumes of sulfuric acid were given off with no blackening of the solution. As has been pointed out by various writers, arsenic will be reduced and lost if the organic matter chars and the solution gives off sulfur dioxide.

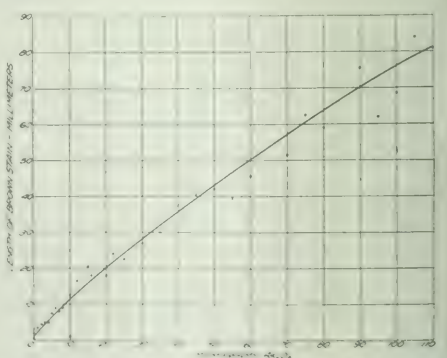


FIG. II—RELATION BETWEEN AMOUNTS OF ARSENIC AND LENGTH OF STAINS OBTAINED IN ONE SERIES OF TESTS

Small amounts of bromine water were added to make sure of the oxidation of the arsenic. The arsenic was precipitated by the use of 2 g. of microcosmic salt, an excess of magnesia mixture and ammonia to complete the precipitation. After standing over night the precipitate was filtered, washed once with 2.5 per cent ammonia, and then dissolved in about 50 cc. of dilute sulfuric acid containing 10 cc. of the concentrated acid. After solution of the precipitate and washing of the filter, the volume was about 75 cc. One gram of sodium chloride was added and the solution heated nearly to boiling, about 90° C. One cc.

of solution containing 0.5 g. stannous chloride was added and the warm solution stirred occasionally for 10 min. The solution was now cooled, 10 cc. more of concentrated sulfuric acid added and the mixture again cooled. The liquid was now transferred to a 4-oz. bottle and made up to a volume of about 120 cc. When the stopper was in place the air space was about 20 cc. The bottles were placed in a pan of water and brought to a temperature of 20° C. Four pieces of stick zinc were now added. Two pieces were new and were 18 mm. long and 7 mm. in diameter. Two of the pieces had been used in previous determinations. The stopper carrying the tubes with the lead acetate paper, glass wool saturated with lead acetate, and the mercuric bromide paper were put in place immediately after the addition of zinc. Practically all of the stain was formed in one hour, but the strips of paper were regularly left for 3 hrs.

The samples of hops were divided into portions of about 18 g. In order to eliminate errors from the presence of arsenic in reagents and vessels, a sample of one gram of hops was digested with the same amounts of sulfuric and nitric acids and bromine as were used for the 18-g. sample. The digestion mixture of each sample was filtered. That from the 18-g. sample was made up to 200 cc. and volumes of the 200 cc. solution were taken corresponding to 1 g., 6 g. and 11 g. These aliquots were precipitated in the same manner as the solution from the digestion of the 1-g. sample. After the stains were made by treating these samples in the generator, the lengths were measured. The difference between the length of the stain for the 1-g. sample and the stain obtained for $^1/_{18}$ of the 18-g. sample indicated the amount of arsenic obtained from the digestion reagents. By reading on the curve the amounts of arsenic corresponding to the stains obtained for the 1-g., 6-g. and 11-g. sub-samples, any error from the reagents used in precipitation could be eliminated. The difference between the 6-g. sample and the 1-g. sample was taken as the amount of arsenic in 5 g. of hops, and the difference found between the 11-g. sample and the 1-g. sample was taken as the amount of arsenic in 10 g. of hops.

About 1000 tests were made in the course of this work and the treatment outlined above gave in nearly all cases satisfactory stains of which the length could be measured with certainty and the results which were obtained leave little doubt as to the amount of arsenic present in the samples which contained as much as 0.5 p. p. m. The average of several concordant results is probably within 10 per cent of the true value for quantities of 3 or 4 p. p. m.; the samples contained as little as 0.1 or 0.2 p. p. m.; the amount of arsenic obtained from the reagents and vessels used in the work was greater than that present in the sample, so that there is some uncertainty as to whether the amount reported as 0.2 really means any arsenic at all. If it were desired to settle the question as to whether the sample taken contained no arsenic or 0.1 p. p. m., it would be worth while to spend more time in making sure of the purity of the reagents.

ARSENIC IN SULFUR

To determine the arsenic in samples of sulfur, 1 to 15 g. of sulfur were treated with from 5 to 25 cc. of bromine as described by W. Smith[1] for the estimation of selenium in sulfur. The sulfur bromide and bromine were shaken cautiously in a separatory funnel with 2 or 3 portions of from 20 to 40 cc. of bromine water. From 90 to 95 per cent of the arsenic were found in the bromine water portion at the first separation and, except with large amounts, two separations gave all the arsenic, together with the selenium which was present, and some sulfuric acid. The bromine water extracts were united, filtered and the excess of bromine removed by passing air through the solution. The arsenic was precipitated by the use of phosphate solution and magnesia mixture. The precipitate was collected on a filter, washed once with 2.5 per cent ammonia and dissolved. If the amount of arsenic was small it was determined colorimetrically as in the case of hops. If a larger amount was present the precipitate was dissolved in 25 cc. of dilute hydrochloric acid (sp. gr. 1.10) and the arsenic reduced by heating for 10 min., after the addition of 1 cc. of solution containing 0.5 g. stannous chloride and 2 cc. of solution containing 0.375 g. potassium iodide per cc. The selenium was largely precipitated at this point, carrying with it much of the arsenic. If the precipitate is not filtered out the arsenic is all recovered. More hydrochloric acid was added to bring the total amount of concentrated acid up to 28 cc. The solution was washed into the generating bottle which had a capacity of about 140 cc., and the volume was made to about 120 cc. Six pieces of zinc were now added and the gas passed into mercuric chloride solution, as described by Smith. Glass wool moistened with lead acetate solution served to keep back hydrogen sulfide. The generator was cooled to about 10° C. at first, so that the action would not be too violent. After 2 or 3 hrs. the mercuric chloride solution with the precipitate was boiled gently one-half hour. When cool, the precipitate of mercurous chloride was collected on ignited asbestos in a Gooch crucible, washed with alcohol and dried at 110°. After weighing, the crucible was ignited to drive off the mercurous chloride and weighed again to give the weight of precipitate. The results by this method were as satisfactory as those given by Smith in his description of the method.

RESULTS

The sun-dried hops contained from 0.1 to 0.2 part of arsenic (As_2O_3) per million, the sulfured hops from 0.2 to 26 p. p. m., and the samples of sulfur gave from 3.6 to 356 p. p. m. The relation of the different lots showed very clearly that the contamination of the hops must have come from the arsenic in the sulfur. This naturally led to consideration of the possibility of contamination of dried fruits which are treated with sulfur fumes. Samples of peaches and apricots collected at a local store gave 0.2 to 2.0 parts of arsenic per million parts. Samples of peaches which had been collected for another purpose contained from 0.7 to

[1] This Journal, 7 (1915), 849.

2.0 parts of arsenic per million. Samples of dried apples which were in storage gave from 0.1 to 0.5 part of arsenic per million. Mr. R. S. Hiltner, who was engaged in an investigation of the drying of fruit from other points of view, kindly furnished 10 samples of sulfured peaches and apricots and samples of the sulfur used in treating them. The samples of dried fruits contained from 1.4 to 3.4 parts of arsenic per million. The samples of sulfur contained from 5 to 500 parts. The source of the samples of sulfur was not known. The samples of sulfur which were studied in connection with the occurrence of arsenic in hops were all Japanese sulfurs.

In connection with this subject, some samples of Japanese sulfur were collected at the port of San Francisco and examined for arsenic. They contained from 55 to 700 parts of arsenic per million. Through the kindness of Mr. Philip S. Smith, of the U. S. Geological Survey, samples of sulfur were obtained from six of the companies producing sulfur in the United States. It is generally recognized that sulfur obtained from the largest source of supply in the United States is free from arsenic. The sample from this source, and all the other samples examined, showed no arsenic, or less than one part of arsenic per million.

Thus it appears that food products which are treated with sulfur fumes from sulfur which contains arsenic are liable to contamination with arsenic. In the case of hops the use of sulfur containing an amount of arsenic of about 100 p. p. m. will, on the average, introduce about three parts of arsenic per million parts of dried hops. It appears probable that if sulfur which contained less than ten parts of arsenic per million were used for sulfuring hops or dried fruits, it would be almost impossible to detect any contamination of the sulfured products with arsenic. It also appears that the native supplies of sulfur in this country are free from arsenic and if used for sulfuring food products would make it certain that no contamination with arsenic could result from the sulfur. The amount of sulfur burned for curing food products is a comparatively small proportion of the total amount used. The greater part, which is used in making lime-sulfur mixture for spraying and dipping and as powdered sulfur for dusting vines of different kinds, would, of course, introduce no appreciable contamination of arsenic into the food products, even if the sulfur did contain large amounts.

FOOD INVESTIGATION LABORATORY
BUREAU OF CHEMISTRY, U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

SOME CONSTITUENTS OF THE AMERICAN GRAPEFRUIT (CITRUS DECUMANA)[1]

By HARPER F. ZOLLER

Received January 14, 1918

INTRODUCTION

The adoption of the grapefruit in America as a valuable food accessory has spread with amazing rapidity, so that now it is possible to obtain this fruit in season in practically every remote village in the United States or Southern Canada. This wholesale distribution has necessitated an industry which bids to become of greater vastness than either the lemon or orange industries, if proper market conditions and disposal of wastes can be secured. The fact that a successful season in the citrus industry depends upon favorable weather conditions and orchards free from certain pathological plagues, indicates that citrus by-products are sure to become an important factor. In the sorting and grading of the thousands of tons of grapefruit, representing a season's crop, many tons of culls are allowed to rot for the want of an economical disposal. Certain of the producing companies are seriously contemplating the isolation of certain of the by-products, and one or two companies have engaged in extractions on a minor scale. I am of the opinion that with a proper knowledge of the important constituents their commercial production would become profitable and the trades would be supplied with the raw materials which they demand. It seems probable that extended analysis of the grapefruit must have been made by chemists in the employ of the citrus fruit companies, but if these have been made they have not been published at large. It is my purpose in this paper to present some research data on the nature and quantities of certain of the more important constituents of the American-grown grapefruit from different sources, with the idea that it should prove valuable to those intimately connected with the citrus orchards in the South and West.

HISTORICAL AND COMMERCIAL ASPECTS

Before proceeding with the data it would be well to consider briefly the historical and botanical significance of the grapefruit. Textbooks on botany, scientific journals and current publications are remarkably free from allusions to this fruit.[1] Hume says, "No fruit of importance now grown in the United States has such a meagre American literature as the pomelo. Nor is this strange when we remember the fact that it is only within the last fifteen years or so that the pomelo has been regarded as a commercial fruit."[1] * But it is strange that since Hume's edition of his bulletin in 1901 much less literature has ap-

[1] Abstracted before the Spring Meeting, American Chemical Society, Kansas City, Mo., April 1917. The major portion of the work was carried on in the chemical laboratories, Kansas State Agricultural College, Manhattan, Kansas.

[1] In searching through the Library of Congress for early literature on the citrus fruits, with the hope of gaining an insight into the past history of grapefruit, I was fortunate enough to find Giovanni Batiste Ferrari's book on the "Hesperides" published in Rome in 1646. This work, consisting of over 800 pages, and replete with full-page woodcuts of the various species of citrus, proved to be the most complete record of the citrus fruits of the Orient to date. It is not surprising that we find herein described the varieties of the different species from many of the islands of the Pacific (including Java), Egypt, Greece, India and Italy. While Ferrari classifies the species similar to the grapefruit under Aurantium, it is not unlikely that one of the following most closely resembles the grapefruit as we know it: *Aurantium Dulci Cortice et Sinense*, p. 430, *Aurantium Pomum*, or *Pomum Adam*, p. 309; *Aurantium Maximum*, p. 437. It is difficult, from the description and woodcuts, to say definitely just which one most closely resembles our typical American fruit. Perhaps the three are not distinct species, one or more may be hybrid varieties. It is clear that *Aurantium Dulci Cortice* and *Aurantium Pomum* (Adam's Apple) are variously considered as the "forbidden fruit" of the early Orientals; at least so considered by Ferrari, Johannes Commelin (Nederlantze Hesperides, 1676) and Gallesio (*Loc. cit.*); and most reasonably, because of their extreme bitterness.

* Numbers refer to References in Bibliography, p. 373.

peared in proportion to the increased importance of the fruit. Articles have occasionally appeared in horticultural journals and experiment station records, dealing primarily with cultural and rough analytical aspects: the analyses reporting edible portions of fruit, number of seeds, amount of acid, total solids, sugar, and ash. Citation of these will be made later.

That the present name (grapefruit) originated from the fact that the fruit commonly occurs on the trees in large clusters, somewhat resembling clusters of grapes, is well known. But it is not so well known that the term "pomelo" has been applied and adopted by the U. S. Department of Agriculture, American Pomological Society, Florida State Horticultural Society, etc. The English of Ceylon and India call it pomelow, a name probably derived from the Latin words "*pomum melo*"—the melon apple[2]—though it may have been corrupted from pompelmoes, the Dutch name first applied by Rumphius in 1750.[3] The latter seems more probable since all incidents point to the Dutch East Indies, on the Island of Java, as the original home of the grapefruit. To the French and the Germans it is known as pompelmouse and pompelmuse, respectively. The term shaddock has crept into the literature as a synonym for grapefruit in honor of a certain British sea-captain who is said to have introduced the fruit into the West Indies from Java early in the eighteenth century. It is interesting to note that in Java, which is the acknowledged home of the grapefruit, there are two varieties.[4,5] One is small, bitter though edible, and grows in enormous clusters on trees from 10 to 20 ft. high situated in the lower coastal regions of the island. The other variety is much larger (often from 10 to 20 lbs. per fruit), intensely bitter, with a dark-yellow to red pulp. It grows at much higher altitudes, abundantly on the Bandong plateau, and is known there as the non-edible variety. The bitter principle in both varieties is identical,[4,5,6,28] which would lead to their classification as sub-varieties under *Citrus decumana*.[8] This non-edible fruit, because of its prolific growth and large flowers, was a source of "neroli-oil" or oil of bitter orange for a number of years to the inhabitants of Europe and Asia. Both varieties are being extensively cultivated in Southern Europe and Asia at present for food and commercial products.

It is likely that the term shaddock applies more specifically to the above larger and "non-edible" variety (Hume). The smaller variety is the one that most of us are familiar with though it is not unlikely that the larger variety has also been introduced into the West Indies as well as the United States and Mexico. One is safe in saying that the term shaddock will never become generally known as synonymous with pomelo, or grapefruit. This large non-edible fruit may be placed on the market in a few years as a hybrid of either orange or lime, since several of the unpalatable varieties, after undergoing hybridization with other citrus species, have been transformed into very agreeable fruit, commonly known as grapefruit.

It is quite doubtful whether the term pomelo will ever become generally used outside of scientific circles, any more than the term maize will ever supplant the more agreeable word corn. Shamel[9] writes that pomelo has never been accepted by the public or fruit trade and seems to favor the term grapefruit. Hume, though loyal to pomelo, also expresses his doubt as to the common acceptance of the term pomelo. In discussing the probable origin of the term grapefruit he quotes Risso and Poiteau[10] who say, "The author of the *Flora of the Antilles* has equally observed the pomelo cultivated in Jamaica, where the inhabitants call it grapefruit..... The fruits are gathered in clusters of from 15 to 18 on the branch, each of the size of the fist, spherical, firm, with a slightly rough skin of sulfurish yellow." It seems to me that it would be unwise to try to dissuade the public from the term grapefruit, since "usage determines preference" to a large degree and the term has become so firmly rooted in the common vernacular. However, one will agree that it is misleading. The term grapefruit will be adhered to in the following.

Just at what particular date the grapefruit was introduced into this country is not known. While the state of Florida claims the first fruit, it must not be forgotten that the fruit has flourished in Mexico for decades past. While Mexico has proved to be better suited for the production of larger and more luscious grapefruit, and evidences of citrus orchards of extremely early date exist, it is not improbable that the Spaniards first introduced the fruit into Mexico or Central America.* If one relies upon the reminiscences of the horticulturists to aid him in determining the early history, or even the existence, of the grapefruit in America he is bound to be disappointed. Occasional allusions to it as a pomological curiosity, though debased food-material, can be found, indicating that it had at least been noticed in the latter half of the nineteenth century. Watson,[11] in writing of citrus fruits, mentions that, "The shaddock is a still larger fruit, in form more resembling the orange, curious, but worthless." This was in 1859, while in 1885, Spalding[12] remarks, "Meanwhile the pumalo and its congeners when allowed growing space continue to load themselves down with fruit as large as footballs. They are matters of wonder and that is all." Downing, also in 1885,[13] in discussing the grapefruit under the name of shaddock, writes: "The pulp is sweetish or sub-acid and the juice is rather refreshing. It is, however, more showy than useful, and certainly makes a magnificent appearance in a collection of tropical fruits." Many other writers on horticultural topics do not mention it even in writings of the present day. It is noteworthy to learn that a very recent book, "La Culture des Citrus," by Guitet-Vauquelin (1917), contains only a brief paragraph on this subject, while we are indebted to the French for some of the earliest botanical classifications.[14,15,16,17]

* Gallesio, in his "Traite du Citrus," **1829**, p. 344, discusses the introduction of citrus fruits into the Americas through Mexico, and further speaks of its reception by King Montezuma. While he does not explicitly state that grapefruit was among the varieties introduced, he does indicate that he is acquainted with the fruit, for on page 326 he describes the "*Aurantium decumanum*" as the sole variety of the pompelmouse (also known as "*pomme d'Adam*").

While Florida and California practically comprise the entire source of grapefruit in the United States, it is astonishing to learn that an amount equal to one-half of the United States crop is imported for our consumption. According to Vaile,[11] the following shipments of grapefruit have been determined: Florida, 1915, 8,000 carloads; California, 1915, 250 carloads; Puerto Rico, 1913, 500 carloads; Cuba, 1912, 250 carloads. The present shipments run considerably above these values, since hundreds of acres of 5 yr.-old orchards are coming into production each year, and a tree, once producing, continues to produce abundantly for several years if not incapacitated by frost. Mexico is liable to become a contending factor in the grapefruit market in a very short time.* The Mexicans have found to their satisfaction that the grapefruit industry can take the place of the long-tried orange and lemon industry. These latter Mexican-grown fruits cannot compete with the better varieties of oranges and lemons grown in this country, while the grapefruit seems to thrive prolifically in the higher and warmer altitudes of central Mexico, the climatic conditions in Mexico comparing favorably with those on the Island of Java. All the energies of the citrus growers in Mexico are now being bent towards a successful prosecution of a grapefruit commerce. According to Hume,[19] the first shipment of grapefruit from the state of Florida occurred sometime during the years 1880 to 1885 and were sold in New York and Philadelphia, netting the shippers 50 cents per barrel.

Numerous varieties of grapefruit have resulted from the efforts of the citrus growers and horticulturists. As previously intimated, hybridization has played an important rôle in this development. Shamel,[20] Reasoner,[21] Hume[22] and *Bulletin* No. 8, Division of Pomology, United States Department of Agriculture, give lists of the several varieties with brief descriptions. Hybrids of grapefruit with the orange, tangerine and grapefruit from various countries exist. The chief aim apparently is to produce a fruit with a minimum of bitterness and few seeds. The Marsh Seedless is an example of a hybrid grapefruit with few seeds, though it retains the bitterness of the original grapefruit. This is extensively cultivated in California and Florida, and appears on the market in quantities. Since it ripens in California during May to July and in Florida during February to March, it acquires additional importance from a commercial standpoint. The Duncan is another variety possessing few seeds together with much bitterness. In fact, these are about the only varieties possessing a small quota of seeds. The average number of seeds in the other varieties is well above forty. The effort to remove or mask the bitterness is not so well rewarded. A few varieties have lost the bitterness, and at the same time *they have lost all that characterized them as grapefruit.*

A fruit exhibited as grapefruit but without the "quinine" bitterness should no longer be looked upon as a grapefruit, any more than a flower growing on a bush without thorns should be considered a wild rose. Pfeffer,[23] DeVry,[24] Blas,[25] Hoffmann,[26] Lebreton,[27] Will,[28] Hilger,[29] von Rijn,[31] and others, as long ago as 1828–1870, found that the bitter glucoside existing in the "pompelmoes" from Java could be found in no other citrus fruit. Likewise, they found that neither hesperidin nor isohesperidin, glucosides common to certain other citrus fruits, could be found in "pompelmoes" (grapefruit). My research confirms these earlier findings. It is not uncommon to find statements in the literature which are not in keeping with these facts—Kraemer.[30] Truly it may be expected that in some of the more divergent hybrids one may find a commingling of the glucosides characteristic of each parent stock. Whether or not this is true should be determined with utmost expertness in connection with the citrus culture, for *upon the glucosides depends the primary differentiations of the species.* They undoubtedly control the sugar content, flavor, and possibly the color of the fruit through their reversible reactions. The acid content of the fruits (citrus), while varying in amount in each species, is attributed almost entirely to citric acid, so we do not look to this for the basis of differentiation.

THERAPEUTIC VALUE

The dailies and periodicals of promoters in citrus fruit sections abound in attractive quackery on the beneficent medicinal properties of all citrus fruits, and especially grapefruit. This remedial property is being assigned to everything present in the fruits—the "alkaloids" said to be present, the citric acid, the potassium phosphate in the pulp, and the oils in the peel. If it is upon the oil present that we must depend for this elixir, then a tablespoonful of pure gum-turpentine will furnish the same amount of remedial as an entire crate of citrus fruit, providing we eat the peel and all. If it is due to the phosphoric acid as phosphate, as Dygert[2] would have us believe, then a glass of cow's milk would be equivalent to a dozen grapefruit in this life-giving entity. If it is due to the alkaloids present in the citrus fruits, then they have no therapeutic value, for no alkaloid has been detected in any of the citrus fruits regularly marketed in this country, and it is not likely that an alkaloid exists in any of the citrus family.

In LeLong's bulletin,[32] much to my surprise, the following statement appears: "The special alkaloid of most varieties of the pomelo contains a bitter principle, which, while its medicinal virtues are conceded, has not yet, I regret to say, been defined by chemical examination. Neither is it safe to consider it quinine for there are scores of vegetable bitters which are not quinine. The presumption is that it is a unique bitter principle peculiar to this fruit." It would not seem so strange if such a statement came from one who was supposed to be unacquainted with the citrus fruits. The bitter principle of *Citrus decumana* was accurately investigated nearly forty years ago, and its relation to similar principles found in other

* Shamel[9] and Wallschlaeger[13] call attention to Quarantine Regulation No. 5 of Feb. 8, 1913, and subsequent, which forbids the entry into the United States of Mexican grapefruit. This is done to safeguard against citrus fruit pests. It would seem that such a regulation is unnecessary if the conclusions of Aaron Aaronsohn[14] are to be taken in all seriousness, for he writes "The grapefruit possesses marked resistance to some of the numerous parasites of other citrus species."

citrus species compared and published. Specific citations to the literature on this subject will be found later under the heading "Glucoside or Bitter Principle." R. T. Will[33] calls attention to the glucosides appearing in the peel of the orange "principally in certain conditions of ripeness." He mentions hesperidin, isohesperidin and aurantiamarin, and continues as follows: "Aurantiamarin is the principle which gives the orange its bitter flavor; it is very similar to quinine in its physiological action and characteristics." Since Will did not state the specific variety of orange in which these three glucosides are supposed to appear, his allusion to them is of little value. It is only necessary to review Tanret's[34] isolation and investigations of isohesperidin to find that it is a very bitter glucoside and occurs in certain varieties of the orange. Likewise aurantiamarin occurs in the *Aurantii Amari Cortex*[35] as the bitter substance, and probably occurs in some hybrids of this variety, though not necessarily in all hybrids. Hesperidin possesses a slight sweetish taste and has been isolated from a number of the *aurantiaceae*. Now while it is possible for all three of these glucosides to be found in a certain variety of orange, it is not a common phenomenon and it would be interesting to know to which hybrid Will refers. It is wrong to imply, furthermore, that oranges in general are characterized by these three glucosides.

As to the physiological action of aurantiamarin and its similarity to quinine, I was unaware that any pharmacological study of this particuar glucoside had been inaugurated, and since no references were mentioned I am justified in relegating his statement to the same realm as those of the following.

Some of the leading home economics teachers of the country delight to revel in the curative properties of grapefruit, due "to the quinine or similar alkaloid which it contains." In Dygert's "Crops that Pay" we find, "A cool juicy pomelo before breakfast is one of the pleasantest and surest antidotes imaginable for malaria;" though as previously stated, Dygert rather suggests that we should look to phosphoric acid for its medicinal value. LeLong[32] writes, "For medicinal purposes it (grapefruit) leads all the citrus fruits, and its value from this point of view is as yet unknown." Sub-tropical and tropical countries are prone to offer grapefruit or similar citrus as a safeguard against malaria, and publications from these sources contain similar advice.

We have undoubtedly come to this impression of the therapeutic value of grapefruit through a false sense of security. Perhaps our educational system of former years was responsible, in a measure, for Greek, Roman, and Italian literature is crowded with references to the remedial beneficence of "hesperides and citron fruits." Gallesio and Ferrari (see footnotes) both frequently so state and give references to specific passages. For example, Virgil[37] writes:

> "The Median fields rich citron fruits produce,
> Tho' harsh the taste, and clammy the juice;
> Blest antidote! Which when in evil horn,
> The step-dame mixes herbs of pois'nous power,
> And crowns the bowl with many a muttered spell,
> Will from the veins the direful draught expel.
> Large is the trunk, and laurel-like its frame,
> And 'twere a laurel, were its scent the same;
> Its lasting leaf each roaring blast defies,
> Tenacious of the stem its flow'rets rise;
> Hence a more wholesome breath the Medes receive
> And of their sires the lab'ring lungs relieve."

LeLong[32] comes to the real truth when he says that we do not know upon what its real value depends. In the glaring array of these insecure impressions we must admit there is very likely a constituent in the true grapefruit which has valuable properties. Likewise certain others of the citrus species may possess constituents of therapeutic value. That is all that we can say with definiteness.

I have experimented empirically with some purified naringin from grapefruit with this end in view, and while some of the results are encouraging from a therapeutic standpoint, I cannot now report more until a more thorough pharmacological test is finished. The latter is being conducted with naringin which I have isolated and purified.

EXPERIMENTAL

The investigations reported herein covered the greater part of a period of 30 mo., which included three grapefruit seasons. Before planning the work, I satisfied myself that in the published investigations of American grapefruit, very little, if anything, could be found relative to the constituents of the peel and seeds. In proceeding with the work I became aware that during storage (*i. e.*, the period between picking and placing in the hands of the consumer), especially when the period extended a couple of months into the Spring, the juice suffered a marked change in flavor. This observation initiated another series of analyses of the acid-sugar ratio of the juices of fruit found on the market in late Fall and early Spring. In the examination of the seeds several remarkably interesting factors revealed themselves, factors which have undoubtedly considerable influence on the naringin (glucoside) content of the fruit. The analysis of the seeds and their biochemical relationship to the remainder of the fruit merit a separate treatment, and hence no further mention of them in this report will be made, except to call attention to the fact again, that a sane disposal of the bulky seeds, the culls and the spoils is a factor of no small mien in the handling of the by-products.

I have compiled a brief table of the typical analyses of grapefruits found in various bulletins from experiment stations and in other publications. It shows the character of investigations which have been reported hitherto. It also serves well to show the relative quantities and characteristics in various varieties of grapefruit grown in different countries, this correlation being important. In Table I, I have indicated as far as possible the analyst and publisher of the data.

The order in which the following research will be considered is as follows:

I—Constituents of peel, or rind: (*a*) Oil, or essential oils; (*b*) glucoside, or bitter principle; (*c*) pectin.

II—Constituents of juice, or pulp: (*a*) acid; (*b*) sugars.

III—Constituents of seeds (not herein reported). It must be emphasized that these "constituents" mentioned above are not the only constituents to be found in the grapefruit. Others were found to exist, and many more are present, though in minute quantities and very likely of no consequence from a by-products standpoint. For instance, a quantitative and qualitative analysis of the ash from the pulp in case of II was conducted upon two varieties with the idea of ascertaining the amounts of sulfates and phosphates present. While the quantity of sulfates was negligible, the phosphate value was in proximate agreement with those presented by Hume,[19] and, hence, are not given in my results.

TABLE I

Description of Fruit	Av. Wt. Fruit Analyzed Grams	Peel Per cent	Pulp(3) Per cent	Ash Per cent	Acid as Citric Per cent	Sucrose Per cent	Reducing Sugar Total Per cent	Protein Per cent	P_2O_5 Per cent
Philippine Islands(*a*)..	930.0	34.0	61.0	0.63	1.06	6.26	8.86	0.66	...
California(*b*)									
(1).....	477.0	30.0	69.2	0.39	..	3.11	6.22	0.58	...
(2) .	391.0	27.0	73.0	0.39	..	4.77	7.37	0.56	...
(1).....	574.0	28.7	71.0	..	1.28	..	7.50	..	...
(2) . .	561.0	34.9	62.5	.	1.51	..	7.40	..	...
Florida(*d*)									
Royal.....	541.0	27.2	69.3	..	(*e*)	..	(*f*)	0.30	0.040
Pernambuco ..	742.7	28.0	68.5	..	(*e*)	.	(*f*)	0.29	0.056
Manville . .	487.6	20.9	74.7	.	(*e*)	.	(*f*)	0.26	0.054
Aurantium	430.9	28.3	68.6	..	(*e*)	..	(*f*)	0.22	0.053
Walters.....	721.3	28.2	68.6	..	(*e*)	..	(*f*)	0.32	0.049
Triumph	534.6	31.8	65.2	.	(*e*)	.	(*f*)	0.29	0.050

(1) Analysis of standard seedless fruit (10 seeds).
(2) Analyses of seeded variety (59 seeds).
(3) Some writers consider the pulp as that portion of the citrus fruit other than the peel and seeds, *i. e.*, the edible portion; some consider it as the segmented sections; others, as the juice only.

(*a*) Pratt and del Rosario, *Phillipine J. Sci., Sec. A*, **8** (1913), 76. Evidently this fruit is not of a true grapefruit, but must be similar to the Cuban fruit described by Chace, Tolman and Munson, U. S. Dept. of Agriculture, Bureau of Chemistry, *Bull.* **87**, p. 13.

(*b*) Colby, *Cal. Agr. Exp. Repot*, **1892-93**, p. 256.

(*c*) Quoted by Shaniel, *California Citrograph*, No **6** 1916 , p. 5.

(*d*) Hume [19] in this bulletin Hume makes no reference in the tables to the sugar or acid content.

(*e*) (*f*) Chance, Fla., grapefruit analysis, gives the following values for the acid and sugar content of three different fruits, respectively. 1.26, 0.90, 1.58; for total sugars: 6.30, 7.88 and 8.41.

(Further note:) The potash content amounts to 10–25 times that of the P_2O_5 content, these values indicate the total fruit content, while in the case of the seeds the values for these constituents are 1000 per cent greater than for either peel or pulp

The varieties of grapefruit which fell to my lot for examination depended chiefly upon the choice of mid-continental fruit wholesalers, and included Marsh Seedless, Duncan, Indian River, Excelsior, Pernambuco and DeSoto. The Atwood Grapefruit Company, of Manavista, Fla., graciously supplied me with several fine fruit, which, though I am uncertain, were probably of Walters, Indian River or Hall variety. The peel and fiber of all varieties were markedly bitter; if a comparison were to be drawn, the Marsh Seedless and another unknown variety would be classed as the least bitter. Hume and others do not consider the Marsh, because of its flavor, etc., as a true grapefruit and they are undoubtedly right. I have used it in my analysis merely because it possessed an insoluble amount of the bitter constituent, and also because it is to be found so extensively in the market both in early Fall and late Spring.

ANALYSIS OF PEEL OR RIND

ESSENTIAL OILS—For the separation of the essential oils large quantities of peels were obtained at frequent intervals from the hotels and eating-houses in this community. These peels were sorted and only those which were fresh and which represented the Indian River, DeSoto and Excelsior were used for oil analysis. They were thoroughly washed and all juice-sac tissue was removed. It was noticed that the distribution of the oil-sacs in the pericarp varied considerably in the different varieties, some being especially rich in oil, others comparatively poor. The oil content of the grapefruit furnished by the Atwood Company was noticeably deficient. Marsh Seedless averaged from 0.75 to 1.0 per cent of light-colored oil which resembled orange oil more than any other oil.

The cleaned peels were cut by a revolving food chopper into pieces averaging a centimeter in cross-section. Trial methods of isolating the oil were tried. A small hand-press cider extractor was employed, yielding a liquid emulsion of solids, oil and water. When this emulsion was allowed to stand for several hours there was a slight separation of the oil on the upper surface but it was always turbid and intensely bitter. Centrifuging and freezing were tried to free the oil from the accompanying material and while it was in a measure successful, it would be unadvisable on a large scale. Precipitation of the astringent material, pectose and resins by means of gelatin and tannic acid solution gave a somewhat clearer oil, but its flavor was repugnant.

Extraction of the oil by means of volatile solvents gave a good yield of oil but was laborious, and in case of the solvents employed (acetone and ethyl alcohol) the bitter glucoside and resins were extracted at the same time. In order to purify the oil, distillation under reduced pressure, or with steam, would be necessary. The former would affect the original character of the oil, while a combination of the two would give a good product.

The method finally adopted and which resulted in a perfectly clear, slightly-yellow oil was as follows: The finely cut peel was introduced into a roomy container with an equal weight of water. Slight suction was applied by means of a water-pump furnishing a steady reduction of pressure. Live steam was then drawn through the suspended peel and condensed in a suitable condensing apparatus connected with the suction (see *F* in Fig. I). Steam distillation was continued until the condensate was free from turbidity, which point indicated that the oil was entirely removed. A second receiver was connected with the suction in series with *F*, and this second receiver was submerged in brine-ice mixture in order to entrap any of the oils which might tend to be drawn past *F*. Buffers of glass-wool were placed in the second receiver as an additional precaution. A slight amount of oil was recovered this way, but with a suitable condenser no extra receiver would be necessary. The oil separated on the surface after a few minutes' standing, and was drawn off. The remaining traces were removed from the distillate by centrifuging.

From 0.4 to 1.1 per cent of oil per fruit or, by weight, 2.5 to 6.0 g. were obtained. Less than one-half this amount would probably be recovered industrially.

A decrease in the aldehyde content of the oil during storage is manifested.

100 g. of the steam-distilled oil, collected under diminished pressure as indicated above, were washed several times with 50-cc. portions of normal Na_2CO_3 solution, then with water, and finally dried with anhydrous sodium sulfate. The oil in this condition had the following physical properties: Odor, strongly that of citral; color, clear greenish yellow; refractive index at 20° C. = 1.4750 and 1.4785; optical rotation in 100 mm. tube at 20° C. = +72.5 and +78.5; specific gravity at 20° C. = 0.845 and 0.860.

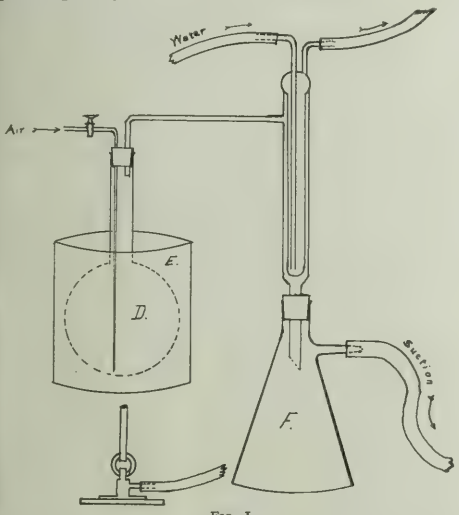


FIG. 1

100 g. of the washed and dried oil were distilled from a flask fitted with a Hempel column under a constant pressure reduced to 12 mm. The distilling flask was immersed in a bath of cottonseed oil and the temperature very gradually increased. The distillate was collected in the following fractions. The boiling point of each fraction was determined and the approximate results are also given in this table.

Fraction No.	B. P. Range	Weight Grams	Boiling Point
1	48– 52°	2.4	158°
2	52– 58°	71.5	172°
3	58– 70°	14.2	178°
4	70– 85°	1.3	181°
5	85–100°	4.8	200°(a)
6	100–115°	3.6	230°

(a) Rapidly rising to 225°, then dropping rapidly and browning.

Fractions 2 and 3 were mixed together for qualitative analysis, also Nos. 5 and 6, since the range in either case is similar.

IDENTIFICATION OF α-PINENE—Fraction 1 and the mixture of Fractions 2 and 3. Pinene was tested for in these separate fractions by the nitrosyl chloride method described by Wallach[38] and Ehestädt,[39] and its presence in both mixtures established by the melting point of the obtained pinene-nitrosochloride, 102 and 103° C. The largest yield was, of course, from Fraction 1. Crystals of pinene-hydrochloride were also prepared from Fraction 1 which melted at 132° C.

IDENTIFICATION OF *d*-LIMONENE—A portion of the mixture of Fractions 2 and 3 distilled under atmospheric pressure gave a distillate which was collected at the approximate temperature of pure limonene, 175° C. The solution was strongly dextro-rotatory, +38 in a 100-mm. tube at 20° C. As further proof, 5 g. of crystalline limonene-tetrabromide were prepared which melted at 104° C. Limonene was also detected in Fraction 4, though in small amount.

TEST FOR ALDEHYDES IN LIMONENE FRACTION—10 g. of the limonene fraction from distillation of the mixture of Fractions 2 and 3 were treated with semicarbazide-HCl and sodium acetate[41] for the production of ketone or aldehyde semicarbazides. None were found, although a slight positive indication of their presence was obtained by means of Schiff's reagent. Test for aldehydes in Fractions 4, 5 and 6 were all positive, Nos. 5 and 6 yielding the largest quantity.

TESTS FOR ALCOHOLS IN LIMONENE AND OTHER FRACTIONS—By acetylation methods the limonene fraction indicated only a possible trace of alcohols. Fraction 4 indicated at least 10 per cent of its weight as of alcohols, calculated as linaloöl $[(CH_3)_2C : CH.CH_2.CH_2.C(OH)(CH_3).CH : CH_2]$. The mixture of Fractions 5 and 6 indicated more than a trace of alcohols, 4 per cent of their combined weight, calculated as geraniol $[(CH_3)_2C : CH.CH_2.CH_2C(CH_3) : CH.CH_2.OH]$.

IDENTIFICATION OF LINALOÖL—Fraction 4 consisting of a little over one gram was shaken in a small glass-stoppered flask with an excess of 5 per cent sulfuric acid. After a short time crystals of terpine hydrate ($C_{10}H_{20}O_2.H_2O$) separated, which melted at 116° C. The oxidation of linaloöl to citral was impossible in this connection, since citral is in the succeeding fraction in large quantity, and probably also present in No. 4, judging by the odor and by the test under aldehydes.

IDENTIFICATION OF CITRAL—While citral was known to be present both from the odor and from the boiling point of the last two fractions, in the latter case suffering decomposition, it was further identified by its semicarbazide preparation. The semicarbazone, prepared according to Zelinsky,[42] melted sharply at 165°.

IDENTIFICATION OF GERANIOL—One gram of Fraction 6, before mixing with 5, was shaken vigorously with 5 per cent aqueous H_2SO_4 and after standing for one hour the acid was neutralized with 10 per cent NaOH. Upon further standing crystals of terpine hydrate separated which melted at 116° C. It was assumed that none of the linaloöl appeared in Fraction 6, since its boiling point is slightly below 200° C. at atmospheric pressure, while Fraction 6 boils under the same conditions at approximately 230° C.

OTHER CONSTITUENTS—While the washed oil showed a small saponification number no attempt was made to determine the esters present. It might be expected that both linalyl- and geranyl-acetate are present, from the analogy of this oil with the other citrus fruit oils.

From the analysis and the distillation figures it would seem that the constituents present in the oil examined are in about the following proportion:

d-Limonene	90–92 per cent
Citral	3–5 per cent
α-Pinene	0.5–1.5 per cent
Geraniol	1.0–2.0 per cent
Linalool	1.0–2.0 per cent
Citronellal	Some
Linalyl and Geranyl Esters	Some

The oil has a very pleasing odor and flavor and when 30 per cent by volume of pure ethyl alcohol is added it seems to keep as well as either lemon, orange or lime oil. Its properties seem to place it between the lemon and the orange in value.

GLUCOSIDE, OR BITTER PRINCIPLE—The residue remaining in the container after steam distillation of the peels was fibrous and intensely bitter. Several liters of the residue were pressed through bags of cheesecloth and the liquid allowed to stand for several days, while the oils were being analyzed. The fibrous mass remaining in the cheesecloth bags, after expressing the juice, was found to be free from bitterness. It was apparent that the hot water was sufficient to extract the "bitterness." A few days after the above liquid had stood at room temperature I was surprised to find a rapid fermentation in progress. Numerous rosettes of small crystals were forming on the sides of the glass container near the bottom, while several centimeters of a white snowy product had collected on the bottom. Microscopical examination of this snowy mass revealed multitudinous spine-like crystals, with here and there some unbroken rosettes. It was finally found that these crystals could be separated from the remaining liquid by pouring through a funnel in which a tuft of absorbent cotton was placed. Most of of the yeast cells filtered through, though slowly, of course. The crystals and contaminating yeast cells were taken up with hot water (90°), just enough water being used to dissolve the crystals; the solution was then filtered through filter paper and allowed to recrystallize. After repeated recrystallizations from water and finally from alcohol the product was assumed to be pure. The fermented solution from which the first crop of crystals appeared was still strongly bitter, and only when the solution was placed in ice water did more crystals separate; the bitterness had then decreased to a noticeable trace. Doubtless the alcohol formed during fermentation was responsible for the retention of the bitter principle, since it is quite soluble in cold alcohol diluted with water and refuses to crystallize from this mixture even when lowered to the freezing point.

The following method was devised for the direct extraction of the bitter principle from the chopped, fresh peel. An extraction apparatus according to Fig. II was set up. The percolator *A* held the finely chopped peel from 15 large grapefruit. A small tuft of glass wool was placed in the bottom of the percolator to prevent the return tube from being stopped up. One and one-half liters of 96 per cent alcohol were placed in *B*. *C* contained water for the bath. The operation is automatic and simple after the first dumping of *A*. Ten hours are sufficient for the complete extraction of the glucoside from each charge of peel. Of course, the oils, resins and other substances are extracted along with the glucoside, but no pectose material is present in the extract. To facilitate the evolution of a continuous current of alcohol vapor from *B*, a glass tube of 0.5 to 1.0 cm. bore is sealed at one end and inverted in the round bottom flask. The vapor expanding in this tube causes a continuous succession of bubbles, which tend to prevent both bumping and froth. The extract from *B* is then poured into

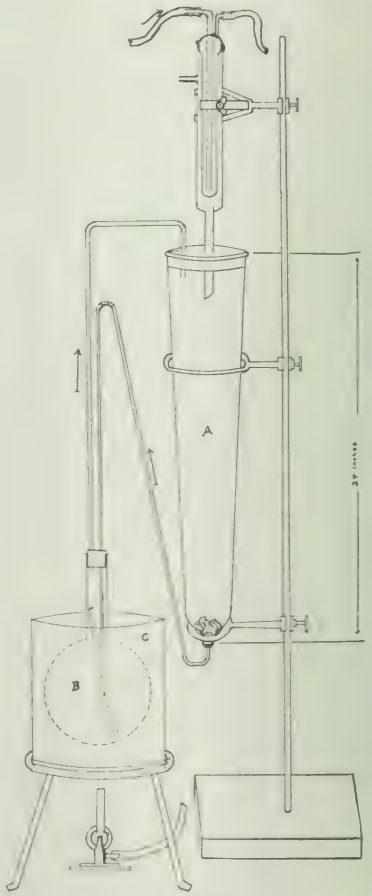


FIG. II

flask *D* of Fig. I. *F* is again used for a water bath, the temperature of which must not remain above 80°. *D* is connected with a Hopkins condenser with a glass seal, and the condenser in turn connected with a receiver to which suction to the pressure of 10 mm. may be applied. A fine capillary tube with stopcock extends to the bottom of *D* to regulate the distillation by means of a free current of air. The alcohol and oils are collected in *F* and may be used for the extraction of another charge of peel without redistilling.

The residue in *D* should be a golden yellow syrup, which is taken up in water and treated with a few cubic centimeters of 25 per cent basic lead acetate solution to precipitate out the material other than naringin, the glucoside. The mass is filtered without suction and the excess lead removed with hydrogen sulfide, from hot solution. The clear filtrate from the PbS precipitate is allowed to stand for a few hours, when the white rosettes begin to form on the sides of the containing vessel, analogous to those from the fermenting liquor. Mild shaking induces instantaneous crystallization which fills the container, and from which considerable heat is evolved. Purification is accomplished as previously mentioned.

The white crystals are monoclinic, glistening, and when compacted are light cream in color. They are exceedingly fluffy so that the quantitative yield appears larger than it really is—from 0.2 g. to 1.6 g. per fruit. The crystals are soluble in water at 20° to the extent of one part in 8000 of water, though even at this dilution it is intensely bitter. This emphasizes the fact that it is of a greater degree of bitterness than quinine, for which it has so often been mistaken. Only a few of the physical and chemical properties will be recorded in this paper, for a subsequent paper will treat more fully of the glucoside.

After the determination of its physical constants, elementary analysis, and chemical reactions together with the physical and chemical properties of its hydrolytic products, I was certain that I was working with the same compound that deVry[4] discovered in 1857, in the flowers of the grapefruit trees in Java. DeVry states that it occurs in all parts of the *Citrus decumana* though to a much greater extent in the freshly opened flowers. While both he and Hoffmann,[5] and later Will,[28,40] conducted classical researches on this glucoside, they state that they obtained their raw product from the residue remaining in the distillation pots at Java after removing the "neroli-oil" from the flowers of the grapefruit tree by steam distillation. Both deVry and Hoffmann were unable to find this same bitter substance in the flowers or fruit of any of a host of other citrus fruits, including the bitter orange.

Hoffmann[5] applied the name "naringin" to the glucoside which deVry and he investigated. Will[28] retained the same term in his investigations with Tiemann.[7] The term originated, according to Hoffmann,* from the Sanskrit word "naringi" for orange.

Solutions of naringin in ethyl alcohol and water are levorotatory; the molecular rotation in alcohol at 18° C. is —65.2. Its empirical formula as determined from carbon and hydrogen combustion, as well as from a study of its cleavage products, appears to be $C_{21}H_{26}O_{11}.4H_2O$ (air-dried). Over sulfuric acid it loses 3 molecules of water, and when dried at 120° C. it loses the remaining molecule of water. In the latter state it is in the form of an impalpable powder, colored a faint tinge of yellow. When naringin is hydrolyzed with dilute (5 per cent) HCl or H_2SO_4, it forms a mixture of rhamnose and glucose, though the quantity of glucose is much smaller than that of rhamnose. At the same time a highly crystalline solid separates, insoluble in water, and was found to be the phloroglucinol ester of *p*-hydroxy-cinnamic acid. Methods of isolation and analysis, together with proof for arriving at the above conclusion regarding its constitution, cannot be presented in this paper, but will be followed by a more detailed and theoretical discussion in a succeeding number of the Journal of the Society.

In passing, let me call attention to the behavior of the glucoside which governed the choice of the extraction method above for its isolation from the peel. When the air-dry naringin is heated in a receptacle over a free flame it melts at about 83° C., and forms a syrupy mass which turns brown on gently increasing the temperature to 100° C., above which violent evolution of H_2O vapor takes place and a hard, glassy, dark brown mass results. This mass is yet bitter but dissolves with difficulty in water. Now, on the other hand, when a water solution of the naringin (pure crystals) is boiled, it rapidly turns yellow to brown, the bitterness gradually disappears and when evaporated on a steam bath a resinous mass results, possessing the odoriferous principles of caramelized sugars together with those of coumarin and certain phenols. No naringin could be extracted from the mass. Likewise, when the peel was ground, dried at 110° C., and lixiviated with water, very little naringin was obtained. Hence in the separation of the glucoside from the fresh fruit, temperatures above 80° C. should be avoided. In the steam distillation of the peels some of the naringin is hydrolyzed by the steam, though the temperature in the distilling flask seldom registered above 85° C.; stronger suction would prevent this decomposition.

The quantity of glucoside in the grapefruit examined was approximately as follows:

TABLE II

VARIETY OF FRUIT	Age of Fruit	Weight of Fruit Grams	Quantity of Naringin from Peel Only Gram
Indian River	Fresh Market	770	0.62
	Old* Market	715	0.35
Walters	Fresh Fruit	682	0.50
	4 mos. at 15° C.[1]	695	0.24
Marsh, Seedless	Fresh Market	539	0.36
	Old Market	570	0.08

[1] It is difficult to give the age to any great degree of exactness. "Old" signifies that the fruit was of the same variety as the fresh market, but that it had been kept for some time between analyses, in order to determine the effect of deterioration on the bitterness. The Walters was secured directly from a fruit exchange and some of the fruit kept at constant temperature for the time specified.

From the table it is quite evident that there is a diminution in the naringin content during storage, more noticeable in some varieties than in others. What has happened to the glucoside is revealed when the sugar content of the pulp is examined over a like period. Of course, it is not argued in this paper that the increase in sugar content of the pulp during storage is traceable solely to the glucoside, in the face of the large pectose content. But a portion of it may be derived from the hydrolyzed glucoside by the aid of the enzymes present in the fruit. Certain flavors and "pink spots" which develop simultaneously with the decrease in naringin and increase in sugars are traceable to the glucoside, when the reactions of this substance are better understood.

* Hoffmann[5] in his paper gives credit to Professor Fluckiger for the suggestion of the derivation. Fluckiger was interested in deVry's early investigations of naringin.

PECTIN—None of the citrus fruits grown for commercial purposes are so rich in pectose materials as the grapefruit. The navel orange ranks second in this respect. Some citrus, of no commercial value hitherto, contain more pectin at certain stages of growth.

The isolation of pectin during this investigation was merely a subsidiary proposition, and was initiated solely because of the coming commercial importance of pectin as a filler for preserves, jellies, desserts, ice creams, etc. A suitable source of pectin among the by-products industries, where other substance besides pectin may be isolated to lessen "overhead" expenses, would be welcome. R. T. Will[33] has indicated the possible isolation of pectin, among other products from oranges. This has been received only half-heartedly by the citrus by-products people, owing to the fear of no demand for the material. It is, therefore, up to home economics and domestic science investigators to help create the demand by more widely heralding the suitableness and value of this natural constituent of many fruits. It is likewise up to the by-products companies to more effectively study the isolation of pectin so that a pure, dry, soluble and merchantable product may be obtained. Coöperation between the above-mentioned laboratories is urged.

No attempt was made to study the theory of pectin formation or its chemistry, for scores of contributions on this subject are to be found in biochemical literature. Mention should be made of its colloidal nature and emphasized, because its isolation and purification must be conducted according to the knowledge of colloidal phenomena. The tenacity with which pectin clings to many of the substances existing along with the pectose complex points to the importance of the above statement, and failure to remove these contaminating substances will mean lack of purity.

After the peels had been extracted with alcohol for the removal of naringin, according to Fig. II, they were placed in water and boiled for 3 hours. This boiled mixture was then decanted through cheesecloth and expressed by hand. The expressings together with the filtrate were boiled for another hour, filtered through absorbent cotton, which filled the apex of a fluted filter paper in the funnel, and then evaporated by means of reduced pressure to a fairly thick syrup, or viscous liquid. Three processes were employed from this point to purify the pectin: (1) Reprecipitation by alternately pouring into redistilled 95 per cent alcohol, and reconcentrating the water-dissolved precipitate by means of reduced pressure mentioned above; (2) freezing and centrifuging to remove excess of water, without causing decomposition of the pectin body, after precipitation in alcohol and dissolving in water; (3) agitated dialysis* in a collodion membrane suspended in running distilled water, of the water-dissolved precipitate after the first alcohol precipitation. It might be mentioned that dialysis was also conducted on the pectin solution obtained after concentration by reduced pressure, without alcohol precipitation. In all cases the pectin, after final concentration, was evaporated in vacuum at temperatures not exceeding 40° C. and resulted in grayish yellow scales easily soluble in water and closely resembling agar in color and texture. Mr. C. A. Utt, of the Kansas State Food Laboratory, was interested in working over the liquid remaining from the spontaneous fermentation of the steam-distilled peels, after the naringin had precipitated, for the recovery of pectin. He also worked with some of the fresh peels and by means of alcohol precipitation alone, after previously boiling with water, obtained a product with scarcely any bitterness. It is possible to isolate the pectin from grapefruit without retaining any of the original bitterness. In the boiling process, a fact to which I have called attention before, the naringin is slowly destroyed. Since working with the pectin an instance has occurred to me wherein I believe it would be very desirable, after purification, to remove the last traces of water from the substance by freezing it and then subjecting it to a very high vacuum. It is a question, however, whether this would be possible on a commercial scale. It would yield an excellent product providing it was economically feasible.

The amount of pectin isolated from the peel of 10 grapefruit (Indian River) weighing 1560 g. was something over 65 g. regardless of loss. Ten grapefruit of the same variety obtained two months later in season, the peels of which weighed 1450 g., yielded about 40 g. of pectin. One would expect the pectin content to decrease markedly during storage. I am firm in the opinion that, if the fruit were examined at the time of picking for market, the average of recoverable pectin from all varieties of grapefruit would be considerably above 10 per cent of peel weight. Naturally, the thinner the peel, the poorer the fruit is in pectin.

ANALYSIS OF PULP OR JUICE

In the preparation of the pulp previous to the analysis, the following method was adopted: Ten average fruit of each variety chosen were picked out and weighed. Five of the fruit of each variety were then stored at nearly constant temperature (15° C.) for a period of 3 mo., and then analyzed according to the same procedure as for the first set. Table III will indicate the varieties analyzed. The fruit were peeled by hand, divided into segments, and the segments freed from as much of the "pith" as possible without rupturing the juice sacs. The segments from each five fruit were then ground in a large mortar with sea-sand in order to free the juice from the fiber and all washed into a flask graduated to hold 5 liters and made up to the mark.

CITRIC ACID—Five 50-cc. portions were removed from the above standard volume, and titrated with standard $N/10$ NaOH in the presence of phenolphthalein. The average of these 5 determinations were calculated to crystallized citric acid ($H_3C_6H_5O_7.H_2O$) and expressed in grams of acid per fruit.

REDUCING SUGARS—100 cc. of the prepared juice were measured into a 200-cc. volumetric flask. 5 cc. of 20 per cent basic lead acetate solution were added,

* By agitated dialysis I mean the introduction of a stirring device in the collodion dialyzing cell in order to hasten and cause a more complete dialysis.

followed by 10 cc. of alumina cream, and the mixture made up to volume with water and filtered through a fluted filter with a small tuft of absorbent cotton in the apex. Reducing sugars were determined in aliquots of the filtrate with Fehling's solution, following the method of Munson and Walker, and were expressed as dextrose in grams per fruit.

It was necessary to clarify the solution in order to remove the sac fibers and other suspended material. Because of the presence of a small amount of naringin in the juice it is inadvisable to determine the sugars polarimetrically, since naringin is not removed by clarification.

SUCROSE—Aliquots of the clarified juice were hydrolyzed according to the usual method (acid hydrolysis) and the total invert sugar determined, after neutralization with Na_2CO_3, by the method of Munson and Walker. The total invert sugar less the reducing sugars, multiplied by 0.95, was used to express the sucrose present in grams per fruit.

TABLE III

VARIETY OF FRUIT	Approx. Age of Fruit Mo.	Av. wt. per Fruit Grams	Av. wt. Pulp per Fruit Grams	Citric Acid per Fruit Grams	Sucrose per Fruit Grams	Reducing Sugars as Dextrose per Fruit Grams
Marsh Seedless...	1	430	290	2.77	6.20	8.57
Marsh (stored)...	4	440	308	1.85	7.58	13.50
Atwood Grapefruit Co. Fruit.	1	680	460	5.98	11.24	14.84
(stored)	4	670	440	3.40	15.15	19.60

In looking at Table III one finds an increase in both sucrose and reducing sugars during storage, while the citric acid decreases. It might be thought that the increase in sugar content could be explained on the assumption that there is a considerable loss of moisture from the pulp during storage. But such a loss of moisture would have to be enormous to account for the large gain in sugars, and no such loss was noticed since the fruit were weighed both before and after storage. Furthermore the citric acid decreases could not be accounted for on the same assumption. Again it might be said that soluble pectose material dialyzing through the sac walls might explain the increase in sugar content of the juice, but while this might explain the increase in reducing sugars it could not explain the sucrose increase. One must look to the continuation of the function of the enzymes of the fruit during storage in order to account for both of these phenomena, the sugar increase and the acid decrease, as well as the naringin and pectin decrease.

From the large sugar, pectin and glucoside content it might be profitable to transform these into easily fermented sugars, and by fermentation of the entire grapefruit, after processing, obtain an economical yield of alcohol for commercial purposes. The citric acid present, if slightly increased by added mineral acids, would be serviceable for the hydrolysis of the glucoside and pectose material to available sugars. From one ton of grapefruit, considering the preformed sugars alone, one would be able to obtain 10–15 gal. of proof spirit, calculations being based upon green weight of fruit.

The values for the sugar content of Marsh Seedless as shown in Table III are somewhat lower than the sugar content found at various times before and after this series of analyses were performed. While the fruit were purchased for Marsh Seedless it is possible that they represent another variety. From Colby's analysis (Table I) it would seem that the above values represented another fruit. However, the same characteristic rise in sugars is noticed in the true Marsh Seedless.

SUMMARY

I—A brief condensed history of the grapefruit is given in an endeavor to trace its introduction into America. It appears that it was grown in Mexico before introduction into the United States. Attention is called to Ferrari's classification of citrus.

II—Lack of previous analyses of constituents is shown, other than general routine analysis.

III—Issue is taken with the various promulgators of the medicinal value of grapefruit for having made no attempt to actually ascertain upon what constituents, or possible constituents, the heralded therapeutic value depends. Mention is made of the writer's experiments with naringin for this purpose.

IV—Analysis of the peel showed recoverable amounts of essential oils (principally limonene, citral, pinene and alcohols), the glucoside naringin, and pectin. Important properties of naringin are shown and serious consideration of naringin as of real significance in the differentiation of *Citrus decumana* from other citrus species is urged.

V—Grapefruit culls may factor in the production of a satisfactory grade of pectin for various purposes if correct methods are employed in its isolation.

VI—The citric acid, naringin and pectin content of grapefruit decrease during storage; reducing sugars and sucrose increase.

VII—Attention is called to the possibilities of industrial alcohol production from the whole culls.

VIII—Naringin and the "bitter principle" of grapefruit are synonymous.

BIBLIOGRAPHY

1—Hume, Fla. Agr. Exp. Station, *Bull.* **58** (1901), 388.
2—Dygert, "Crops That Pay," **1903**, p. 3.
3—Gallesio, "Traité du Citrus," **1811**.
4—DeVry, *Jahresber. für Pharmacognos*, **132**, 1866.
5—Hoffmann, *Ber.*, **1876**, p. 685; also Hoffmann, *Arch. der Pharmacie*, **14**, (1879), 139.
6—Dehn, *Z. Rubenzucker Ind.*, **1865**, p. 564; also Dehn, *Z. Chem.*, **103**, 1866.
7—Tiemann and Will, *Ber.*, **14** (1881), 979.
8—Author's article on classification of grapefruit to appear soon.
9—Shamel, *California Citrograph*, I, No. 5, p. 19, and No. 6, p. 3, 1916.
10—Risso and Poiteau, "History and Culture of Oranges," **99**, 1872.
11—Watson, "The American Home Garden," **1859**, p. 363; also quoted by Hume.[1]
12—Spalding, "The Orange in California," **1885**, p. 89; also quoted by Hume.[1]
13—Downing, "Fruits and Fruit Trees in America," **1885**, p. 579; also quoted by Hume.[1]
14—Gallesio, "Traité du Citrus," **1811**.
15—Lebreton, *J. de Pharmacie et des Sciences Acc.*, **14** (1828), 377.
16—Poiteau, Individual papers.
17—Risso et Poiteau, "Histoire Naturelle des Oranges," **1818**.
18—Vaile's report quoted by Shamel, in *Monthly Bulletin, Com. Hort of Calif.*, **5** (1916), 239; Wallschlaeger, "World's Prod. and Com. in Citrus Fruits and By-Products," in *Bull.* **11** (1914) of Citrus Protective League of Calif.
19—Hume, *Loc. cit.*
20—Shamel, *Monthly Bulletin Com. Hort. of Calif.*, **5** (1916), 239.
21—Reasoner, Division of Pomology, U. S. Dept. Agr., *Bull.* **1**.
22—Hume, "Citrus Fruits and Their Culture."
23—Pfeffer, *Botan. Z.*, **1874**, p. 481.
24—DeVry, *Loc. cit.*
25—Blas *Z. für Chem.*, **1869**, p. 316.

26—Hoffmann, *Loc. cit.*
27—Lebreton, *Loc. cit.*
28—Will, *Ber.*, **18** (1885), 1311; **20** (1887), 294.
29—Hilger, *Ibid.*, **9** (1876), 26.
30—Kraemer, "Text on Pharmacognosy."
31—Von Rijn, "Die Glykoside," **1900**.
32—LeLong, "Citrus in California," **1900**.
33—Will, THIS JOURNAL, **8** (1916), 78.
34—Tanret, *Compt. rend.*, **102** (1886), 518.
35—Tanret, *Ibid.*, **102** (1886) 1518; also Kraemer, *Loc. cit.*
36—Aaronsohn, "World's Production in Citrus Fruits," Trans from Jewish Agr. Exp. Sta., Palestine, *Bull.* **1** (1914), 7.
37—Virgil, Georg. book II vers 178.
38—Wallach, Liebig's *Annalen*, **245**, 251.
39—Ehestädt, *Rept. of Shimmel & Co.*, April 1910, p. 164.
40—Will, *Ber.*, **20** (1887), 1186.
41—Mullikan, "Identification of Pure Organic Compounds," **Vol. I.**
42—Zelinsky, *Ber.*, **30** (1897), 1541.

U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LABORATORY AND PLANT

AN INEXPENSIVE ASH LEACHING PLANT

By W. D. TURNER AND B. G. NICHOLS

Received March 25, 1918

The industrial chemistry department of the Missouri School of Mines has erected a small plant for the leaching of wood ashes, and at this time when the potash industry is receiving such frequent mention,[1] a brief description of this installation will be of some interest. The work was started for its pedagogic value but developed to a point where it assumed small commercial dimensions.

APPARATUS

To apply the countercurrent lixiviation principle vertical columns of buckets were arranged. A column was supported on two upright "two by fours," 10 ft. long and spaced 20 in. apart, fastened directly to the floor at the base and braced to the ceiling at the top. At a point 30 in. above the floor and at intervals of 16 in. above this, spikes were driven part way into these uprights and projected outward about an inch to serve as brackets to support cross-rods of $^3/_8$-in. sq. iron bars from which the buckets could be suspended.

The leaching buckets consisted of ordinary 60-lb. wooden lard tubs, in the bottom of which a dozen or more holes were bored. The original handles were removed from these tubs and were replaced by heavier iron loops bent from $^1/_4$-in. round iron rods and fastened to the buckets by driving the ends through holes drilled in the sides of the tubs and bending them up into place. For the water reservoir at the top a bucket was similarly prepared with only one hole in the bottom provided with a loose wooden plug by means of which the flow of water could be regulated. To catch the liquor at the bottom a tub without holes was used. The column thus consisted of a liquor receptacle standing on the floor, above this a series of 5 leaching buckets, and at the top a water reservoir. This column constituted a complete unit. The second unit was constructed beside the first, letting one "two by four" serve in both columns. The two units were identical except that all the bracket spikes in the second were four inches higher than in the first to prevent interference in changing the ashes. The third column was again like the first, and so on.

The liquor was causticized in an ordinary oak barrel into which a current of live steam could be conducted to heat and stir the contents, and from which the clear liquor could be siphoned after the mud had settled. For concentrating the liquor a cast-iron, seamless steam-jacketed kettle was used, though for an isolated installation both this and the causticizing operations could be carried out in open flame-fired kettles. The final evaporation or fusing of the potash was carried out in an ordinary caustic pot.

[1] THIS JOURNAL, **10** (1918), 6, 96, 106, 109, etc.

OPERATION

At the start of operations the bottom of each leaching bucket was covered with about 3 in. of excelsior, which later packed down to an inch, and over this was spread a layer of old toweling or other cloth. The buckets were then filled to the top with ashes and were lifted into place in the columns by means of a small block and tackle which could be suspended from a hook in the ceiling in front of each column. Water was then filled into the reservoir and was allowed to drip through the successive buckets until the ashes in all were saturated. A measured quantity of water, equivalent to half the weight of the ashes in one bucket, was then placed in the reservoir and was allowed to drip through the column, forcing out an equivalent amount of liquor into the receptacle at the bottom. When the top bucket had ceased to drip, it was removed by means of the block and tackle and was dumped. The excelsior and cloth which came out with the spent cake were replaced, and the tub was again filled with fresh ashes. Each of the remaining buckets was now raised successively to the next higher bracket and the fresh ashes were placed at the bottom. Water equivalent to $1^1/_2$ times the weight of the ashes was now placed in the reservoir and was allowed to drip through. This was sufficient to saturate the fresh ashes and force out about half their weight of liquor. This operation of renewing the ashes was then repeated as often as the reservoir could be emptied.

The liquor from the leaching columns was placed in the causticizing barrel until this was about three-fourths full. The calculated amount of lime was then added and the mixture boiled for about an hour by means of the live steam jet. It was then allowed to cool and settle and the supernatant liquor was siphoned into the concentrating kettle. The lime mud at the bottom was then spread over the fresh ashes at the bottom of the leaching columns, so that any potash which it still contained was leached out as it passed up through the successive steps to the top. By this means the customary countercurrent lixiviation of the lime mud was obviated.

The concentration of the liquor was continued until most of the sulfate which it contained separated out

as a granular deposit. The liquor was then drawn off into the caustic pot where it could be evaporated to any desired concentration or could be fused if necessary.[1]

To obtain a clean product without the necessity for calcination, the potash in a part of the liquor was converted entirely to sulfate by neutralizing with commercial sulfuric acid. This operation was carried out in an ordinary oak barrel arranged so that acid could be siphoned into it directly from a carboy. Before neutralizing, the leach liquor was concentrated until

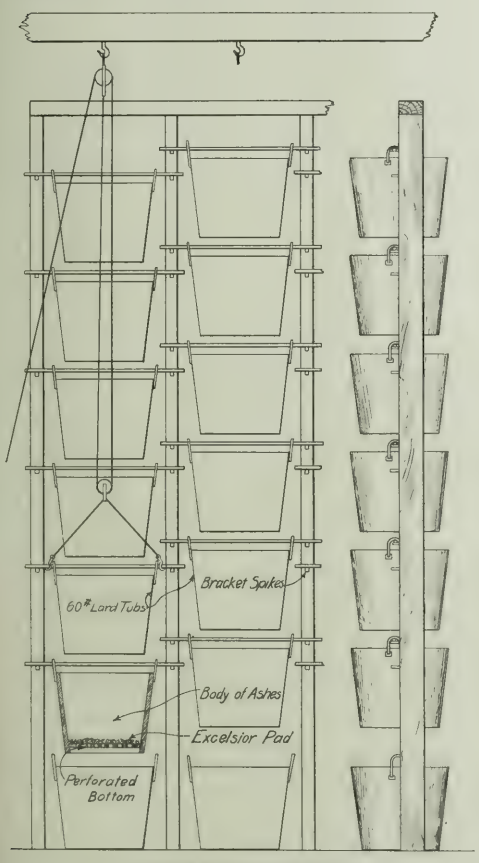


Diagram of Leaching Column

solid carbonate began to appear. It was then drawn off into another container where it was allowed to settle and cool. The clear, saturated solution was then placed in the barrel and the acid allowed to run in until neutral to litmus. This caused a violent reaction and resulted in the precipitation of a large per cent of the potash in a clean, pure, finely divided crystalline mass. This was allowed to settle, the supernatant liquor was returned to the concentrating kettle, and the crystals dried in a centrifugal machine.

[1] Martin, "Salt and Alkali Industry," p. 45.

By this means almost all of the organic matter was removed and the potassium sulfate obtained was nearly pure and colorless, the sodium remaining behind as carbonate in the concentrating kettle, and the organic matter remaining in the liquor.

DATA AND RESULTS

It was found from preliminary experiments that the rate of flow through the ashes was dependent mainly on the area of the cross-section from which the liquor could drain, but was practically independent of the depth. The buckets which were used were 16 in. in diameter at the top and $12^1/_2$ in. at the bottom, and were 11 in. deep. These dimensions gave an area of drain of about 490 sq. in. and a capacity of about 35 lbs. of ashes when loosely packed. Through this body the necessary 7 gals. of water would percolate in about 4 hrs. or less under favorable conditions. It was thus practicable to make three changes per day, making the total capacity of each column about 105 lbs. Since oak ashes average about 11 per cent potassium salts the yield from each column was about 10 or 11 lbs. of potash salt per day. One man could change one column in about 10 or 12 min., so that he ought to handle easily 4 columns per hr. or a total of at least 15 columns, allowing 4 hrs. between changes.

A few average analyses will give a measure of the efficiency of the apparatus. Analysis of the ashes in the vicinity of the School of Mines shows about 4.25 per cent hydroxide, 4.50 per cent carbonate, 2.90 per cent sulfate and 0.02 per cent chloride. If all converted to sulfate this will yield over 15 per cent; if causticized it will yield about 7.8 per cent hydroxide and 2.9 per cent sulfate. Tests on the liquor from the top bucket just before discarding it showed: sulfates a mere trace and total alkali figured as potassium hydroxide 0.3 per cent. But this final liquor is saturated with calcium hydroxide, so that the actual potassium hydroxide content is not 0.30 per cent but about 0.06 per cent to 0.08 per cent. The percentage recovery is therefore 99 per cent or more of the available salt.

For causticizing, a dilute solution of the material to be treated is necessary, and it will be noted that the solution as it drains from the bottom bucket is just about at the right concentration. Analyses on this liquor show about 3.75 per cent sulfate, 5.50 per cent hydroxide, and 5.75 per cent carbonate. This will yield about a 10 per cent solution of caustic potash when completely causticized, a strength which is recommended as most economical.[1] For this conversion the liquor from one bucket will require (allowing a 50 per cent excess) about 1 lb. of quicklime. Thus the average amount of sludge to be returned to each bucket from the causticizing barrel will be less than 2 lbs. and may be spread over the surface of the ashes without detriment. It is probable even that this sludge converts some potassium carbonate to hydroxide during the leaching process.

Typical results may be tabulated as follows:

[1] F. H. Thorp, "Outlines of Industrial Chemistry," p. 84.

TABLE OF ANALYSES

SUBSTANCE	Ashes Per cent	Leach Liquor Per cent	After Causticizing Per cent	Final Hydroxide Per cent	Final Sulfate Per cent
Sulfate	2.90	3.36	3.14	Trace	99.05
Carbonate	4.50	5.22	0.25	4	Nil
Hydroxide	4.25	4.98	8.86	96	Nil
Chloride	0.02	0.02	..	..	...

LEACH LIQUOR FOR A TYPICAL RUN JUST BEFORE CHANGING THE TUBS

Tub No.	1	2	3	4	5
Total alkali (as K_2CO_3), per cent	0.33	1.99	3.59	6.88	12.30

SODIUM[1] AND POTASSIUM IN PRODUCT

Na_2SO_4 Per cent	K_2SO_4 Per cent	Moisture Per cent
1.6	97.4	1.0

[1] Sodium by difference.

SUMMARY

A small, inexpensive ash-leaching plant is described in which the principle of countercurrent lixiviation is applied, with certain resulting advantages:

1—Minimum initial expense and low upkeep.

2—Low operating cost. The leach liquor requires no concentration before causticization and the caustic sludge requires no separate lixiviation.

3—High efficiency. Recovery is 99 per cent or better.

4—Rapid manipulation. Each column furnishes a spent charge and a unit of full-strength leach liquor every four hours.

MISSOURI SCHOOL OF MINES
ROLLA, MISSOURI

ANTIMONY SULFIDE AS A CONSTITUENT IN MILITARY AND SPORTING ARMS PRIMERS[1]

By ALLERTON S. CUSHMAN[2]

Received March 29, 1918

Toward the end of the year 1916 and throughout 1917, the production of military ammunition for all arms began to be tremendously speeded up in the United States. At the same time, the overseas commerce of the world was interfered with by trade conditions incident to the war and shortage of ships. The result of this combination of circumstances produced a very unusual condition with regard to the chemical constituents used the world over in the manufacture of military primers of all kinds.

For years past tersulfide of antimony has been used in almost every type of primer and is considered a necessary ingredient thereof, although the percentage quantity used in various formulas varies within wide ranges. The principal sources of antimony tersulfide for this purpose are the crude stibnite ores which are found native in many parts of the world, including England, Canada, United States and Alaska. Nevertheless, the principal supply of tersulfide of antimony as far as the United States is concerned is from Japan and China and at the present time principally from China. It is probable that the segregation of this business into the hands of the nations of the Orient is largely due to cheap labor, so that if on account of any condition incident to the war it became difficult or impossible to import antimony sulfide from overseas, the result would be that the price of the crude materials would advance. Native antimony sulfide could then be produced in sufficient quantity and of a sufficiently satisfactory grade to assure the country an adequate native supply.

Antimony occurs in nature chiefly as the tersulfide (Sb_2S_3) in the mineral stibnite and to a smaller extent in combination with other metallic sulfides under a variety of names, such as bournonite, pyrargyrite, kermesite, etc. For the purpose of this paper, however, it will be sufficient to confine the discussion to the consideration of the more or less pure stibnite ores that occur in nature. As these ores are rarely free from a siliceous gangue, it is necessary in the preparation of the material for use as a primer constituent to melt or liquate the ore out of contact with the air. Stibnite, when pure, melts at approximately 550° C. In the process of melting, a certain amount of metallic antimony is separated from the melt and goes to the bottom, while, on the other hand, the siliceous gangue impurities rise to the top. On cooling down the melt, therefore, the intermediate layer represents the liquated antimony sulfide which should be carefully separated from the other two layers and represents the raw material of the antimony sulfide used as a primer constituent. If during the process of melting down, the antimony sulfide comes into contact with oxygen of the air, it is to a greater or less extent oxidized and the material is not pure sulfide of antimony but contains an indefinite proportion of oxide, and possibly some in the form of oxysulfide intimately associated with the tersulfide which has not been oxidized or burned.

The work of liquating the crude ores is principally done in China and Japan before the material is imported into the United States, with the result that heretofore there has been but little control of this process and the antimony sulfide available in the open market has shown a wide variation in its chemical analysis and therefore in its quality. Textbook and periodical literature on the subject of specification of antimony sulfide as a constituent of primer mixtures is for the most part meager and often misleading and inaccurate. It is usually the custom to direct that the purity of the antimony sulfide in question shall be determined by analyzing the material for antimony by any of the well-known volumetric methods and then calculating the percentage of antimony to the basis of the tersulfide (Sb_2S_3) which in a sample of pure stibnite should figure out very close to 100 per cent.

A number of chemists have become aware of the fact that analyses and calculations made on this basis very frequently led to results running over 100 per cent, which was assumed to be due to the fact that some slight amount of free antimony accompanied the antimony sulfide. On the other hand, when calculations were made on the same basis of analyses and came out less than 100 per cent, it was considered that this showed an unsatisfactory grade of purity in the material.

The fact that the antimony determination is easily and quickly made, while the determination of sulfur in the material has been considered a difficult and unsatisfactory determination, has probably been the principal cause of this state of affairs.

[1] Published by permission of the Chief of Ordnance

[2] Lieutenant-Colonel, Ordnance Department, N. A.

The assumption has always been made by explosives chemists that the material required for making efficient primers was pure tersulfide of antimony (stibnite) of as high a degree of purity as the market or methods of treatment of the original ores would make it possible to obtain. It has at no time, as far as the writer of this paper is concerned, been suspected that very possibly, if 100 per cent pure stibnite was available on a large scale, it would not lend itself so efficiently to the manufacture of high quality primers as does the ordinary liquated crude antimony sulfide which can be made practically available in large commercial quantities. In fact, the whole question as to the proper grade or condition of the antimony sulfide for the commercial production of high-grade primers has been so obscured by theory, opinion, rumor and loose statement that it has been almost impossible for a worker in this field to make any definite decision with regard to this important subject.

The primer, as its name implies, is expected to initiate every explosion which takes place from the first burning of the propellant powder to the final explosion of the shell, if such explosion is designed to take place, when it arrives at the final place where detonation is required. It is therefore quite apparent that the success of ammunition, and very often the final decision in war, must hang directly upon the efficient and proper functioning of the greatest possible number of all primers loaded. It is apparent that the efficient functioning depends upon the proper selection of the constituent materials which enter into the priming mixture.

There are, of course, a number of different types of primers and quite a wide variety of selection is made in different types of constituent chemicals, but since antimony sulfide is common to almost all primers, for the purpose of this paper, no discussion of the other chemicals aside from antimony will be included.

As far as antimony sulfide is concerned, it can be reiterated that the book references as to the quality which should be sought are generally vague and unauthoritative. As an example of this, it will be sufficient to cite the paragraph with which antimony sulfide is dismissed in the latest (1917) edition of Marshall's compendium on "Explosives, Properties and Tests," Volume II, page 686:

"This material is found native in England and other countries; it has a density of 4.63 and the pure substance melts at 555°. At high temperatures it is volatile. The crude ore is refined by melting out the antimony sulfide, which then forms bluish gray lumps with a metallic luster and very brittle. It is also produced artificially, but in Germany it is forbidden to use in explosives the artificial product, or such as contains iron. It is absolutely essential that it should be free from sulfuric acid, as this has a very deleterious effect on the stability of explosive mixtures containing a sulfide and a chlorate, such as cap compositions. When treated with aqua regia it should not leave a residue of more than 0.5 per cent. It should be examined to see that it is not adulterated with sulfide of lead or iron, and that it contains little arsenic. The value of the substance as a constituent of cap compositions seems to be due largely to its hardness and crystalline form, which render the compositions sensitive to blows and friction."

It will be noted that the above paragraph gives very little information on the subject. The impression is given by the paragraph that what is wanted is practically pure stibnite and, above all, that it should be free from sulfides of lead or iron and contain little arsenic. It further states that the residue after treatment with aqua regia should not amount to more than 0.5 per cent. It will be the object of this paper to show, as the result of an extended and exhaustive research, that none of the statements made in the above-mentioned paragraph are based upon facts and that they are mainly incorrect. As a matter of fact, it may fairly be doubted whether any antimony sulfide used throughout the world in primer compositions at present would be found to leave a residue after treatment with aqua regia of not more than 0.5 per cent. In fact it would probably be impossible to obtain such material in large commercial quantities, even if such a specification were essential.

As a matter of fact, very good primers can be made with antimony sulfide containing up to 5 per cent residue insoluble in aqua regia. This residue, as would be expected, is mainly siliceous and the objection to its presence can only be because, just to the extent that it is present, it reduces the proportionate quantity of active sulfide of antimony. Moreover, high percentages of silica in the form of grit will wear away the charging tools which are part of the machines which are used in the manufacture of the finished primer. Certain primer mixtures are loaded dry, in which case the presence of any considerable amount of gritty silica will lead to explosions in the presses, which, though not of a very serious nature and which are always expected to occur to a certain extent, are, of course, not desirable.

For this reason it is well to select antimony sulfide with as low silica content as possible, but very excellent primers can be manufactured if properly compounded, in which the silica content of the sulfide runs from 2 per cent to 3 per cent, which is within the bounds of practical accomplishment on a large commercial scale of operation.

The statement that the antimony sulfide should be free from sulfides of lead or iron, can be shown to be a totally unnecessary specification, for this paper will set forth the results of investigations in which sulfide of lead and iron have been entirely substituted for antimony sulfide, with the results that very excellent primers have been made from these materials. It is not logical to assume that if excellent primers can be made with these sulfides, with the exclusion of antimony, small quantities of such sulfides existing as an impurity in the antimony sulfide would necessarily be deleterious. As a matter of fact, such textbook statements naturally increase the anxieties and difficulties which press upon the explosives chemist in the proper specification of constituent materials for primer mixtures. This subject will be returned to in detail in a later portion of this paper.

It should suffice, however, at this place, to point out that if authors preparing textbooks on explosives would be careful to include only such information as is based upon authoritative evidence with citations to the literature, the whole question of production of ammunition on the sudden large scale demanded by modern warfare would be made easier for all concerned in its manufacture.

Probably the most important point, and one that has been most discussed and debated with reference to the proper grade of antimony sulfide for use in primers, has reference to its degree of purity as governed by the amount of actual antimony tersulfide present, irrespective of outside impurities. By this is meant the degree of oxidation of the sulfide which has taken place in the process of liquation. It has been this point which has led to quite extreme differences of opinion among explosives chemists and on which but little evidence and data were available until the investigation set forth in this paper had been concluded.

Up to October 1917 specifications for ground antimony sulfide as used at Frankford Arsenal prescribed that the ground material shall on analysis show a percentage of antimony sulfide not lower than 98 per cent of Sb_2S_3. In the light of present knowledge, this specification was irrational and impossible. The specification was based on the percentage of antimony found and did not take into consideration the percentage of sulfur present or rather the amount of oxide or of sulfide that had been formed in the process of liquation.

Liquated Chinese antimony sulfide comes into the market under the trade names of "crude" or "needle" antimony. As the earthenware pot furnaces in which the liquating is carried out are presumably never quite air-tight, the product is to a greater or less extent oxidized and contains oxygen in the form of oxide and oxysulfide. Numerous careful analyses of the antimony, sulfur and oxygen content of various samples of "needle antimony" made at Frankford Arsenal show that this material as prepared for primer manufacture throughout the United States and Canada approximates around 80 per cent Sb_2S_3, 18 per cent Sb_2O_3, and 2 per cent aqua regia insoluble. Just how the oxide is associated with the sulfide in the needle-shaped crystals of liquated antimony sulfide must remain for the present a matter of conjecture. It is apparent that there may be several possibilities: the oxides may be present as oxysulfide or oxide either in the form of a solid solution (eutectic) or as mixed crystals. A careful microscopic research would determine this point if it were considered worth while.

In the meantime, however, it is known that if powdered "needle antimony" is boiled or washed in a ten per cent solution of tartaric acid and immediately washed with water and dried, the product will analyze with a higher percentage of antimony sulfide. Tartaric acid treatment has therefore been used as a method of analysis for determining the amount of oxide present in a given sample. As a method of analysis, however, the tartaric acid extraction is extremely crude and inaccurate, for not only is antimonious oxide in a crystalline form difficultly soluble in the acid, but also the crystalline sulfide is not entirely insoluble. Manifestly, the only correct method of determining the percentage present is by igniting the sample in a combustion tube in a stream of pure, dry hydrogen sulfide and collecting and weighing the water formed.

It is evident, however, that both the tartaric acid and the ignition in hydrogen sulfide treatments furnish a method which might be adapted to the commercial scale of operation if it were desirable or necessary to attempt to increase the percentage of actual Sb_2S_3 present. In fact, treatment with tartaric acid has already been recommended by several workers, who are interested in the manufacture and inspection of primers, as a method of washing and purifying ground "needle antimony" intended for use in the manufacture of military primers. That such a method of treatment would involve not only an additional amount of troublesome and expensive work, but also grave danger, cannot be denied.

In a program of manufacture which comprehends the production of millions of primers per day, such a treatment of the ground antimony sulfide for use in the mixtures would be a serious consideration to any manufacturer, whereas, if all of the reacting tartaric acid is not perfectly and completely washed out of the material before re-drying, a new danger is injected into an already difficult and dangerous process of manufacture. If, however, it could be proved necessary to add this additional treatment to the preparation of high-grade antimony sulfide for the purpose intended, neither the expense, time nor danger would constitute a sufficient reason for not carrying out the process.

The question is, is it necessary and to what extent? Will experimental data collected by an exhaustive investigation serve to show that better primers can be manufactured with antimony so treated than with the commercial grades of Chinese "needle antimony" which are at the present time available for the purpose?

It was with these considerations in mind that the investigation which is the subject of this paper was undertaken and the results of which investigation will now be set forth. It is obvious that such an investigation must not confine itself merely to the problems of analytical chemistry involved, but must also carry the problem into the actual manufacture of military primers and to the subsequent problem of drying, loading and proving. This can be carried out efficiently only when the chemical laboratory is working in the closest coördination and coöperation with the small arms manufacturing department and with the proof house where the actual ballistic records of different experimental lots of primers can be put to the last and final test in all types of small arms, including the 0.45 caliber pistol and revolver and the 0.30 caliber for rifles and machine guns of all types at present used in the service.

ANALYSIS

It has already been stated that it has been hitherto the common practice among most of the purveyors and consumers of antimony sulfide to specify and grade the material on the basis of purity calculated from the percentage of antimony found on chemical analysis, instead of from the percentage of sulfur.

It is now known that this practice was wrong and has led to great confusion of thought and opinion

As an instance of this, the following is quoted from the announcement of a leading dealer in ground antimony sulfide:

"Antimony sulfide (needle). Guaranteed metallic antimony minimum 70 per cent—equivalent to about 98 per cent sulfide. Lump or 150 mesh."

As a matter of fact, this particular brand, based on the sulfur content of 22.36 per cent, really contained about 80 per cent Sb_2S_3 and 18 to 19 per cent Sb_2O_3.

The chemical methods which have been used in the determination of sulfur, may be roughly divided into (1) fusion, (2) evolution, (3) wet oxidation, (4) electrolytic. The most consistent and accurate results are obtained by digestion of the finely ground sample in bromine and carbon tetrachloride with subsequent dilution, filtration and precipitation of barium sulfate. Consistent results have also been obtained with bromine and acetic acid as the oxidizing medium.

Designating these methods as "A" and "B," respectively, the following check results have been obtained in the course of this investigation. All other methods for the determination of sulfur have been rejected as leading to inconsistent results. The samples included in the table were as follows: F. A. 42 and F. A. 88, representing material purchased to a specification very similar, except as to granulation, to the dealer's grade quoted above.

It may be stated at this place that many millions of eminently satisfactory primers have been manufactured from the lot of antimony sulfide represented by these samples. There have also been manufactured many millions of primers from this same lot that were defective. In the defective ammunition, however, the granulation of the antimony sulfide was not correct and other subsidiary causes of the defects were discovered.

The sample marked C. L. was a picked sample of Chinese lump from a consignment recently imported. The sample J. S. was pure stibnite from the Ichino Kawa Mine, Iyo, Japan, where magnificent groups of brilliant crystals up to 20 inches in length of very high purity are found. The results of the analytical work are given in Table I:

TABLE I

Sample	Method A Sulfur found Per cent	Method B Sulfur found Per cent	Acid Insoluble Per cent SiO_2, etc.
F. A. 42	22.36 22.54 22.08	22.37	2.5
F. A. 88	22.53 22.50	22.69 22.75	2.5
C. L.	26.34 26.42	26.42	0.2
J. S.	28.52	28.50	None

Calculating the percentage of Sb_2S_3 present in F. A. 42 and F. A. 88 from the sulfur content found, we get 78.4 and 79.1 per cent, respectively, instead of approximately 98 per cent calculated from the antimony content.

The above-described work establishes the fact that granulated Chinese "needle antimony," such as has been in common usage for many years in munition manufacture, does not run better than approximately 80 per cent actual Sb_2S_3. The following questions immediately suggest themselves:

1—Would it be of material advantage to the end in view to use antimony sulfide of a higher degree of purity?

2—Would it be practical and worth while to attempt to treat the 80 per cent sulfide in order to increase its purity, and if so, what impurities are the ones to be considered harmful?

In order to get light on these questions, the investigation was directed to the study of treating ground samples of antimony sulfide with tartaric acid solutions of varying strength under varying conditions. After numerous experiments it was found that a 10 per cent solution of tartaric acid was as effective for the purpose in view as stronger solutions and, further, that in order to get the maximum results without producing decomposition of the antimony sulfide itself, boiling for 30 min. is required. If cold digestion is resorted to, 5 or 6 days are required to approximate the maximum extraction of oxide. On the other hand, the purest Japanese sulfide free from oxide yields 1 per cent extract on 30 mins. boiling and 4 per cent on 3 hrs. boiling in 10 per cent acid when 150-mesh samples are being used. In the same time F. A. 88 antimony sulfide yielded 16 per cent and selected Chinese lump 6 per cent extract in the 30-min. test.

The above work has shown very clearly that while treatment with tartaric acid does remove a considerable portion of oxide that is present as oxide, it does not remove oxysulfide and, moreover, it is shown that even the purest antimony sulfide is to some extent decomposed by the acid. It is, of course, obvious that while the oxide impurity is being lowered, all acid-insoluble impurities present, such as silica, are being increased. The danger of the introduction of tartrates into the final product is objectionable. The conclusion drawn by the author as the result of this part of the investigation is that tartaric acid treatment of antimony sulfide intended for use in military primers should not be permitted.

It is apparent from what has been stated that commercial liquated antimony sulfide is never a pure product containing antimony and sulfur in the proportions of Sb_2S_3, but is always contaminated with oxygen, which it absorbs while in the molten state. Munitions laboratories have heretofore generally based their specifications on purity calculated from the amount of Sb_2S_3 figured from the percentage antimony found, instead of from the percentage of sulfur. This practice is shown to be wrong. As a matter of fact, most commercial needle antimony sulfide will run from about 80 to 85 per cent actual Sb_2S_3 and from material obtained to 80 per cent specification very excellent primers can be manufactured as will be demonstrated in the succeeding pages.

The correct analyses of a number of samples of antimony sulfide in actual use by manufacturers of military primers are given in Table II:

TABLE II—ANALYSES OF ANTIMONY TERSULFIDE (NEEDLE ANTIMONY)

	Antimony Per cent	Sulfur Per cent	As as Sb_2S_3 Per cent	Insol Per cent	Oxygen Per cent	Iron Per cent	Lead Per cent	Arsenic Per cent
F. A. 88	69.6	22.6	79.1	2.8	4.6	0.06	Trace	None
F. A. 42	70.0	22.4	78.4	2.1		0.06	Trace	None
Chinese Lump	71.3	26.4	92.4	0.21		0.04	Trace	None
Manufacturer A	69.0	21.3	74.6	8.5				
Manufacturer B	70.0	23.2	81.3	2.4		...	...	...
Manufacturer C	71.3	22.0	76.9	1.2		...	...	...
Manufacturer D	70.6			1.3				
Dealer A (Treated Sb_2S_3)	71.8	24.5	75.8	1.6		...	...	...
Dealer B	70.0			2.2		...	...	...
Pure Japanese Stibnite	71.4	28.5	99.9	0.00				

The method of determining sulfur adopted by the Frankford Arsenal Laboratory as giving fairly quick and accurate results is as follows:

Treat 0.5 g. of the powdered sample in a covered No. 2 beaker or small flask with a mixture of 1 cc. H_2O, 9 cc. glacial acetic and 6 cc. liquid bromine at room temperature, let stand overnight. In the morning add 20 cc. conc. HCl and warm gently for half an hour. Remove the cover and evaporate to "soft dryness" on steam bath. Take up with 10 cc. conc. HCl and a little water. Add 2 g. of tartaric acid and dilute to 150 cc. with hot water. To the warm solution add 0.5 g. powdered aluminum, a little at a time, until the antimony is precipitated as metal. Filter at once and wash the precipitate with hot water. Allow the filtrate to cool. Dilute to about 600 cc. and precipitate $BaSO_4$ by adding 25 cc. of a 10 per cent solution of $BaCl_2$ from a burette.

The method used for the determination of antimony in needle antimony sulfide is as follows:

Weigh accurately 0.3 g. of sample and brush carefully into an 800 cc. Erlenmeyer. Add 35 cc. HCl (sp. gr. 1.19) and let stand in the cold for thirty (30) min., after which the hydrogen sulfide is expelled by heating on the water bath. Then add 20 cc. conc. HCl, 20 cc. conc. H_2SO_4 and 100 cc. water. Boil 15 to 20 min. to drive off all SO_2 and H_2S, dilute to about 600 cc. and cork up with a connection to a bottle of Na CO3 and cool under tap quickly. Titrate at once to first pink with $N/10$ $KMnO_4$ standardized against Bureau of Standards' sodium oxalate, prepared according to Sorensen, or run a blank against C. P. metallic antimony.

The method selected for the determination of lead and iron is as follows:

Weigh 5 g. of sample into a small beaker and treat with 60 cc. HNO_3 (sp. gr. 1.4). When Sb_2S_3 is completely decomposed, take down to moist dryness, add 5 cc. conc. HNO_3, dilute to 100 cc. and filter through a double filter (595 S. S.). Wash free from acid and determine lead in the filtrate by adding 10 cc. H_2SO_4 (1–1). Evaporate to dense white fumes on any suitable hot plate; cool, add water and filter the $PbSO_4$ on a prepared Gooch crucible. Wash in diluted H_2SO_4 (1–100), once in alcohol, and dry at 250° C. for one hour. Cool and weigh. $PbSO_4 \times 0.6831 = Pb$.

Transfer the lead filtrate to a 600 cc. beaker, boil off alcohol; then add 3 g. of ammonium chloride and heat the solution to boiling. Precipitate the iron with a slight excess of ammonium hydroxide. Cover and boil for 5 min. Remove the cover and let settle for 20 min., filter on a fast running paper and wash well with diluted ammonia (1–5). Wash well three times with hot water. Redissolve the iron with 15 cc. HCl (1–1), using this acid to rinse the beaker. Add 2 g. of NH_4Cl and a few drops of HNO_3. Reprecipitate the iron and filter. Wash three times in diluted ammonia, twice with hot water. Dissolve the iron off the paper with 20 cc. of H_2SO_4 (1–4) into a small Erlenmeyer. Add 1 g. of 20-mesh zinc, warm on a hot plate and when dissolved titrate with $N/30$ $KMnO_4$ to a permanent pink.

The method used for determining oxygen in needle antimony sulfide is as follows:

One gram of the finely powdered sample is weighed into a porcelain boat and heated in a glass combustion tube in a stream of pure, dry hydrogen sulfide. After all air has been displaced, the combustion tube is heated very gently at first and finally to the fusion point of the sulfide, about 550° C. Care must be taken not to allow the temperature to rise much above the melting point, as Sb_2S_3 and Sb_2O_3 volatilize at higher temperatures. The water formed in the reaction is collected in an absorption tube in the usual manner and after displacing the hydrogen sulfide with dry air, is weighed. Blanks should be run on pure stibnite to calibrate the apparatus.

The determination of aqua regia insoluble impurities in antimony sulfide is determined as follows:

Weigh 5 g. of sample into a 400 cc. beaker and treat with 200 cc. aqua regia (1 part HNO_3, 3 parts HCl). Keep on hot plate for one half hour to complete solution and expulsion of all H_2S. Filter on well packed asbestos Gooch. Wash free from acid and once with alcohol. Dry at 250° C. and finally ignite to volatilize any separated sulfur. Cool, weigh and report as insoluble in aqua regia.

BALLISTIC TESTS

The quality and ballistic accuracy of small arms ammunition depends upon a number of factors. If it be assumed that the powder, cases and bullets are O. K. in a given lot, erratic ballistic results are invariably ascribed to the primers. The primer is unquestionably the heart of the cartridge and is dependent on to initiate the functioning of each and every shot. In its turn the functioning of the primer *per se* involves a number of factors, each one of which in an ideal primer (if such a thing indeed existed) must not only be right in itself, but must coördinate with all the others in just the right way. Small arms primers are made of an intimate mixture of reacting chemicals, which mixture is then machine pressed into small brass or gilding metal cups foiled with a paper disc, a small brass anvil inserted and the primers dried, after which they are ready for the loading operations.

The chemical mixture or composition varies widely in the different formulas developed by the separate munition manufacturers and governments. It is not the intention of this paper to enter into a discussion of the comparative defects or merits of different well-known primer mixtures, many of which have been patented. It may be stated briefly, however, that primer compositions divide roughly into two types—detonating and burning. In the detonating type mercury fulminate, lead azide or some similar substance which can easily be detonated by a percussive blow is made the base of the composition. In the burning type we have to consider more or less well-balanced mixtures of fuel and oxygen-carrying constituents. For the oxygen carriers the main dependence is potassium chlorate with sometimes an additional small quantity of barium or some other nitrate. The fuels selected are usually sulfur or some sulfide or sulfo salt with or without the addition of carbon or carbonaceous material.

The one striking thing about primer composition in general throughout the world is that they almost invariably contain some proportion of antimony sulfide regardless of whether they are representative of the detonating or burning type. The author is familiar with only one modern primer composition which was made up without antimony sulfide, but this has not been a success and it is understood that the manufacturers have recently modified it by an addition of antimony sulfide to the formula.

Since antimony sulfide is so generally admitted to be a necessary ingredient of good primer compositions, the question at once suggests itself as to just what rôle it plays in the functioning? On this subject there has been much difference of opinion on the part of various authorities. It must be very generally conceded that in order to burn the powder properly, a primer should function at the instant it receives the percussive blow of the firing pin without showing delay action leading to "hangfires." In particular, it should also show a high heat of combustion, a good depth of penetration, not too violent explosion and large gas production of such a nature as to produce a long flash of flame. Above all, it must possess

properties which will prevent its deterioration in storage and in service and must be of a sufficient but not too high sensitiveness.

Now it is possible that the presence of antimony sulfide affects all of these desired qualities, although not all to the same degree. There are in addition to the above, three other possible functions of antimony sulfide in primer compositions.

1—The hard, smooth grain of the needle crystals may act the part of a friction agent similar to that produced in certain primer compositions by the introduction of powdered glass.

2—The needle grains may hold apart or insulate the more reactive chemical agents in the mixture and thereby control sensitiveness and reduce tendency to deterioration.

3—The needle antimony may act in part or as a whole as a contact or catalytic agent and modify the explosive reactions.

It may be admitted that for one or all of these reasons antimony sulfide or its equivalent is a necessary constituent of all primer mixtures. Since it is known that the present source of supply of needle antimony is from China and Japan and since it is not without the bounds of possibility that at some time or other importations might be interfered with, it is important to determine whether antimony sulfide of a grade of purity which could be produced in this country would be equally as effective as the imported material and also whether other domestic mineral sulfides which occur in sufficient abundance could be substituted in an emergency.

The answers to these questions can be obtained only by making up lots of experimental primers, loading them into ammunition and making the usual ballistic tests for muzzle velocities, barrel pressures, sensitiveness and freedom from misfires and hangfires.

It is not necessary in this paper to discuss in detail all the required ballistic specifications that finished small arms ammunition has to meet. but the following requirements are quoted from *Ordnance Pamphlet* No. 544:

"On inspection and tests of finished cartridges, the standard velocity at 78 feet is 2640 foot seconds. The mean velocity must not vary from these standards by more than 30 f. s (2610 f. s. - 2670 f. s.) in the model of 1903 rifle. The mean variation in velocity must not exceed 20 f. s. in the model of 1903 rifle.

"The maximum pressure must not exceed 52,000 lbs. per square inch in the model of 1903 rifle."

It will be seen from the above that if the powder cases and bullets are quite right, the primer must burn the standard charge of powder in such a manner as to produce a muzzle velocity of about 2640 ft. seconds at a pressure not to exceed 52,000 lbs. per sq. in. If a primer is weak from any cause, pressure and velocity will run low. A good primer will tend toward maximum velocities with minimum pressures. If pressures run high for normal velocity, discussion is in order to determine whether the powder or the primer is at fault. It is apparent, therefore, that a primer can be too strong and that the narrow limits of satisfactory functioning present the most perplexing problems to the primer manufacturer.

One method by which the manufacturer seeks to gain information and control of his production is by means of the drop test by which samples usually about one-half per cent of output are shot. All misfires must be accounted for or the lot of primers represented by the sample rejected and destroyed. Perhaps the greatest value of the drop test lies in the fact that in expert hands it can be used to measure the comparative sensitiveness of different lots and types of primers and it serves to keep the character of the functioning continually under observation. When improperly used and interpreted there is no test more confusing or misleading. Unfortunately, the type and arrangement of drop testing machines has not been standardized. Each manufacturer pursues his own method of testing and there are many conflicting opinions in regard to specifications for sensitiveness.

The object of this paper is to set forth the results of tests made to determine to what extent the degree of purity of the antimony sulfide used in the primer composition effects the sensitiveness of the finished primers. All other variables such as the granulation, or grain size of the antimony, were kept constant and based on the standard practice used by the author at Frankford Arsenal in the manufacture of the service F. A. 88 primer. The sensitiveness test selected for this investigation was the minimum height of fall of a 3-oz. weight with firing pin attached that would just begin to show misfires. The primers under test were inserted with all necessary precaution in a steel die. The regular F. A. 88 primer was made the standard for comparison. The composition of the F. A. 88 primer will not be given in this paper, but it may be stated that it is of the non-fulminate or burning type and that it is made so as to contain 17 per cent of specially grained needle antimony sulfide. The analysis of the needle antimony has already been given in Table II and it will be noted that it is not by any means pure, but contains about 18 per cent of oxide.

The fact that F. A. 88 is a highly efficient and satisfactory primer under service conditions, proves conclusively that needle antimony containing about 80 per cent actual Sb_2S_3 is sufficiently pure for primer manufacture.

The first question that naturally arose was: What results would be obtained if the F. A. 88 primer was made up using pure stibnite in the place of crude needle antimony? Through the coöperation of the National Museum, a sample of pure crystalline antimony sulfide (stibnite) was made available. The results of the sensitiveness test were as follows:

TABLE III

F. A. 88 regular 3-oz. weight	F. A. 88 with pure stibnite 3-oz. weight
100 O. K. at 19.5 in.	100 O. K. at 19.5 in.
100 O. K. at 19.0 in.	100 O. K. at 19.0 in.
97 O. K. 3 misfires at 18.5 in	100 O. K. at 18.5 in.
	96 O. K. 4 misfires at 18.0 in.

The above results show that pure stibnite increased the sensitiveness about 1/2 in. for the 3-oz. weight. Carefully calibrated indentation tests have shown that a weak-spring gun with 14-lb. pull corresponds to a 22-in. drop, so it is shown that the slight increase

in sensitiveness gained by the use of pure stibnite would not justify the expense of obtaining it on a commercial scale.

FIRST EXPERIMENT—The ballistic proofing of finished ammunition is the best test of the primer, and therefore experimental lots of hand-loaded ammunition were made up and fired for pressure and velocity in the usual way. The results of the competitive firings between F. A. 88 (regular) and F. A. 88 (pure stibnite) are as follows:

TABLE IV

	F. A. 88 (Regular) Powder charge in each shot 48.8 grains		F. A. 88 (Pure Stibnite)		
Shot No.	Velocity Ft.-Secs.	Pressure Lbs.	Shot No.	Velocity Ft.-Secs	Pressure Lbs
1	2649	50150	1	2646	48700
2	2660	44850	2	2649	48200
3	2681	49850	3	2646	47750
4	2656	46750	4	2649	48450
5	2646	46350	5	2672	48900
6	2665	46800	6	2651	46650
7	2646	48400	7	2655	46150
8	2656	45750	8	2656	47700
9	2646	46800	9	2632	46650
10	2644	46250	10	2635	47150
Mean	2655	47155		2649	47330

Powder, primers, bullets, cases, O. K.

An examination of the above table will convince anyone familiar with the ballistics of small arms ammunition that as far as these firings were concerned, there is nothing to choose as between the primers made with needle antimony sulfide of about 80 per cent purity (Sb_2S_3) and those made with stibnite 100 per cent purity (Sb_2S_3).

SECOND EXPERIMENT—Starting with pure 100 per cent stibnite, it was decided to try the effect of the deliberate addition of 18 per cent of soft powdered yellow antimonous oxide thoroughly mixed with the granulated stibnite. It was further decided to make up another lot with the needle antimony sulfide which had been purified with tartaric as described in a previous paragraph. The results of the ballistic tests are given in Table V and are comparable with those given in Table IV.

TABLE V

	F. A. 88—With pure antimony sulfide plus 18 per cent Sb_2O_3 Standard powder charge 48.8 grains		F. A. 88—With antimony sulfide treated with tartaric acid		
Shot No.	Velocity Ft.-Secs.	Pressure Lbs.	Shot No.	Velocity Ft.-Secs	Pressure Lbs.
1	2722	49350	1	2720	46500
2	2714	49850	2	2723	48200
3	2701	46950	3	2694	46400
4	2698	48650	4	2697	47900
5	2689	46050	5	2716	49450
6	2694	48500	6	2626	48500
7	2664	47050	7	2702	47150
8	2709	47900	8	2700	47900
9	2667	47300	9	2697	47050
10	2694	47550	10	2694	47100
Mean	2698	47865		2697	47615

Powder, primers, bullets, cases, O. K.

When we compare the above results with each other and with the results given in Table IV, there is little to choose between them. All four series are ballistically satisfactory. On the drop test, all primers shot O. K. at 21 in. It is very clearly indicated that the presence of 18 per cent of antimonous oxide, whether it occurs as a natural impurity or as a deliberate introduction with pure antimony sulfide, need not be a source of anxiety in the manufacture of military primers when a good mixture is being used.

THIRD EXPERIMENT—It will be remembered that in an earlier paragraph of this report a statement was quoted from Marshall's book on explosives[1] to the effect that sulfides of lead and iron were objectionable in cap primer compositions. The statement was not qualified as relating to the fulminate type exclusively, and it was felt that a mere statement unsupported by data was unconvincing. The easiest way to get at the desired information seemed to be to make up lots of F. A. 88 primers in which the antimony sulfide was entirely replaced in one lot by crystalline lead sulfide (galena) and in another by crystalline iron sulfide (pyrite). Fairly pure samples of these two minerals were obtained, granulated and sieved to the standard grain of the antimony sulfide ordinarily used in the F. A. 88 primer.

The results obtained were somewhat surprising as the author had thought that the primers would prove themselves to be defective and show tendencies to being either too sensitive or not sensitive enough. Why antimony sulfide was originally selected by explosives chemists as the only possible sulfide for use in primer compositions and why the impression prevails that the antimony sulfide used must be of very high purity is not explained by the results of this investigation.

TABLE VI

	F. A. 88—Made with lead sulfide (galena) instead of antimony sulfide Standard powder charge 48.8 grains		F. A. 88—Made with iron sulfide (pyrite) instead of antimony sulfide		
Shot No.	Velocity Ft.-Secs.	Pressure Lbs	Shot No.	Velocity Ft.-Secs	Pressure Lbs.
1	2697	46150	1	2696	49050
2	2700	46900	2	2689	46750
3	2713	48200	3	2725	48350
4	2715	49200	4	2692	46550
5	2688	47400	5	2708	49450
6	2723	47500	6	2703	48050
7	2715	50050	7	2720	48600
8	2692	46650	8	2703	46250
9	2697	46650	9	2694	48700
10	2700	46750	10	2708	46650
Mean	2704	47845		2704	47840

Powder, primers, bullets, cases, O. K.

The drop test sensitiveness of the foregoing lots of primers was satisfactory for the lead sulfide at 21 in. The iron sulfide was a trifle more insensitive at 22½ in., whereas 22 in. is the calibration factor corresponding to the 14-lb. weak-spring gun. As far as shooting quality is concerned, the iron sulfide and lead sulfide primers showed up in these tests slightly superior to the regular F. A. 88 primer. Retests were made in nearly all series of shots given in the above tables, but as essential checks were obtained in all cases, for the sake of brevity, only the first ten shots fired in each series have been tabulated.

In making up all experimental lots, the greatest care was taken in regard to the granulation of the antimony sulfide and its substitutes. It is well known that the sensitiveness and stability of primer mixtures is affected by the grain of the antimony which should not be too coarse or too fine. In all the above described work equal quantities of three sieve sizes were used. The ground material was passed through sieves so as to divide in 100- to 150-mesh, 150- to 200-mesh, and through the 200-mesh. Equal quantities of each size were then weighed and the whole very intimately mixed. These precautions of even graining should always be carefully followed in carrying on

[1] *Loc. cit.*

comparative tests on primer mixtures of varying compositions.

SUMMARY

This paper has set forth some of the results obtained in the course of a long and exhaustive research on a large number of primer compositions and forms of finished primers. Much of this work is of too confidential a nature at the present time to justify publication, but it is believed that the data as given here will be of benefit to many workers in this field without disclosing information that would be harmful.

For some time past there has been some anxiety felt in regard to adequate supplies of very pure antimony sulfide. This paper should, it seems, serve in some measure to allay this fear.

CONCLUSIONS

I—The purity of liquated "needle antimony" should be determined from the sulfur content. The method of basing purity on the antimony content is shown to be incorrect.

II—The method of purification of "needle" antimony which depends on treatment with tartaric acid is shown to be unjustifiable, if not actually dangerous.

III—The methods for the complete analysis of antimony sulfide are set forth.

IV—"Needle" antimony sulfide of an approximately 80 per cent purity, containing about 18 per cent of oxide, is shown to be as efficient for the manufacture of primers as approximately 100 per cent stibnite.

V—Sulfides of lead and iron are shown to work satisfactorily when substituted for antimony in a non-fulminate primer.

VI—It is indicated from V that the presence of sulfides of lead and iron existing as impurities in antimony sulfide would not be harmful, textbook statements to the contrary notwithstanding.

VII—The conclusion is drawn that in case of deficient supplies of overseas antimony sulfide, domestic ores would serve every purpose and that other more abundant minerals might be substituted. Further investigation as to stability of primers made with other mineral substitutes for antimony sulfide would be desirable before attempting their use on a large scale.

VIII—The fact that primers made with lead sulfide (galena) and iron sulfide (pyrite) showed a higher velocity for a normal pressure than those obtained with regular antimony sulfide, is interesting and suggestive but by no means conclusive as a much more extensive experimental program would have to be carried out before any definite conclusion could be reached.

In concluding this paper the author desires to express his great appreciation of the interested and able assistance which he obtained in carrying out the experimental part of this work from Mr. J. K. Miller and Mr. Sydney N. Greenburg, Explosives Chemists, employed at Frankford Arsenal.

PHILADELPHIA, PA.

ADDRESSES

FOOD CHEMISTRY IN THE SERVICE OF HUMAN NUTRITION[1]

By H. C. SHERMAN

Received March 26, 1918

At the suggestion of your President I propose to speak this evening of the application of food chemistry to problems of human nutrition with special reference to the economic aspects of our present food situation, *i. e.*, to consider how in the light of our present knowledge we can best combine adequacy of nutrition with economic use of food—remembering, too, that economic in this connection and at this time should mean not only the wisest expenditure of money for food from the standpoint of the consumer, but also such conservation of the food resources of the entire country as shall enable us to furnish our Allies and our armies abroad with the largest possible share of those foods which are adapted to their needs and suitable for exportation.

Briefly and somewhat crudely, the material requisites of an adequate diet may be summarized under five heads. It must (1) provide sufficient amounts of digestible organic nutrients to yield the necessary number of Calories of energy; (2) furnish proteins in ample amount and of suitable sorts; (3) supply adequate amounts and proper proportions of the ash constituents, salts or inorganic foodstuffs; (4) furnish enough of those as yet unidentified substances, the food hormones or so-called vitamines; (5) it must include a sufficient amount of material of such physical character as to ensure the proper handling of the food mass and its residue in the digestive tract.

Since we are here to deal with the chemical rather than physical aspects, discussion may be limited to the first four of these requisites. Logically each of these four categories calls for subdivision.

[1] Lecture delivered before the Harvey Society, Academy of Medicine, New York City, January 12, 1918.

As sources of energy the carbohydrates, fats, and proteins function interchangeably to a very large but not to an unlimited extent. If our understanding of the relation of the energy value of food to the energy requirement of the body is to be complete we must study the intermediary metabolism of each of the organic foodstuffs and its relation to the energy exchange, including the problem of its specific dynamic action.

Similarly the problem of protein requirement divides itself into a group of problems having to do with the requirements of the body for each of 15 or 16 amino acids which constitute the building stones of the body tissues, and which are less widely interchangeable than are the energy values of the different foodstuffs.

The ash or mineral matter comprises at least 10 chemical elements not contained in simple proteins, fats, and carbohydrates and which are not only not interchangeable but are in some cases actually antagonistic in function. Under ordinary conditions and with our usual ample use of table salt the only mineral elements requiring special consideration from the standpoint of adequacy of nutrition are phosphorus, calcium, and iron.

The vitamine or hormone value of foods is due to at least two substances distinguished by McCollum as the Fat Soluble A and the Water-Soluble B.

It cannot be denied that the rapid progress of our knowledge of nutrition during the past few years has tended to complicate rather than simplify our conceptions of food values and nutritive requirements. But while the problem has become more complex it also has become clearer because we now for the first time have good reason to believe that all of the substances needed for normal nutrition have been recognized and can be reckoned with even

though the chemical identification is in some cases not yet complete.

It is most fortunate that the recent progress of research in nutrition, so largely the work of our own countrymen, has brought us to this stage in our knowledge of nutritive requirements in time for us to apply it to the problem (now for the first time really urgent in this country) of making a more economical use of our national food resources.

The efficiency with which economy in the use of food and conservation of the food supply can be combined with entire adequacy of nutrition is chiefly dependent upon the extent to which we can state the various essentials of an adequate diet in quantitative terms.

THE QUANTITATIVE STUDY OF THE ENERGY REQUIREMENT has been so recently summarized and so fully discussed before this Society by the very men to whom we are chiefly indebted for its progress in recent years[1,2,3*] that to review the subject here would involve unnecessary repetition. Suffice it to say that all authorities are now in substantial agreement as to the principles of the energy metabolism and the fundamental facts as to the energy requirement of the body—particularly of the normal adult. So well do different investigators agree in their estimates of the basal metabolism of normal men, that it seems safe not only to accept their average results as expressing the basal energy requirement with a satisfactory approach to exactness, but also to tabulate together the measurements made in different laboratories upon the energy output under various conditions of work and rest so as to furnish a table of "hourly factors" from which the day's energy metabolism and therefore the day's food requirement so far as it is measured in terms of energy may be computed. Reduced to a common basis of 70 kilograms (154 pounds) of body weight and averaged in round numbers, the data thus compiled are as follows:

TABLE I—HOURLY EXPENDITURE OF ENERGY BY AVERAGE SIZED MAN [70 KILOGRAMS (154 POUNDS) WITHOUT CLOTHING] UNDER DIFFERENT CONDITIONS OF ACTIVITY (APPROXIMATE AVERAGES ONLY)

	Calories
Sleeping	60–70
Awake, lying still	70–85
Sitting at rest	100
Standing at rest	115
Tailoring	135
Typewriting rapidly	140
Bookbinding	170
"Light exercise" (bicycle ergometer)	170
Shoemaking	180
Walking slowly (about 2½ mi. per hr.)	200
Carpentry	240
Metal working	240
Industrial painting	240
"Active exercise" (bicycle ergometer)	290
Walking actively (about 3½ mi. per hr.)	300
Stoneworking	400
"Severe exercise" (bicycle ergometer)	450
Sawing wood	480
Running (about 5 mi. per hr.)	500
"Very severe exercise" (bicycle ergometer)	600

For a healthy man or woman of normal physique the energy requirement for 24 hours can be calculated from the number of hours spent in each degree of muscular activity, using the hourly rates of energy expenditure indicated in the table and reducing or increasing the total according as the body weight is less or more than 70 kilograms.

If the degree or intensity of muscular activity is consistently interpreted, the results thus calculated will be found entirely consistent with the generally accepted estimates of the food requirements of people of differing occupations.

The available data on the energy requirements of growing children vary over a somewhat wider range so that average figures are more difficult to give and less accurate to use. Du Bois has constructed a curve of basal metabolism per square meter of body surface at different ages, but the condition predicated for the measurement of basal metabolism—complete quiescence on an empty stomach—is so remote from the usual status of a healthy growing child, that it is necessary to make large assumptions in arguing from the rate of the basal metabolism to the total requirement for a day of normal activity. Estimates of the energy requirements of healthy children must therefore allow for considerable individual variations. It is necessary in making food allowances for individual children to exercise much judgment as to the activity of the child and also as to whether he is maintaining not only a normal rate of growth in weight but also a desirable ratio of height and weight, in other words a desirable degree of fatness.

TABLE II—FOOD ALLOWANCES FOR HEALTHY CHILDREN[4]

AGE	CALORIES PER DAY	
Years	Boys	Girls
Under 2	900–1200	900–1200
2–3	1000–1300	980–1280
3–4	1100–1400	1060–1360
4–5	1200–1500	1140–1440
5–6	1300–1600	1220–1520
6–7	1400–1700	1300–1600
7–8	1500–1800	1380–1680
8–9	1600–1900	1460–1760
9–10	1700–2000	1550–1850
10–11	1900–2200	1650–1950
11–12	2100–2400	1750–2050
12–13	2300–2700	1850–2150
13–14	2500–2900	1950–2250
14–15	2600–3100	2050–2350
15–16	2700–3300	2150–2450
16–17	2700–3400	2250–2550

Indeed the maintenance of an optimum degree of fatness (which as Symonds has shown is very near the average of healthy Americans) is usually the best evidence that the energy value of the diet is well adjusted to the needs of the individual. "Counting the Calories" in the food eaten is not necessary as a means of establishing the adequacy of the customary food intake if this is already established by the obvious condition of nutrition of the individual concerned—but if there be any question of *prescribing* the food—of rationing either an individual or a community—then adequate energy value of the ration is the first thing which should be considered, for only when the energy supply is adequate can the "tissue building" constituents of the body and of the food be conserved to the best advantage.

THE PROTEIN REQUIREMENT has not been so accurately and conclusively measured as has the energy requirement. Chittenden's well-known investigation of over a decade ago[5] remains the largest single contribution to this subject and the criticisms evoked at the time by his advocacy of a standard for protein consumption only a little higher than the rate of catabolism shown by his observations—corresponding to 44 to 53 g. of protein per man of 70 kg. per day—are perhaps as suggestive as any which have been offered. Notable among these criticisms were Meltzer's argument[6] that the usual high rate of protein consumption constitutes an important factor of safety which it would be a mistake to forego by reducing the protein content of the ration to a figure near the minimum requirement, and Benedict's criticism[7] of the low protein diets as likely to be accompanied by a less complete digestive utilization of the non-protein food. In connection with the latter point it is interesting to note that Mills[8] found a better utilization of subcutaneously injected fat when the experimental animals (cats) were fed a high protein diet than when they were fed on low protein or fasted. Mills suggested that this might be because the high protein diet furnished more lipase in the body, and Falk and Siguira[9] found that their castor bean lipase preparations were composed essentially of protein material, as had already been shown in the case of purified preparations of pancreatic and malt amylases.[10,11]

Since the criteria of purity ordinarily used in chemical research are not applicable to unstable colloidal substances like the digestive enzymes, it is easy to say that such enzyme preparations

* Numbers refer to corresponding numbers in "Bibliography," p. 390.

may be far from pure. It has been suggested that the protein matter of which these enzyme preparations chiefly consist may be only an impurity or a "carrier," while the "real enzyme" is something of wholly unknown chemical nature. There is, however, no positive evidence in support of this latter suggestion. On the other hand, there is much evidence which, while not conclusive, is direct and positive in character, tending to show that the common hydrolytic enzymes, such as those concerned in the utilization of foodstuffs, either are proteins or contain protein matter as an essential constituent. Probably therefore the food protein must furnish material for body enzymes as well as for body tissues.

TABLE III—FORMS OF NITROGEN IN PROTEIN MATERIALS AND ENZYME PREPARATIONS

(Expressed in Percentage of the Total Nitrogen in the Material)

Forms of Nitrogen	Case-in(*a*)	Edes-tin(*a*)	Hemo-glo-bin(*a*)	Hair(*a*)	Pan-creatic Amyl-ase(*a*)	Malt Amyl-ase(*b*)	Castor Bean Li-pase(*c*)
Arginine N.....	7.4	27.0	7.7	15.3	14.6	14.2	24.7
Histidine N.....	6.2	5.8	12.7	3.5	6.0	5.4	6.2
Lysine N.....	10.3	3.9	10 9	5.4	7.4	5.5	4.3
Cystine N.....	0.2	1.5	?	6.6	2.5	4.9	3.1
Amino N of Filtrate	55.8	47.5	57.0	47.5	50.4	52.4	49.4
Non-Amino N of Filtrate.....	7.1	1.7	2.9	3.1	4 6	4.5	.
Ammonia N.....	10.3	10.0	5.2	10.0	8.1	7.9	12.1
Melanine N.....	1.3	2.0	3.6	7.4	5.3	5.6	3.3

(*a*) Van Slyke (1910).
(*b*) Sherman and Gettler (1913).
(*c*) Falk and Siguira (1915).

Both this consideration and the more familiar one that individual amino acids furnished by the food proteins may serve as precursors of body hormones,[12,13] naturally tend toward caution in the acceptance of a low protein standard, especially since the proteins have been shown to vary widely in their amino acid make-up and in their nutritive value when fed singly, especially in experiments upon growing animals.[14,15]

These differences in nutritive value among proteins, especially as correlated with chemical structure by Osborne and Mendel, are of the greatest importance, but we should be careful not to mistake them as justifying a reactionary attitude or even a needless degree of timidity in accepting and applying the results of experiments upon the amount of protein required for normal human nutrition. Rather they furnish us the information necessary to enable us to plan economical use of protein wisely and with confidence.

The best guide to the amount of protein actually needed in the food of the adult is to be found in the rate of nitrogen output when the intake is restricted to an amount barely sufficient or not quite sufficient to maintain equilibrium.

The nitrogen output on a diet markedly deficient in protein and involving a large loss of body nitrogen may be less than the nitrogen requirement since a large nitrogen loss from the body might not be convertible to equilibrium by the addition of an equal amount of food nitrogen to the intake; but where there is nitrogen equilibrium on a low protein diet it seems safe to conclude that such diet is meeting all the demands of the normal nutrition as far as protein is concerned. Also when the nitrogen output is only very slightly greater than the intake it seems permissible to regard the output as approximating the actual requirement. It might perhaps be argued that even a small loss of nitrogen from the body might, if long continued, be serious, possibly on the ground that the extra nitrogen of the output over that of the intake may conceivably represent the catabolism of some particular important amino acid which the food does not supply in sufficient amount and whose continued loss would be detrimental. The experimental evidence, however, does not seem to support such a pessimistic view. In experiments, for example, in which gelatin is the sole protein we do not find a merely small loss of body nitrogen which might be mistaken for approximate equilibrium, but a loss large enough to indicate plainly that the food protein in such a case is inadequate. Similarly in the well-known experiments of Osborne and Mendel in which rations containing a single protein are fed to experimental animals, the feeding of zein rations results in prompt and considerable losses of body nitrogen and body weight.

It is therefore very unlikely that a diet which maintains approximate nitrogen equilibrium is so deficient either in the kind or amount of protein which it contains as to make it a source of danger even if long continued. On the contrary, a small negative balance usually means simply that the body has not yet completed the adjustment of the rate of output to the rate of intake. In most such cases it is altogether probable that the continuance of the low protein diet would soon lead to nitrogen equilibrium and that in taking the output as a measure of the requirement we are quite on the side of safety and are probably overestimating the real protein requirement.

We have therefore thought it worth while to bring together the data of all experiments of which we found record in which the dietary conditions and the nitrogen balance were such as to indicate that the output of nitrogen might be reasonably construed as approximating the actual nutritive requirement. In order to minimize the personal equation in interpretation, we have uniformly excluded all experiments showing a loss of nitrogen greater than 1 gram per day. There remained 86 experiments upon adults showing no abnormality of digestion or health, in which the diet was sufficiently well adjusted to the probable requirement and the nitrogen balance showed sufficient approach to equilibrium to make it appear that the total output of nitrogen might be taken as an indication of the protein requirement. These experiments are taken from 20 independent investigations in which 41 different individuals (37 men and 4 women) served as subjects. For purposes of comparison the daily output of total nitrogen in each experiment was calculated to protein and this to a basis of 70 kg. of body weight. Reckoned in this way, the apparent protein requirement as indicated by the data of individual experiments ranged between the extremes of 20.0 and 79.2 g., averaging 49.2 g. of protein per man of 70 kg. per day. Thus the average falls well within the range of Chittenden's estimate of the amount of protein required for normal nutrition when the energy value of the diet is adequate.

Examination of the data recorded in the original papers indicates that the wide differences in amounts of protein catabolized in the different experiments cannot in these cases be attributed primarily to the kind of protein consumed nor to the use of diets of fuel values widely different from the energy requirements. Apparently the most influential factor was the extent to which the subject had become accustomed to a low protein diet.

In view of the fact that individual proteins when fed singly, especially to growing animals, have shown striking differences in nutritive efficiency, it may seem strange that in the experiments hitherto made to determine the protein requirement of man, the kind of protein fed has not had more influence upon the amount required. There is, however, no real discrepancy between the two sets of findings. Experiments like those of Osborne and Mendel, for example, were for the object of comparing individual proteins isolated even from the other proteins which always accompany them in natural or commercial food materials, and were conducted largely upon rapidly growing young animals in which there is an active synthesis and retention of protein so that a deficiency in the supply of any amino acid which is required in the construction of body protein is apt to be quickly and plainly reflected in a diminution or cessation of growth. On the other hand in experiments, the purpose of which is not to compare proteins but to measure the normal protein requirement, the diet is naturally made up, not of isolated proteins or even of single or unusual foods, but (ordinarily at least) of such combinations of staple foods as are believed to represent a normal diet, so that even a relatively simple ration arranged for the purpose of such an experiment would probably contain a number of dif-

ferent proteins, among which any peculiarities of amino acid make-up would be apt to offset each other, at least to a considerable extent. Moreover, the experiments of the group now under discussion have been made entirely upon adults whose protein requirement was limited to that of maintenance. In such cases there is no longer a demand for amino acids to be built into new tissue but only to maintain the equilibrium which already exists between amino acids and proteins in the full grown tissues. Any of the amino acids whose radicles are contained in tissue proteins may be expected to contribute something to the maintenance of such an equilibrium whereas there can be no growth unless *all* the necessary amino acids are present. In the protein metabolism of growing children or nursing mothers the influence of food selection would probably be much more pronounced—and even in the case of adult men protein requirement will probably be found to be considerably influenced by food selection when experiments suitably planned to test the question are carried out. The inadequacy of gelatine as a sole protein food and its inferiority to meat or milk protein when substituted beyond a certain proportion is well known. A series of experiments, designed to demonstrate differences in nutritive efficiency for man of the protein supplied by different staple articles of food, was carried out by Karl Thomas[16] in Rubner's laboratory and the striking results reported have been widely quoted, often on Rubner's authority. These results, however, have as yet failed of confirmation, and on some important points have been so directly refuted by later workers using longer experimental periods, as to make it appear that Thomas' plan of experimenting and mode of interpretation were not entirely suited to the solution of the question at issue.

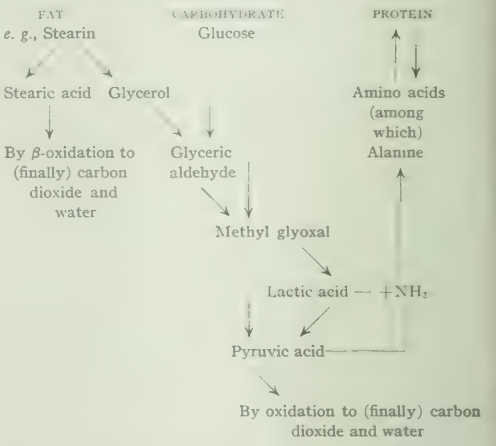
Thomas thought he had demonstrated that meat protein was greatly superior to bread or potato protein for the maintenance of body tissue; but Hindhede[17] finds no such difference, being able to maintain normal nutrition with either bread or potato nitrogen in relatively small amounts.

Rose and Cooper[18] have also demonstrated the high value of potato nitrogen in the maintenance of nitrogen equilibrium, and a few experiments in the writer's laboratory[19] have tended to confirm Hindhede's finding that nitrogen equilibrium may be maintained on a relatively low intake of protein in the form of bread. Of at least equal practical importance are those experiments[20] which show the maintenance of nitrogen equilibrium over a long period on low protein diet in which bread was the chief source of protein but was supplemented by small amounts of milk.

At a time when compulsory rationing is being seriously discussed and when we know that in any case economic conditions are forcing the majority of people to an increased use of the less expensive foods which may mean that a larger proportion of the protein consumed is not of the kinds having highest nutritive efficiency, it becomes important to consider somewhat more closely the question of the utility of the so-called incomplete proteins in nutrition, and the protein-sparing action of the fats and carbohydrates which may operate to conserve the protein supply by diminishing protein catabolism. In order to do this we should, I think, recognize that protein metabolism is not an affair of two distinct and separate processes—anabolism and catabolism—but is rather to be conceived as involving a series of reversible reactions or of approximate equilibria in the body. The tissues always contain protein and amino acids which in a grown man are constantly in approximate equilibrium, represented by

$$\text{Amino acids} \rightleftarrows \text{Protein}$$

The supply of amino acids in the tissues is constantly being augmented by the digestive products brought by the blood, and at the same time is constantly being depleted by deaminization. If amino acids are brought to the cell more rapidly than they are removed or deaminized, the concentration of amino acids is increased and this must tend to push the above reaction toward the right, *i. e.*, to check the rate of protein catabolism or to conserve the protein of body tissue, and vice versa. Similarly the intake of ammonia salts under proper conditions may check the deaminization of amino acids and thus indirectly take part in the maintenance of nitrogen equilibrium. But ammonia may also contribute to the actual formation of amino acids in the body as shown by Embden and Knoop and by Dakin and this probably furnishes us the best explanation now available of the protein-sparing action of carbohydrates and fats as illustrated in the accompanying diagram.



Since pyruvic acid appears to be regularly formed in the metabolism of carbohydrate and of the glyceryl radicle of fats, and ammonia is always being formed in protein catabolism (by deaminization of amino acids), and since the ammonium salts of α-ketonic acids, such as pyruvic acid, are convertible into amino acids which are building materials for body protein, we have here a mechanism by which an intermediary product of carbohydrate metabolism (pyruvic acid) takes up a "waste product" of protein metabolism (ammonia) and turns it back into protein material again. Thus carbohydrate, in undergoing metabolism, "spares" protein, not only by serving as fuel so that protein need not be drawn upon for this purpose, but also by furnishing material which in combination with ammonia (otherwise a waste product) can actually be converted in the body into some of the amino acids of which the body proteins are composed and with which they are in equilibrium. This explains how an increased intake of carbohydrate, with resulting increase of pyruvic acid, naturally leads to increased synthesis of amino acids and thus to a tendency toward protein storage, or, to express the same thing in somewhat different terms, tends to push the reaction, Amino acids $\rightleftarrows$ Protein, toward the right.

According to present theory, most, if not all, of the energy of the carbohydrate becomes available through oxidation processes which involve the intermediate production of pyruvic acid, an α-ketonic acid whose ammonium salt is capable of conversion into amino acid. Of the fat only the glyceryl radicle (about one-twentieth of the fuel value is oxidized through pyruvic acid, while the fatty acid radicles, representing about nineteen-twentieths of the energy of the fat, are metabolized through β-oxidation processes which yield, so far as we know, no product whose ammonium salt is convertible into amino acid in the body. Hence, complete withdrawal of carbohydrate, even though substituted by sufficient fat to yield an equal number of calories, must be expected to result in increased excretion of nitrogen.

Under war conditions, while we may have to economize in the use of sugar, there will probably be at least an equivalent pres-

sure for economy in the use of fat so that the energy requirement will tend to be met largely by the use of starchy foods, such as potatoes, cornmeal, and oatmeal. Hence there should be at least as high a proportion of carbohydrate in the war diet as in that of peace and the full protein-sparing effect should be realized.

Now that we have a chemical explanation of the protein-sparing action of carbohydrates and fats which is based on reactions which have been definitely demonstrated to take place in the organism, we see that only a few of the simplest amino acids can be conceived as synthesized by this mechanism and yet we know from the results of many feeding experiments that the "sparing action" of carbohydrates and fats is a large factor in conserving the protein of the body or of the intake. In harmony with this we find that "incomplete" proteins, furnishing some but not all of the amino acids of which body proteins are composed, may still play a very important part in the protein metabolism of maintenance.

McCollum in 1911[21] called attention to the rather surprising nutritive efficiency of zein in cases in which only maintenance was involved, and offered the suggestion that "repair" processes may not involve the disruption and reconstruction of entire protein molecules. The same idea may be expressed from a slightly different point of view by saying that having in the cell under conditions of maintenance an equilibrium, Amino acids $\rightleftarrows$ Protein, between protein and a whole group of amino acids, the catabolism of protein will be diminished by increasing the concentration of any (even though not all) of the amino acids into which the protein molecule tends to be resolved.

Thus food proteins which do not furnish all of the amino acids needed for the construction of body tissue and which therefore could not properly be made the chief reliance in the feeding of growing children or of women during pregnancy or lactation, may still be depended upon to a very large extent for the ordinary maintenance of adults.

Nor does it seem necessary to assume that because of the differences in nutritive value among proteins, a very large margin for safety must be allowed above the average amount found in the 86 experiments cited above. This would be true only if the diets in these experiments had been selected from among materials whose proteins are of more than average value, which in general is not the case. In fact in the low protein diets used in these experiments there was often if not usually a more than average proportion of bread or other grain protein so that, if anything, the experiments tend to overstate the amount of protein which an ordinary mixed diet must furnish in order to cover the requirements of normal protein metabolism in the adult. Under these conditions it seems abundantly liberal to allow when planning for an economic use of food, a protein "standard" 50 per cent higher than the average estimate of the actual requirement (which as already shown is probably an overestimate). Such a 50 per cent margin for safety would lead to a tentative standard allowance of about 75 g. of protein per man per day. The requirements of children for protein as well as other tissue-building material will be considered as proportional to their energy requirements and therefore much higher per unit of weight than in the case of adults.

THE PHOSPHORUS AND CALCIUM REQUIREMENTS have in the past been much less studied than the protein requirement, although in principle they are equally well adapted to investigation by the method of quantitative comparison of intake and output. Such experiments as could be found in the literature have been summarized elsewhere [22] In general it may be said that the results were not sufficiently numerous or concordant to give us much confidence in the validity of the average and that as a basis for general conclusions regarding phosphorus and calcium requirement in human nutrition they were open to the further criticism of having been made almost exclusively upon male subjects. Experiments upon women therefore were plainly needed, and since the effects of the monthly cycle upon phosphorus and calcium metabolism had not been studied, it was especially desirable that the determination of intake and output should continue for an entire month without intermission. Four young women, graduate students and research workers in the writer's laboratory, have served as subjects in such experiments, taking diets uniform from day to day for 28 or 30 days, consecutively, with quantitative determinations of intake and output of nitrogen, phosphorus and calcium balanced in experimental periods of 3 or 4 days each. Three of the four subjects have each made two such series of experiments. From the data of all these experiments there does not appear to be any distinct monthly cycle in the total quantitative metabolism of either phosphorus or calcium; nor was the output of either of these elements in the menstrual flow large enough to materially affect the average daily metabolism for the entire month. From this standpoint the material lost in menstruation is essentially blood and as such is important to the estimate of the average daily requirement for iron, but is of very minor consequence in the phosphorus and calcium metabolism.

The determination of phosphorus and calcium balances in 3- or 4-day periods for 28 or 30 days without intermission gave therefore in each case a series of 7 to 10 experiments of unusual value for the purpose of studying the requirement, since the diets were so arranged as to furnish the desired numbers of calories and amounts of protein with quantities of phosphorus and calcium small enough to test the ability of the body to establish equilibrium on the amounts furnished, and to show to how low a level of phosphorus or of calcium metabolism the body could adjust itself.

The minimum requirements thus found, computed, for convenience of comparison and application, to a basis of 70 kg. of body weight, correspond respectively to 0.91, 0.72, 0.83, 0.89 g. phosphorus and 0.49, 0.38, 0.44 g. calcium "per man per day."

Averaging these results with those of several other experiments made in this laboratory upon both men and women, and with all comparable data found in the literature, indicated a mean requirement per 70 kg. of body weight of 0.88 g. phosphorus and 0.45 g. calcium per day.

Considering both the number of experiments contributing to the average and the range of results in each case, it would seem that our present knowledge of the quantities required for normal nutrition is probably about equally accurate as regards protein, phosphorus, and calcium. This being so, we have as much reason to set phosphorus and calcium "standards" as to set a "standard" for protein, and it seems logical to allow as much margin for safety in the one case as the other. The accompanying table summarizes the data on which these estimates of "requirements" and "standards" are based and shows also the relative frequency of American dietaries which fall below the standard or even the bare minimum requirement in each case.

TABLE IV—NUTRITIVE REQUIREMENTS AND ACTUAL INTAKE

"Per Man per Day"	Protein	Phosphorus	Calcium
Number of experiments	86	87	63
"Requirement" grams			
Range	20.0–79.2	0.52–1.19	0.27–0.78
Average	49.2	0.88	0.45
"Standard" 50% above "requirement"	75 grams	1.32 grams	0.68 gram
Actual amounts in 246 dietaries			
Average	106 grams	1.60 grams	0.74 gram
Below "Standard"	7 per cent	29 per cent	53 per cent
Below "Requirement"	Less than 1 per cent	4 per cent	16 per cent
Below "Requirement" if total food were 3,000 Calories	None	2 per cent	12 per cent

It must be stated with all possible emphasis that the words "requirement" and "standard" are used here only for lack of better terms and that they have not and cannot have the unconditional significance which is apt to be attached to them. McCollum's recent work[23] emphasizes the fact, which earlier work on the metabolism of calcium and iron[24,25] had illustrated,

that the amount of any one nutrient required will depend to a considerable extent upon the amounts of other nutrients furnished. In taking the average of the minima of various investigations as an estimate of the "requirement" we do not mean that just this amount will be literally required in each case. The very experiments from which this average is derived are sufficient to show that the minimum or requirement varies with the subject and the diet if not with other conditions. Similarly in taking an amount 50 per cent above the average minimum as a "standard" it is by no means intended to imply that this amount will be always the most desirable. On the contrary a larger amount might easily be advantageous, especially in the case of calcium as a safeguard against failure of completely normal absorption in the digestive tract.

Thus the quantitative statements of what are here called "requirement" and tentative "standard" must not be literally interpreted nor rigidly applied. They are, however, directly useful as a concrete basis for classifying the results of dietary studies as to whether they contain liberal or scanty amounts of the element in question. An intake less than the so-called requirement does not necessarily mean a continuing deficit leading finally to disaster in every individual case, but does mean that there is always this danger wherever such low intakes are habitual.

In individual cases in which intake and output are quantitatively determined and the inability of the subject to establish equilibrium is demonstrated, there can be no doubt that the intake is inadequate for the subject and conditions of the experiment and such a deficiency with reference to any particular element (calcium, for instance) may be established with entire certainty by the laboratory evidence without awaiting the development of any pathological symptoms.

Of the 246 dietary studies here referred to, 144 were originally recorded by the United States Department of Agriculture and have recently been subjected to more detailed analysis and computation, especially as regards the mineral elements, in connection with the investigations upon mineral metabolism at Columbia University; 102 were collected and studied in detail by Miss Gillett, working under the joint auspices of the University and the New York Association for Improving the Condition of the Poor. Nearly all of the latter were from New York City. Of the 144 government studies, 54 were made in New York City, 46 in other large cities, 44 in small cities or towns and rural regions. In every group calcium is the element most often deficient and of which the average intake shows the least margin of safety above the bare requirement. It is particularly interesting to note the agreement of this result with that of McCollum[26] who has found in his studies of laboratory animals that it is largely if not chiefly because of insufficient calcium that such animals do not show normal nutrition on rations derived too largely from seeds. American dietaries, both urban and rural, tend to consist too largely of the products of seeds (breadstuffs, etc.), meats, sugar and fats, all of which are poor in calcium—and too little of milk and vegetables which should be used in larger proportion both for their mineral constituents and for the vitamines which they furnish.

As might be expected in view of New York City's great size and the difficulty and expense of bringing in adequate supplies of perishable foods—milk for instance, having to be brought from 7 states and from distances sometimes as great as 400 miles or more—the New York City dietaries show a smaller average calcium content than those of other cities, while the small towns and rural regions show the best average.

Most of the New York City dietaries recorded by the United States Department of Agriculture were observed in 1895–1896; by the time of the Association for Improving the Condition of the Poor investigation in 1914–1915 the average calcium content had improved about 14 per cent. Undoubtedly this is chiefly due to the increased per capita consumption of milk which is known to have occurred during this 20-year period, and which in turn is no doubt largely attributable to the good influence of the public and private agencies which have been working in New York City for a better understanding of the importance of milk by the general public, largely due to the efforts of the dietitians, visiting nurses, and other visitors of the social and relief organizations, and the teachers of domestic science in the public schools. That the calcium content of the dietary is very closely related to the amount of milk used and that the latter can be influenced by education are both well illustrated by data of the New York City investigations which have been presented elsewhere.[27] By analysis of the data of the 44 dietaries studied in small towns and rural regions it was found that here also the adequacy of calcium intake depended chiefly upon the amount of milk consumed, adequate calcium being found, on the average, only in those dietaries which contain at least one-third of a quart of milk per man per day.

These results indicate very strongly that the average American dietary contains a much more liberal margin of protein than of either phosphorus or calcium, and that while the danger of a protein deficiency is rarely serious the danger of a deficiency of phosphorus or calcium is more important. Phosphorus deficiencies are plainly more frequent than are deficiencies of protein, and calcium deficiencies are more frequent still. The old assumption that adequate protein may be taken as meaning adequate supplies of all tissue-building material is found to be wholly misleading. Adequate energy intake is, in practice, more apt to ensure adequacy of mineral elements, but even if all of the 246 dietaries had been brought to a basis of 3,000 Calories per man per day, 12 per cent of them would still have furnished less than the average "requirement" of calcium.

THE IRON REQUIREMENT is much less definitely known than that for phosphorus or calcium. From the few experiments[25,28] which now appear trustworthy, it would seem that the actual requirement may average about 0.010 g. and the corresponding standard be placed at 0.015 g. "per man per day." On this basis it would appear that the danger of a deficient intake of iron on freely chosen diet is less than in the case of calcium but much greater than is the danger of a deficiency of protein.

STANDARD ALLOWANCES OF PROTEIN, PHOSPHORUS, CALCIUM AND IRON FOR CHILDREN'S DIETARIES—It will of course be understood that in all these statements regarding adequacy of family dietaries or of food allowances for a family or a community, the child's requirement for protein, phosphorus, calcium or iron is reckoned as proportional to his energy requirement and therefore as much more than proportional to his weight. Starting with the food allowances for healthy children already proposed in terms of Calories it may be convenient to reckon the requirements of children or of families containing children as follows:[28]

Protein	2.5[a] grams per 100 Calories
Phosphorus	0.048 gram per 100 Calories
Calcium	0.078 gram per 100 Calories
Iron	0.0035 gram per 100 Calories

[a] Which should be mainly in the form of milk protein in the dietaries of growing children.

THE "VITAMINE" REQUIREMENT cannot be stated in terms of actual weights of Fat-Soluble A and of Water-Soluble B, but the percentages of certain foods rich in the one or the other of these essentials which suffice to make an otherwise satisfactory diet adequate for normal growth and reproduction have been determined experimentally for several food materials by Osborne and Mendel and by McCollum and his associates[29] so that we now know in a general way the relative richness of several of the chief types of food in each of these dietary essentials and can take account of this factor of food value in considering the prominence which should be given to each type of food in planning an adequate and economical diet. It is very interesting and important to find how generally the types of food rich in calcium—milk, eggs, vegetables—are rich in vitamines as well, so that in

safeguarding against deficiency of the element most likely to be deficient, we at the same time secure an ample intake of the food hormones or vitamines.

TO APPLY KNOWLEDGE OF NUTRITIVE REQUIREMENTS IN THE CHOICE OF FOOD any one of several plans may be followed.

1—The actual quantity of each essential element could be calculated for every proposed combination of staple food materials, but this method would be too cumbersome for general use.

2—Since in the past it has been customary to treat protein as the tissue-building material of the food and since we now know that dietaries containing enough protein do not necessarily contain enough of other building materials such as phosphorus and calcium we might seek to remedy the situation with a minimum revision of past habits of thought by so specifying the kind of protein as well as its amount as to ensure that adequate protein supply shall really ensure (what we formerly erroneously assumed) an adequate supply of all essential elements. Thus in specifying that the protein in the dietaries of growing children shall be mainly in the form of milk, we ensure not only a good form of protein but an adequate supply of calcium, of phosphorus, and of both types of vitamines as well.

3—Again, since food values are commonly stated in terms of Calories and the 100-Calorie portion of food is becoming a more and more familiar unit, it is possible by building up a dietary of such units and specifying the number to be drawn from each type of food, to ensure that in covering the energy requirement an adequate supply of protein, of each of the inorganic elements, and of each type of vitamine shall also be supplied. This is perhaps the most satisfactory procedure in those cases in which the balancing of the diet is attained by careful planning of each meal from day to day, and its application has been greatly facilitated by the publication of the excellent series of meal plans for which we are indebted to Mrs. Rose.[30]

4—Still another method of balancing the dietary and ensuring an adequate supply of each essential nutrient without undue expenditure or extravagant consumption in any one direction is to follow a food budget, or, in other words, apportion the money expended for food among the different types of food materials. This plan, while less logical from a scientific standpoint than those previously mentioned, has the merit of simplicity, of requiring no use of technical terms, and of facilitating comparison with food statistics which are as apt to be reported in money value as in weights and measures and in any case are much more readily reducible to money value than to food value when the latter is construed as broadly as we now must construe it to cover all the constituents of food which we know to be essential to normal nutrition.

FOOD SUPPLIES OF AMERICAN FAMILIES—The results of inquiries by the United States Bureau of Labor Statistics in over two thousand families and of very accurate records obtained by the United States Department of Agriculture and the New York Association for Improving the Condition of the Poor in over two hundred households carefully chosen as representative of different economic groups, are quite consistent in showing that of the total expenditure for food about one-third is for meats and fish, about one-tenth for milk, one-twentieth for eggs, one-tenth to one-sixth for breadstuffs and other cereal products, about one-sixth for butter and other fats, sugar and other sweets, about one-sixth for fruit and vegetables, and one-twentieth to one-tenth for all other foods and food adjuncts. This estimate of the relative prominence of different types of food is confirmed by the statistical estimates of the values of annual products of the different food industries of the United States after allowing for imports and exports.

Are the habits of food consumption which those statistics reveal the ones which we must consider the best in the light of our present knowledge of nutrition? If they are capable of modification for the better, can this be accomplished in a manner consistent with our responsibilities in the present world food situation? I think there is no doubt whatever that the average American dietary can be modified to meet all the wishes of the Food Administration and be materially improved at the same time.

We are asked by the larger use of perishable foods including such grain products as are more perishable than wheat flour to "save," or reduce, our consumption of wheat, meat, fats and sugar. It is in fact precisely because of the free use of meat, sugar, fat and white flour in American dietaries that so many of them are deficient in one or more of the mineral elements, particularly calcium, so that the partial substitution of other foods for each or any of these four will tend directly to remedy the commonest defect in the nutritive value of our food.

That the mineral and vitamine content of the average American dietary can and should be improved by the larger use of milk and vegetables, even if this means a decreased consumption of meat, is now well recognized by students of nutrition. Because of the economic limitations under which the food for most families must be provided, the use of so much as one-fourth to one-third of the food money for meat practically results in too great a limitation of the consumption of fruit, vegetables and milk. Even if there were no war we should teach a lessened use of meat and sugar in order that more milk, vegetables and fruit may be purchased and consumed. Since sugars and fats are practically devoid of inorganic foodstuffs or of water-soluble vitamine, as well as of protein, a diet in which the use of purified sugars and fats is reduced and the same number of Calories supplied by an increased use of other food material, is almost sure to be improved as regards its calcium, iron and phosphorus content as well as made richer in protein and vitamine.

True, the substitution of other fats for butter may diminish the intake of "Fat-Soluble A," but if the diet contains as much of milk and green vegetables as is desirable, this need not be a cause for anxiety. The saving of meat, sugar, and fats by substitution of other foods seems therefore to be wholly desirable from a selfish nutritional, as well as from the ethical and the national economic standpoint.

The duty placed upon us by the present food emergency, to eat less meat and more of such perishables as milk, vegetables and fruit, is therefore precisely what the recent advances in our knowledge of food and nutrition have shown to be for our best interest in any case.

It seems a good general rule for families of any level of income or standard of living (1) to spend at least as much for milk as for meat, (2) to spend at least as much for vegetables and fruit as for meats and fish. By redistributing the expenditure of a typical family of low income reducing the allowance for meat and increasing those for fruit and vegetables (together) and for milk so as to make the expenditures for these three items equal, a food supply much better according to our present knowledge of nutrition could be obtained without any increase in cost.

If it be objected that many people "simply cannot buy" milk at present prices, it should be said in reply that while every increase in the cost of milk to consumers is greatly to be regretted and should be avoided if possible, yet milk at any price which it has yet reached or is likely to reach is a better investment than meat. Lusk's admonition to the housewife to "buy three quarts of milk before buying a pound of meat" is still good advice notwithstanding the general rise in prices. Any family that can afford meat at all can better afford milk.

It may perhaps be asked whether we should not use less milk in order that more may be condensed for shipment abroad. Under present conditions it is unlikely that such an attempt would work out as intended. In relatively few cases are city milk dealers equipped with plants for the production of canned condensed milk. More generally the market milk business and the making of canned condensed milk are distinct industries, usually centered in separate localities and with present difficulties

of transportation and high prices of beef (and of cattle feed) there is great danger that a diminution of demand for market milk would lead to slaughter of the cow rather than to her shipment to a distant milk-condensing region.

In general the milk condenseries compete with butter and cheese factories rather than with city milk dealers so that if we wish to increase the supply for the condensery we should diminish our consumption of butter rather than of milk.

We are asked by the Food Administration both to economize in the use of meats, sugar and fat, and to consume less wheat.

To the extent that the saving of white wheat flour means an increased use of the coarser flours and of oatmeal and potatoes in breadmaking (or potatoes in place of white bread) this also will result in an improvement in the mineral and vitamine content of the diet. To the extent that wheat flour is replaced by cornmeal, we may anticipate no appreciable gain or loss in nutritive value.

The rat-feeding experiments of McCollum, often continued for the lifetime of the experimental animal and sometimes through more than one generation, have shown that the corresponding products from the different cereal grains are very similar in their nutritive properties, and preliminary experiments in our own laboratories, upon the substitution of corn protein for wheat protein in human nutrition, tend toward the same conclusion.

In these experiments it has been found that nitrogen equilibrium can be maintained, and apparently all the requirements of the protein metabolism fully met, by low protein diets in which at least four-fifths of the protein is from wheat or wheat and corn (maize) and that the results are apparently as good when maize is substituted for a considerable part of the wheat as when wheat furnished all of the grain protein.

Beginning this discussion with a reference to the *material* requisites of an adequate diet we have so far not felt called upon to specifically discuss psychological aspects, but we have not forgotten that "aside from all questions of physiological need, eating has an immense vogue as an amusement." In the present world food situation we would perhaps be justified in asking that people regard food primarily as a source of nutrient and only secondarily of entertainment, since it is possible for us to find our entertainment in "amusements" which do not involve depriving our friends abroad of their daily bread. But particularly in this very matter of the use of other things than patent flour in breadmaking we have been so often and emphatically warned that any change must be considered from the standpoint of psychology as well as nutrition that it may not be out of place to ask whether American psychology will be always and altogether on the side of conservatism as against conservation. It is commonly assumed that our national psychology is and always will be opposed to any change in the color or flavor of our familiar white wheat bread. But is this necessarily true? Is there not a psychology of conviction, of ethics, of patriotic emotion if you will, as well as a psychology of habit and prejudice? As our people come to realize more fully and more keenly the needs of our friends abroad, a pure-white, all-wheat loaf may possibly cease to be regarded as the standard of excellence and desirability and a bread tasting of corn or tinted by oatmeal may come to seem a more worthy staff of life.

BIBLIOGRAPHY

1—Lusk: "Science of Nutrition," 3rd Ed., 1917.

2—Benedict: "Metabolism during Inanition," Harvey Lectures for 1906–1907, p. 170, and *Publications of the Carnegie Institution of Washington*.

3—DuBois: "The Respiration Calorimeter in Clinical Medicine," Harvey Lectures for 1915–1916, p. 101, and papers in the *Archives of Internal Medicine*.

4—Gillett: "Food Allowances for Healthy Children," published by New York Association for Improving the Condition of the Poor.

5—Chittenden: "Physiological Economy in Nutrition and The Nutrition of Man."

6—Meltzer: "The Factors of Safety in Animal Structure and Animal Economy," Harvey Lectures for 1906–1907, p. 139.

7—Benedict: "The Nutritive Requirement of the Body," *American Journal of Physiology*, **16** (1906), 409.

8—Mills: *Archives of Internal Medicine*, **7** (1911), 694.

9—Falk and Sigurta: *Journal of the American Chemical Society*, **37** (1915), 217.

10—Sherman and Schlesinger: *Ibid.*, **34** (1912), 1104, **37** (1915), 1305.

11—Sherman and Gettler: *Ibid.*, **35** (1913), 179.

12—Willcock and Hopkins: *Journal of Physiology*, **35** (1906), 88.

13—Osborne and Mendel: *Journal of Biological Chemistry*, **17** (1914), 328.

14—Osborne and Mendel: "Feeding Experiments with Isolated Food Substances," *Publications of Carnegie Institution of Washington*, 1911, and subsequent papers in the *Journal of Biological Chemistry*.

15—Mendel: "Nutrition and Growth," Harvey Lectures for 1914–1915, p. 101.

16—Thomas: *Archiv für Anatomie und Physiologie*, 1909, p. 219.

17—Hindhede: *Skand. Archiv für Physiologie*, **30**, p. 97, **31** (1913–14), 259.

18—Rose and Cooper: *Journal of Biological Chemistry*, **30** (1917), 201.

19—Sherman and Osterberg: Unpublished.

20—Sherman and Wheeler: Unpublished.

21—McCollum: *American Journal of Physiology*, **29** (1911), 215.

22—Sherman, Mettler and Sinclair: U. S. Dept. Agriculture, *Bull.* **227**, Office of Experiment Stations; Forbes and Keith: Ohio Agricultural Experiment Station, Tech. Series, *Bull.* **5** (1914).

23—McCollum and Simmonds: *Journal of Biological Chemistry*, passim.

24—Von Wendt: *Skand. Archiv für Physiologie*, **17** (1905), 211.

25—Sherman: Office of Experiment Stations, U. S. Dept. Agriculture, *Bulletin* **185**, p. 37.

26—McCollum, Simmonds and Pitz: *Journal of Biological Chemistry*.

27—Sherman and Gillett: "A Study of the Adequacy and Economy of Some City Dietaries" published by New York Association for Improving the Condition of the Poor.

28—Sherman: "Chemistry of Food and Nutrition," 2nd Ed., 1918.

29—McCollum: "Supplementary Dietary Relationships Among Natural Food Materials." Harvey Lectures for 1916–1917.

30—Rose: "Feeding the Family."

COLUMBIA UNIVERSITY
NEW YORK CITY

PERMANENCE AS AN IDEAL OF RESEARCH[1]

By S. R. Scholes

Truth, beauty, and goodness are accepted as the ideals for human endeavor. Of these ideals, truth is the special goal of the man of science, and he must lead in its discovery and establishment. And among scientific men, it is the chemist who must discover the truth about the changes that occur or may be made to take place in the composition and constitution of material things.

The outstanding attribute of truth is its eternal character, it endures, it is permanent. We deny the notions of the early chemists who held the phlogiston theory, because it did not stand the test of time. We call Lavoisier the Father of Modern Chemistry because his master-concept of the quantitative character of chemical reactions has endured and become stronger through the years. Permanence is the criterion of ideas, in our Science as in any other; but this test should be applied more severely, not only to ideas, but to things, to the utilities that chemistry produces, that justify it to the world.

If right ideas are permanent, so also must be the material things into which natural resources are made, if they are to be worthy of final acceptance. Against this ideal of permanence stands the great natural tendency of all things to disintegrate and decay—to pass into a useless state. The action of the elements, of abrasion and vibration, erosion and corrosion, disintegration and destruction continually operate to nullify the labors of man and to bring to naught his best material achievements. Steel, for example, is the strongest and most adaptable of our engineering materials, but it yields to the action of the atmosphere, and eventually falls into useless rust. With few excep-

[1] Summary of Address delivered at the October 1917 meeting of the Pittsburgh Section of the American Chemical Society. Reprinted from *The Crucible*, the monthly of the Section.

tions, all our materials follow similar courses, so that the ultimate triumph of decay is voiced in many a pessimistic proverb.

Here is a challenge to the chemist. How to meet it seems a problem more worthy of his effort than is the extension of the number of substances, regardless of their lasting character, or even the establishment of new laws of chemistry, except as they have a bearing on the question of permanence: to make steel in large quantities, not only strong and cheap but resistant to rust, vibration and other destructive forces; to protect wood from the attack of air and moisture, of insects and fungi; to make glues and cements that will last as long as the substances they bind together; to make dyes that will not fade, and paints and varnishes that will retain color and protective power; to develop rubber so that its useful life is years instead of months; to improve clay products, mortars, and Portland cement until they are indifferent to heat and cold, dryness and moisture; to discover new treatments for textile fabrics that will greatly increase their strength, and resistance to wear and the agencies of decay, and even to fire itself while preserving all their useful characteristics; to improve paper so that the printed page may have some of the lasting qualities of the carven tablets of antiquity; to take from glass some of its fragility—these are among the aims that our research must seek, if our science fulfills its highest mission.

In addition to the value of such results merely as ideals, there would be tremendous economic gains, and, as a corollary, a vast improvement in the condition of the race. So long as the forces of ruin hold their present sway over our best and strongest materials, so long must a large part of the available human energy be expended in repairing and rebuilding. If such duplication of effort could be eliminated, not only would the wealth of the world increase much more rapidly, bringing us more of the useful things for our enjoyment, but the economic leisure of all men would be extended, with all the beneficial results which sociologists can hope from that desideratum.

We are already making progress and considerable research is now under way as everyone knows, along these lines. Most of the work remains to be done and the initiative rests with the chemists who can understand both the necessity and the promise of research; who have intelligent dissatisfaction with present achievement and imaginations trained to picture ideal materials and to plan for their manufacture.

Here in this great manufacturing district, where huge quantities of engineering materials are made and fabricated, the call for such research is doubly emphatic. It is not only a call, but an opportunity to win fame and fortune together with the deep satisfaction of having rendered real and lasting service.

H. C. Fry Glass Company
Rochester, New York

THE DEDICATION OF GILMAN HALL, UNIVERSITY OF CALIFORNIA

The University of California celebrated its semicentenary during the week March 18 to 23, 1918, with an appropriate and interesting program of events, one of which was the dedication on Friday, March 22, of a new building for chemistry which as it now stands is the front wing of the future Chemistry Building of the University. It was erected at a cost of $220,000; measures 190 by 60 feet; has four floors, a basement and a sub-basement; and constitutes a departure from the architecture of the new University in being built of reinforced concrete.

The addresses delivered at the dedication exercises, at which Professor Edmond O'Neill, of the University of California, presided, are printed in full below.—[Editor]

INTRODUCTORY ADDRESS

By Edmond O'Neill, Professor of Chemistry, University of California

We meet to-day to dedicate this building. It is called Gilman Hall, in honor of Daniel Coit Gilman, the first President of the University, from 1870 to 1874. Under his administration the University was organized, the Faculty enlarged, and the course of instruction amplified. Unusual for the administrators of his day, he believed in the importance of science, and it was through his efforts that the College of Chemistry was established and the first laboratory built.

Afterwards, as the first president of Johns Hopkins University, he had a larger field for his administrative genius, and we all know the impetus given to science as the result of the establishment of Johns Hopkins, of the eminent leaders of science that were gathered in its halls, and of the influence of its sons in so many American universities. For these reasons it is eminently fitting that this building should commemorate his name, and the words Gilman Hall will ever serve to bring back his personality and the services he rendered to this University.

The dedication of a building is like the launching of a ship. The architect, or the designer, must plan his building, or his vessel, keeping in mind the experience of the past, endeavoring to correct errors, planning improvements, giving rein to his imagination to create a new design more beautiful, or more harmonious, or better fitted for its purpose. And then comes the period of building when the architect or designer sees his dream take form, when the artisans fashion the stone and the steel and the wood, each workman a specialist in his task, each craftsman doing the work that lies before him, in apparent confusion and aimlessness. But gradually the structure shapes itself, the casual onlooker can understand the meaning of the seeming disconnected efforts, can recognize the outlines of what it is meant to be, and finally the building or the ship is finished and ready for its purpose.

The launching or the dedication is a gala day, a day of festivities and celebration. The vessel glides down the ways festooned with banners and streamers, with the sound of music and the plaudits of the assembled multitude. The dedications of great buildings are carried out with pomp and ceremony. Are those ceremonies and festivities merely in commemoration of the completion of a great work? Only in part. It seems to me that it is more a mark of what the future will bring. The ship sails away to foreign shores, with its passengers and cargo, bearing new materials and new ideas to other parts of the world and returning with a freight of material and spiritual things for our enlightenment and betterment; and so it is with this building. We commemorate its completion, we recall to our mind the labors and devotion of the architect and advisers and builders of this beautiful structure. But still more, this dedication is to mark the promise of the future. Year after year students, instructors and investigators will work in these laboratories, teaching the experience of the past; expounding the knowledge of the present, and unveiling the mysteries of the future. Future generations will throng this hall; professors and students, mutually helpful, pioneers in science exploring new fields, attacking new problems, solving the riddles of the Universe.

To-morrow is the fiftieth birthday of the University. The founders of the College of California are not here to witness the development of their little college. I remember as a boy going to the evening lectures of Professor Carr, the first professor of chemistry, where he presented the elementary principles of chemistry, illustrated with experiments. Although it was fifty years ago, I remember the lectures and experiments as though they occurred yesterday. It fired my imagination and gave me my first insight into the charm and interest of science. Little did I think then that fifty years later I would assist in the dedication of a chemical laboratory, many times larger, many times more costly, than the entire college of those days. Would that

the men of those times could be present here this week, to see the great tree that has grown from the little seed they planted in the sixties.

The development of the Department of Chemistry may be divided into three periods: the first period from 1870 to 1890, the second period from 1890 to 1918, and the third period to-day. The beginning of each of these epochs is marked by the erection of a new building.

South Hall, the first edifice on the Campus, was to a large extent devoted to chemistry. The original plan was to build it entirely of granite, but owing to lack of money the granite was used only to the first floor, the remainder being of brick. But the building was good. Only the best material was used. Iron straps, for bracing and binding, were freely used and the building has stood the test of time, weather, earthquakes, and use, for nearly fifty years, and it is as sound and good as it ever was. The cost, when labor and material were a fraction of what they are now, was $180,000. The architect was David Farquharson. The furnishing and equipment were of the highest quality. The interior furnishings were of California laurel; the laboratory desks were of black walnut; the hoods were made of plate glass. Everything was of the very best, and the laboratory when completed was far superior to any in America and unexcelled by any in the world. The faculty was small, the students few in number, but the spirit was fine. Of the chemistry instructors of those days two have passed away, Professors Rising and Christy. Professors Stillman and Slate are still with us. Under their inspiring and enthusiastic leadership, together with the smallness of the classes, and the lack of distracting avocations and activities, now unhappily so prevalent, we could devote ourselves to study and reflection and discussion in a leisurely way which now no longer is possible. The closeness of association of professor and student, so often referred to by the old graduates, was the rule. The small college in the midst of uninhabited fields of Berkeley had a charm that can never come again.

The University grew, and with it the Department of Chemistry. In spite of the erection of a number of other buildings, South Hall became too small for the accommodation of the chemistry students and, in 1890, the Regents erected the adjacent Chemistry Hall, devoted entirely to chemistry. The late Clinton Day, an alumnus of the College of California, was the architect. The cost was $62,000. Additions were made from time to time until the cost as it now stands amounts to about $100,000. This structure marks the second stage in the development of the College of Chemistry.

Just as the building was devoted to chemistry alone, so the course of instruction in the College was narrowed to specialized chemistry. In the early days the College of Chemistry served the purpose of a College of Natural Science, which at that time did not exist. Students interested in general science enrolled in the College of Chemistry. The creation of the College of Natural Science, now merged with the College of Letters, as the College of Letters and Science, gave the general science student greater freedom in the choice of his studies, and the College of Chemistry could devote itself to its more special instruction.

This condition continued until the advent of Professor Lewis in 1912, when the graduate and research departments were organized. The conditions of the seventies were reproduced, the graduate school taking the place of the early College. The small number of students, the group of young and enthusiastic instructors, the close relations in the laboratory and the seminar, serve as a reminder of the old laboratory in South Hall.

This building, in a material way, brings back recollections of the seventies. Like South Hall, it has its deep foundations, its massive wall, its tons of steel reinforcement. It will prove a monument to the architect, John Galen Howard, and to the State of California, who, as in 1870, provided the great sum of money for its erection.

But this structure, beautiful and genuine as it is, its varied and costly equipment, with electric furnaces that will melt platinum or granite, its liquid hydrogen plant, by means of which we will approach the absolute zero, its delicate measuring instruments which will show a variation of 0.00001 degree, will all be valueless if they are not put to real use. Real use will require real men. If a company of instructors and students imbued with the true spirit of research, with genuine love for learning, with intelligence and will, with enthusiasm and persistence, with patience and industry, will devote themselves to solving the secrets of science, the mysteries of nature, then this building will serve its purpose. I can safely say that within this hall is gathered such a company, and it is with the confidence of this knowledge that we assemble here to-day to dedicate this building to its high purpose of advancing knowledge, to reach a little further into the unknown, to teach the truth, and to help mankind in its quest for happiness.

We have spoken of the spirit of the old laboratory in South Hall, of the fine relations between instructor and student, and of the charm of the environment. One of the men who exemplified this spirit is with us to-day, John Maxson Stillman, student in the College of Chemistry, 1870 to 1874, Instructor of Chemistry in the University of California, 1875 to 1882, later Professor of Chemistry and Vice President of Stanford University, now Professor Emeritus. Dr. Stillman is a most fitting representative to take part in the dedication of this building. I wish to take this opportunity of paying a personal tribute to him in the part he played in the early University. He has been identified with the development of chemistry in California since the beginning. His influence as a teacher has been wide-spread and far-reaching. With respect and affection, I present him to you and will ask him to tell us something about the early University and what this dedication means to him.

ADDRESS

By John Maxson Stillman, Professor Emeritus of Chemistry, Leland Stanford University

Permit me first to express my appreciation of the courtesy extended to the University I represent and of the honor conferred upon me by the authorities of the University of California, in inviting me to participate in the dedication of this new and splendid temple to Chemical Science

As a representative of the Department of Chemistry of Stanford University, I take pleasure in extending to the University of California and to our friends and colleagues of the Department of Chemistry our heart-felt congratulations upon this important addition to the equipment and therefore to the efficiency of chemical training in the University.

I voice the sentiments of my colleagues of Stanford in expressing our hope and confidence in an ever-increasing development and an ever-widening influence of this department upon the growth of chemical science in America.

It is, however, not only as a representative of a sister institution that I am deeply interested in the occasion which brings us together here. When, forty-five years ago, the University first established itself at Berkeley, laboratory instruction in chemistry was first systematically undertaken, and it was my valued privilege, as assistant, and later as instructor, to have participated in the work of the pioneer period of this Department of Chemistry.

It is not an easy matter to span this gulf of years with full realization of the different conditions prevailing then and now —conditions affecting not merely the facilities of this University for the teaching of chemistry, but the relations of chemical education to public demand and appreciation. Indeed, it is difficult to now realize the great difference in the relations of university ideals in general to the popular comprehension which underlies public support, as they obtained then as they now exist.

The last published catalogue of the University shows a student body in the Colleges at Berkeley numbering 6780 students. In the first year at Berkeley the total registration was 191.

The latest register shows a teaching force in the Chemistry Department of eight professors, one lecturer, five instructors, and fourteen assistants, or thirty altogether. In 1873 to 1874 there was but a single professor, Professor Willard B. Rising, who came to the work fresh from several years' training in the best laboratories of the old world and who brought with him methods and ideals of chemical training abreast of the time. He was assisted that first year by but three undergraduate assistants, seniors in the College of Chemistry. While the spacious laboratories of chemistry have been in recent years continuously overcrowded by their almost thousands of workers, the two modest laboratory rooms in old South Hall were in those early years never overcrowded by their few dozens of students.

And these comparative figures are indicative of, and to a great extent a measure of, the changes that have taken place in the public appreciation of the value of university ideals, and of the importance of chemistry to the public welfare.

The career of the chemist in those days offered few inducements and little of promise. The Pacific Coast in particular still lingered in the epoch of exploitation of its rich natural resources in gold and silver, grain, cattle, and timber. The occupation of chemist meant to the general public little more than that of assayer of gold and silver, or pharmacist. Outside of mining, the chemical industries were few and were conducted primitively and on traditionally established lines. Indeed, the chemical industries of the whole United States were largely contented to depend upon the scientific and technical achievements of Europe.

Those were years of sacrifice and of many trials for the little band of teachers with advanced concepts of university education and for their relatively few but very earnest supporters in California. Isolated by distance from sympathetic co-workers in the Eastern States, struggling against public apathy, and battling against attempts to obstruct their aims or to divert from the young University its needed financial support, their disappointments were frequent and their discouragements many.

So much the greater honor to those who nevertheless against all opposition kept the course of the University ever steadily onward toward the highest ideals, until such time as the people of California, recognizing at last the value of the service rendered, rallied loyally and generously to its support.

A great leader of those who formulated and fought for high university standards was he who from 1872 to 1875 held the office of President of the University, Daniel C. Gilman. Though but for three years he was with us, those were critical years. The organization of Johns Hopkins University, the unique position it very soon commanded among American universities and the prestige it so long maintained are the lasting monuments to the high ideals and the organizing ability of President Gilman. And if not so conspicuously, no less effectively, was his influence exerted in the infancy of the University of California.

The clear judgment, the sound ideals of scholarship, and the friendly encouragement of President Gilman awakened and nourished the ambitions of many of the students of those early years to persevere in attaining the most thorough training obtainable for the educational career, when conditions generally were disheartening to such aspirations.

And so it appeals to me as very appropriate that this new laboratory, devoted to the extension of chemical knowledge, should bear the name of Gilman, our pioneer leader, whose far-seeing vision, and whose wise initiative laid broad and deep the foundations upon which, under enlightened leadership, the splendid superstructure of our State University has been erected.

I have a letter from President Gilman written forty years ago which will not be without interest to-day.

Baltimore, February 16, 1878

MY DEAR STILLMAN:

There are no letters (except family letters) which give me so much pleasure as those I receive from California, and within a few days I have been favored with excellent varieties of the species, from your pen and Mr. Stearns'. My last previous letter was from Prof. Rising. . . . . I have had many printed papers referring to the progress of the University of California, including the notes of Mr. Bacon's proposed gift, the Report of the Regents, the lectures of Prof. Becker, etc. In all these signs of growth and progress I rejoice with all my heart. I have always believed that the good forces in California would overcome the bad elements, and that we should see a university on the Berkeley slopes, strong and sound, helping on all the interests, social, industrial, political, literary and scientific. It is a great pleasure to me to see on the Register, which has also come lately to hand, the names of former students enrolled among the instructors. The faculty of a college, as it seems to me, should be in part composed of alumni of the institution and in part from men trained elsewhere. The former know the situation—its good points and bad, they love their Alma Mater and are quick to defend and advance her interests. The latter bring in good ideas from other institutions and prevent the concern from moving in too firm a routine. As I write, your name and Jackson's and Christy's, and Slate's, and Rowell's and Parkers' and Hinton's and ever so many more occur to me as those on whom the University might well rely. Royce would be a great addition to your company. He has certainly a very remarkable mind and is I think likely to become a man of great distinction. . . . . Give my kind regards to all your comrades and believe me ever your friend.

Sincerely,
D. C. GILMAN

It is at a momentous time in our national history that Gilman Hall is opened for research and instruction. But it is also an auspicious time. For do we not all see now, as we have never seen before, that America must never again be satisfied to be dependent upon any other nation for the vital necessities of national life, either in her industries or in the scientific knowledge upon which these are founded? Yet it is in the chemical field that in the past our unpreparedness has been most flagrant. The many serious problems, which in this time of war are tasking to the utmost the chemical skill and science in this country, are not more serious and not more numerous than those which will call upon chemical science in the strenuous years to follow, when peace shall some time come to this war-torn world.

May Gilman Hall, under direction of its wise faculty and with the loyal support of the people of California, contribute in generous measure to the solution of the future problems confronting the chemists of America. For the American people are at last fully aware that the security and the prosperity of this nation is dependent in no small measure upon the self-dependent character of its chemical science and chemical industries.

. . . . . .

Professor O'Neill then introduced the next speaker as follows:

Dr. Stillman represents the old University. Since his time a new generation has come into the field to carry on the work. We older men must lay down our burden to be taken up by the younger ones.

Dr. Lionel H. Duschak is a fitting representative of this younger group. A graduate of Michigan and Princeton, Superintendent of the Berkeley Division of the Bureau of Mines, a specialist in physical chemistry, he will serve in the ranks of chemists and carry forward the banner of the scientist. For a long period yet to come, he and his contemporaries will see the uses to which this building will be put, will watch the work that will be done in it, and will make use of the results and discoveries made in this laboratory. As a representative of the younger generation of chemists, I present Dr. Duschak.

ADDRESS

By LIONEL HERMAN DUSCHAK, Superintendent, Berkeley Station, U. S. Bureau of Mines

As a representative of the younger men who are engaged in chemical work, I deeply appreciate the honor of being invited to participate in the dedication of Gilman Hall. We have

watched with a real interest the recent growth and progress of the Chemical Department of this University and note with gratification that its needs for better facilities have been met by this excellent new building. May I extend to the University and the Chemical Department our congratulations on the event which gives rise to this ceremony?

It will occur to all of us that this occasion is one of particular significance to our part of the chemical world. Standing as a permanent addition to the chemical group, Gilman Hall is a milestone marking an important step in the development of the chemical work of the University. I wish to indicate by a few words what this development may mean to us. The underlying thought which I wish to convey to you is suggested by considering for a moment the relation of this University in its entirety to the commonwealth. I shall not attempt to define this, but wish only to call your attention to certain facts which have impressed me. As a part of this University we find colleges of mining and agriculture, which in many States form separate, and all too frequently, competing institutions. We find courses in music, in commercial education and in other branches which are frequently offered only in special schools. We observe a quick response on the part of the University to growing popular interest in any new line of endeavor. This is not to be interpreted in any sense as a concession to faddishness, but rather as an evidence of virility, of alertness, of a desire to assist in realizing the greatest good from each new activity by giving it the benefit of the scientific study and technical direction available in the great University workshop. This University has maintained to an unusual degree a close and helpful contact with the complex and ever-changing activities of the life about it.

May we not take it for granted then that this splendid new building will be used by the Chemical Department for corresponding efforts in its own particular field; that the increasing chemical activity within the University implies a corresponding increase in the helpful influence which will emanate from this center to the broad and varied fields of chemical activity without?

Research in so-called pure science has been aptly referred to as the foundation upon which all scientific work rests. One should not think of this foundation, however, as a mass of concrete lying cold and inert in the earth, but rather as the trunk of a great tree, which is constantly pushing forth its roots into new and unpenetrated earth, tapping new sources of vital energy. We shall expect first of all then that the activities in this new building will supply leadership in the field of theoretical chemistry, a field in which this Department already occupies a prominent place. This leadership will come in part from the trained men continually going out from the University.

Consideration of the practical value of a theoretical advance is rarely, if ever, the compelling motive of the investigator. He has a less material vision before him. To-day, however, no one regards it as a degradation of science that such practical application should be made. It is an interesting fact that some of the recent and highly fundamental theories and conceptions of physical science have received direct practical application. As an example, the new type of X-ray apparatus developed at the research laboratory of the General Electric Company may be cited. In fact, chemistry would enjoy but a restricted existence and would probably suffer decay were it not making its rich and varied contributions to the daily needs of the world.

The ideal and the material must go hand in hand, and in this new building, which is being dedicated to-day, there is abundant evidence that both aspects of chemistry will be given due attention. The variety and extent of the material resources of the Pacific Coast are more or less well known. Their utilization has only just begun. In unlocking the great storehouses of this region the chemical pioneers will look to the University for assistance in many ways. In this connection it is well to remember that as we pass from experimental work for a theoretical purpose to that with material ends in view, we usually approach operations of an extremely simple character. The basic principles will be obvious and well understood and the technician's skill is more particularly required in detecting and controlling what may superficially appear to be details of small importance. The solution of a seemingly minor problem may bring major results.

Members of the Chemical Department will be proud to recall later on that much of the equipment for experimental work of a more practical character was first used in the study of problems having to do with the utilization of local materials in meeting the needs of our country in the present great conflict.

The relation of chemical work within the University and that without should not be one-sided. We on our part wish to stand in the most friendly and helpful relationship to the Department, to assist where possible, to the end that it may achieve the largest measure of usefulness. With the idea of friendly coöperation and mutual helpfulness in mind, the dedication of this new and splendidly equipped building has an almost individual significance to each one of us.

In the years to come there will grow up about Gilman Hall rich memories like those which now enshroud its older companions. In this new era just beginning the Chemical Department will continue true to its early ideals and traditions and will carry forward the standards so splendidly maintained throughout the past.

CURRENT INDUSTRIAL NEWS

MACHINERY FOR FRANCE

Shortage of labor has shown that modern methods of breadmaking are comparatively little employed in France, in spite of the country being one of the largest consumers of bread in the world. Even in the big cities the ancient and unhygienic method of hand kneading is still adopted. It is now urged that mechanical breadmaking is essential, seeing that a reduction of 50 per cent in the labor employed could be effected thereby. In certain quarters it is suggested that the French Government should do what has been done by certain South African Governments, viz., forbid bakers to carry on except by machinery, and it is suggested that establishments turning out bread on a large scale for the army should supply bread after the war in a similar way to the smaller baker who would thus be transformed into a tradesman merely for the sale of the article. There should, then, be a good market open to manufacturers of breadmaking machinery.—A. McMillan.

EXPORTS FROM GOLD COAST

During the years 1915 and 1916 the exports of nuts and oil from the Gold Coast were as follows:

	1915		1916	
	Quantity	Value	Quantity	Value
Kola Nuts	8,677,100 lbs.	$106,815	6,760,898 lbs.	$652,830
Copra	760 tons	$ 64,105	633 tons	$ 71,920
Palm Nuts	4,063 tons	$282,560	5,857 tons	$429,495
Palm Oil	330,969 gals.	$128,845	450,360 gals.	$191,495

The decrease in kola nuts is probably due solely to the difficulty of getting the product shipped to its principal market, Nigeria. A record total value for copra was reached in 1916. Considerable progress has been made by companies engaged in developing the palm oil trade and their activities give promise of a revival of the industry. The increase in palm kernels and palm oil corresponds approximately to the decrease that occurred in 1915 and is due to the stimulus given by the increased price and demand in Europe.—M.

ENGLISH POTTERY INDUSTRY

According to the *Chemical Trade Journal*, **62** (1918), 32, the output in the North Staffordshire pottery industry was considerably reduced last year, owing to depletion of staffs and difficulty in obtaining raw materials, some of which are now costly. The English potters have had the home and oversea markets largely to themselves and selling prices have shown considerable increase. Greatly augmented business has been opened up in South America. It is thought that the china-clay combine in Cornwall and Devon must lead to more expensive china. Manufacturers have been notified of an advance of $33^1/_3$ per cent. Important research work has been done and is proceeding at the Stoke Pottery School. It is stated that experiments to manufacture hard paste porcelain from English materials to compete with the German hard paste porcelain, hitherto a great rival to English pottery, have reached a practical stage and bodies have been prepared and supplied to manufacturers in order that the latter may experiment in making this class of china.—M.

SOAP DEMAND IN MOROCCO

A report published recently in the *Boletin de la Cámaras de Comercio* (Madrid) calls attention to the favorable opportunity, which to-day presents itself, for the supply of soap to the Spanish Moroccan market provided an effort is made to suit customers' demands. The kind mostly asked for is blue and white mottled soap packed in cases containing 64 bars, each weighing 780 g. Although the price in normal times was $5 per case, a case is now obtained with difficulty for $14. The annual consumption of soap in Spanish Morocco is some 2,500 to 3,000 metric tons. There is also a good demand for stearine candles in cases containing 100 packets (of from one to twelve candles) each weighing 287 g. A case at present brings $13 to $14.—M.

FERRO-CONCRETE SHIPBUILDING

A company, says *Engineering*, **105** (1918), 65, has been formed in Denmark for carrying on the Alfsen method of ferro-concrete shipbuilding. Suitable sites have been secured on the Limfjord, at Norre Sundby, and close to the Coöperative Cement Works. The undertaking will be started on a fairly comprehensive scale and under satisfactory auspices, and it is the intention to build not only lighters but sea-going vessels up to 1000 tons dead weight. Mr. Alfsen is a member of the Board. The Alfsen method will also be adopted by a company, with a capital of $275,000, which is constructing a yard at Arendal on Tromöen especially laid out for the building of ferro-concrete vessels of 1000 tons dead weight. A company in Sweden has been formed for building vessels of the same class, and the original Alfsen yard in Norway, the Porsgrund Cement Works, is about to increase its capital by some $195,000.—M.

RAILWAY MATERIAL FOR JAPAN

Japan, says the *Times Trade Supplement*, will be one of the countries eager to import railway material of all descriptions after the war, as it is extremely unlikely that the several developments of this nature contemplated in that country can be carried out with locally manufactured supplies. The proposal for the construction of a light underground electric railway at Tokyo has been discussed again, the overcrowding in the Tokyo tramways having called attention to its desirability. The scheme is preferred to the establishment of an omnibus service by reason of the narrow streets. A line, 9 mil. in length, is proposed, but it is recognized that it will take 5 yrs. before such a system is completed. There has also been a revival of the scheme for increasing the gauge of the Japanese government railways.—M.

GRAPHITE FOR BOILER SCALE

A very finely powdered graphite, says the *British Clay Worker*, placed in a boiler immediately after it has been cleaned circulates with the water and rubs against the steel to which it imparts a graphite polish on which scale does not readily form. When the initial quantity is regularly followed up by smaller ones, the graphite by mechanical motion gradually softens and disintegrates any old scale that may still be present and, if new scale thereafter forms, and it always will to some extent, it forms with that scale so that all may be easily broken up and removed. Inferior grades cannot with safety be allowed in steam boilers.—M.

SWEDISH GAUGES

It is stated in *Machinery*, **11**, 470, that bar gauges of the Johansen type are already being made by the Pitter Ventilating and Engineering Company, Woolwich, England. The bars can be made to an accuracy of ± 0.00001 by female labor on special lapping machines at a high rate of production. It is of interest to mention that the first set tested by the National Physical Laboratory, London, was satisfactory in flatness, parallelism and hardness and "wringing," and that 33 per cent showed no appreciable error in dimensions.—M.

SOUTH AFRICAN IRON ORE

The *Mining World*, **94** (1918), 180, states that considerable deposits of iron ore have been located in Ermelo district. It is said to be of great purity, assays of nearly 70 per cent having been obtained. A large tonnage is being made ready for transport to Vereeniging where it will be tested by the Union Steel Corporation. If the results are satisfactory it will be possible to get the necessary machinery required for the erection of an up-to-date steel producer plant which will render South Africa largely independent of outside supplies. So far the Steel Corporation has principally smelted scrap and imported pig iron, but the existence of a large quantity of good iron ore with an ample supply of the necessary flux in the neighborhood should lead to the Union producing all the steel required by the colony and perhaps other parts of Africa.—M.

SOUTH AFRICAN DIAMONDS

From a report the total output of diamonds from the diamond mines in South Africa for the year 1916 was 1,403,514 carats valued at $16,966,555. This total is exclusive of the result of débris washing which accounts for 8,362 carats valued at $51,705. The average value of the diamonds produced by the mines during the year was $9.60. Taking the average price realized per carat for the first quarter of the year against that realized in the last, we find an increase from $8 to about $11—a rise of almost 40 per cent. That the average price per carat of both mine and alluvial stones in 1916 was the highest since Union, is a striking fact, says the report, bearing conclusive testimony to the success of the sound policy of control exercised during the disturbing influences of the war. With regard to the alluvial diggings, the report of the Cape inspector shows that the output for 1916 was 98,879.75 carats of the value $3,271,380. The great increase over 1915 is apparent when it is stated that the previous year's production was 61,933.25 carats valued at $1,296,060. The average price realized for the alluvial product for the year 1916 was $31.80 against $20.80 for 1915. The 1916 average transcends all records, at least for recent years, the highest figure having been $29 in 1912. Taking the last quarter of 1916 by itself, the average price realized was no less than $30. In view of the above figures, the year has been one of extraordinary prosperity in the digging generally.—M.

SHORTAGE OF ELECTRICAL APPLIANCES

According to the *South African Mining Journal*, electrical materials are becoming very scarce in Johannesburg. The prices of key-sockets and switches have sharply advanced of late. Lamps coming on the market are quickly absorbed and all kinds of cable material are particularly difficult to obtain. On the other hand, the demand for motors has fallen off somewhat as the municipality is not in a position to supply newcomers.—M.

MARGARINE INDUSTRY IN HOLLAND

The 1916 Yearbook of the Chamber of Commerce at Rotterdam states that 30,000 metric tons of animal and vegetable margarine are consumed every year in Holland and that the ratio of export is normally five times that of consumption, or 150,000 tons out of a production of 180,000 tons, 1916. Practically all vegetable and animal fats can be used in making margarine. The principal fats are: vegetable—cottonseed, peanut, sesame, soya bean, palm kernel, rapeseed, linseed, Kapok seed and copra; animal—oleo oil, oleo stock, tallow, neutral lard, imitation neutral lard, butter and milk. Salt water is always mixed with the various ingredients. Deodorizing machinery has been developed in Germany and Holland to an extraordinary degree so that many oils and fats of no use elsewhere can be introduced without harm. There are about 30 principal margarine manufacturers in Holland but, of these, several have recently been bought up by Jurgens Margarine-fabriken Oss with headquarters in North Brabant.—M.

ELECTROLYTIC ZINC

News from Australia states that the electrolytic plant now established at Risden, Tasmania, has proved the possibility of the application of the electrolytic process to Australian ores and concentrates for the production of zinc. The chairman of the Electrolytic Zinc Company states that the present plant has a capacity of 15 tons per day which can be increased tenfold. Competition between the technologists of the Risden electrolytic process and the Port Pirie retort furnacing process has already produced metallurgical improvements. Leading members of the staff believe that, with the new conditions, they will beat the results already obtained from the older process. The outcome of these operations will, it is said, vitally affect the Empire's zinc industry.—M.

TRADE DEVELOPMENTS IN SWEDEN

The British Attaché at Stockholm reports that two important chemical factories have been amalgamated in a new company which has been established at Stockholm for the manufacture of aniline dyes and drugs. Negotiations are said to be proceeding for the purchase of or coöperation with other Swedish companies. The capital of the new company has been fixed at about $3,000,000. Other industries and inventions which are projected or are being developed in Sweden at the present time include the following: the manufacture of train oil from fish liver, and fish meal from fish waste; the establishment by the Swedish Government of a whale industry for state account; the production of fats and oils from coast animal substances and the exploitation of a recently discovered method of making aluminum from clay deposits. Electrolytic copper, as well as nickel and cobalt are to be produced by a new Swedish firm whose works are to be erected at Vasterus. It is also reported that preparations are being made to establish an oil industry to utilize Swedish deposits, and experiments are said to have yielded very promising results. Some large financial groups are interested in this enterprise.—M.

RUBBER INDUSTRY IN JAPAN

It is stated in the *Board of Trade Journal* that two well-known firms, one American and the other Japanese, have established a joint company in Yokohama for the manufacture and sale of rubber goods in Japan as well as in the Far Eastern countries. The Japan company, it is reported, owns rubber plantations in the Federated Malay States. The new company will have capital of about $1,250,000 and plans are already in hand for the erection of a four-storied factory building on the Yokohama site which has been acquired. At the outset, the general run of mining and industrial goods will be manufactured, as such a line represents the largest volume of business in Japan at the present time. The saving effected by manufacturing goods in Japan itself is estimated at 30 per cent on landed goods. Later on, the company intends to manufacture motor-car, ricksha and cycle tires, specially compounded to withstand road conditions in Japan. In addition, rubber boots and shoes, rainproof materials; vulcanite for battery jars, telephone switchboards, fountain pens, etc.; also druggists' sundries, surgical instruments and sporting requisites. American experts will supervise the production of the goods and the company's patents and processes are to be utilized in the Japanese works.—M.

SORGHUM AND PAPER

The French chemist, André Piédalla, has presented to the Paris Academy of Agriculture, a report showing the marvelous utility of this grass, which according to minute researches made by him supplies sugar, fodder, paper, dyes for textiles, and flour. The grass is indigenous to equatorial Africa and thence was carried to Egypt, India and China. In the fifteenth century, it was found growing in Italy, in Genoese and Venetian territory. In 1850 it was recommended to agriculturists in France but, at that time, it was not considered of sufficient value to interest cultivators. The *Temps* recently devoted a lengthy article to this once despised grass. Its yield of sugar is very considerable in appropriate climates; thus in China it yields 0.7 ton per acre. The fibers, rich in cellulose, yield 2 tons paper pulp per acre and Mr. Piédalla has produced from the pulp a superb paper of dazzling whiteness. In addition, the leaves serve admirably as fodder, the roots are useful for the production of alcohol and the seeds supply starch, nitrates and fatty matter that give a grayish flour of good taste, easily mixable with the usual breadstuffs, and it is enveloped in gluten which furnishes excellent coloring matters. As regards paper pulp, says the *Paper Maker*, it can be said that experiments dealing only with the utilization of sorghum date from many years back and seem to have given excellent results. The employment of sorghum for this purpose, however, seems to have made no progress and this, seemingly, for reasons independent of its value as a pulp-producing commodity.—M

COLLOIDAL NICKEL

Suspensions of colloidal nickel can be prepared in various ways. From the oxides and certain salts nickel is reduced to the dry state by hydrogen at 200° C. In a recent paper in the *Berichte d. deutschen chem. Gesellschaft*, C. Kelber states that he tried this reduction by hydrogen in solutions. He dissolved nickel formate together with gelatine in glycerine, heated the solution to 200 or 210° C. and passed a current of hydrogen through this solution. The latter assumed a brownish color which did not turn turbid when exposed to the atmosphere and could be mixed with alcohol. Water precipitated a chestnut-brown colloid which, when purified in the centrifugal apparatus and dried at ordinary temperature, gave a colloidal nickel soluble in acidulated water, dilute acetic acid, glycerine, and alcohol.—M.

JAPANESE INDUSTRIAL DEVELOPMENTS

The chemical industry has made wonderful advances in Japan since the outbreak of war. According to the *Chemical Trade Journal*, 62 (1918), 134, no less than twenty new companies are said to have been formed with a capital of $15,025,000, and twenty-eight factories are under their control. Among their chief products are ammonium sulfate, potassium chlorate, sodium peroxide, iodine, fatty and stearic acids, caustic soda, bleaching powder, potassium sulfate, potassium carbonate, sulfide of sodium, chloride of sodium, nitric acid, glycerine, oils, dyes, drugs, fertilizers, disinfectants, and phosphorus. Large stocks of potassium chlorate are on the market and the price has accordingly fallen. One company is producing indirect dyes for domestic needs exclusively, while direct dyes are being produced for the export trade. Another company claims to have produced ultramarine equal to that formerly obtained from Germany. For the manufacture of paints, three new companies have been formed with capital of $450,000. Their chief products are zinc and house paints, paints for ships' bottoms, antiseptic paints, rust-preventing paints and paint-substitutes. Six companies have been established with a capital of $8,250,000 for the production and refining of mineral oils. Fish grease is to be used for the manufacture of soap and glycerine by a recently formed company, while crude sulfur from a recently exploited mine is being refined by a special process.—M.

MINERAL DEPOSITS IN MALAY STATES

Mining engineers, who have recently visited the southern Siamese Malay States, have come to the conclusion that one of the richest mineral areas in the world is to be found there. In addition to wolfram, rich deposits of tin alluvium are found in the valleys and gullies of all the hills in which wolfram has been found. According to *Eastern Engineering*, in most of the hills the number of wolfram lodes already located exceeds ten and in all of them tin has also been found. Plenty of water with sufficient head is said to be available for washing out the tin in the rainy season and there are possibilities for storing water in reservoirs for the dry season. There is a waterfall close by with sufficient head to develop electric power for working a large number of mines. In northern Siam, mineral areas adjoining the new railway extension have been opened. Lead and antimony ores are the minerals worked, the lead being mixed with zinc and containing some silver.—M.

BUTTER SUBSTITUTE FROM FISH OILS

The attention of the British Board of Trade has been directed to a report appearing in a Norwegian paper to the effect that a process has been discovered in Norway by which butter substitute can be manufactured exclusively from Norwegian fish oils. The production of the substitute will, it is stated, be undertaken by a refinery which alone can produce sufficient to cover the requirements of the country. The Provisions Director will purchase the fish oils required. In addition to whale oils, all kinds of fish oils and particularly oil from herrings will be used.—M.

COD LIVER OIL FROM NEWFOUNDLAND

Owing to the fact that the large quantities of cod liver oil produced in Newfoundland as a by-product in the fishing industry were of inferior quality to that produced in Norway, the Newfoundland oil was not greatly esteemed in this country for medicinal purposes. Now, however, a great improvement in the quality of Newfoundland oil has been effected through the Government's action in sending a Norwegian expert to instruct the Newfoundland refiners in the methods of preparing the finest oil. The result of these measures has been to considerably improve the quality of Newfoundland oil and it is claimed that this oil is now equal to the best Norwegian oil.—M.

INDIAN OILSEEDS

The current number of the *Bulletin of the Imperial Institute*, London, contains an interesting report dealing with the Indian trade in oilseeds. It appears that the Indian production is worth annually about $250,000,000 and the export value of oilseeds and oilcake amounts to about $92,500,000. Great Britain is now India's best customer for these articles although, before the war, Germany had secured a monopoly for certain classes of Indian oilseeds. This was due to the fact that her specially controlled market enabled her to buy the most valuable seeds, the products from which were eventually exported in the form of margarine and other edible fats. The recent great increase in the manufacture of margarine in England may possibly alter the state of this permanently. The report referred to, we may add, contains full information regarding the Indian oilseed resources, the world's production, and demand for oilseeds, and the part which India plays as a source of supply. The Bulletin is published by J. Murray, Albemarle St., London.—M.

PRESERVATION OF PIT TIMBER

In view of the importance in present circumstances of preventing wastage in pit timber as much as possible, the British Department of Scientific and Industrial Research has issued a bulletin in which Prof. Percy Groom suggests some preventive and remedial measures against decay. He points out that the fungi which are for the most part responsible for the decay often clothe the surface of the wood with a fluffy or cottony material (spawn) which rapidly spreads and may be conveyed through the air and attack other wood. These fructifications should be removed and burned. For dealing with the spawn the men should carry a swab, cloths and a pail of antiseptic solution; the antiseptics suggested are creosote, zinc chloride and copper sulfate—the last should not be used if the mine is rich in iron. This treatment, once begun, should be systematically pursued and an attempt made to render the wood immune to infection, perfect protection being ensured only by impregnating the wood throughout. Iron sulfate is not recommended as an impregnating agent.—M.

OIL-PRESSING PLANT FOR INDIA

Although it has not been practicable to purchase modern oil-pressing plant from abroad, owing to war exigencies, the Board of Industries in the United Provinces is assured that oil pressing there has been accepted by capitalists as one of the most promising fields for development after the war. It is already a well established domestic industry. Works extensions are proposed as soon as they become practicable, while other capitalists have intimated their readiness to put up modern oil mills when conditions for the purchase of plant are favorable.—M.

RUSSIAN ASBESTOS INDUSTRY

The gradually increasing demand for asbestos, says the *Mining Journal*, is reflected not only in the opening up of new deposits such as those in South Africa, but also in the more active working of older fields. Considerable increase was shown in the Russian output previous to the war and although for the time being any further development has been stopped, in view of the considerable areas in which asbestos occurs, the future is regarded as important. The chief centers from which the present production is obtained are situated in the Urals. The output for recent years is as follows:

Year	Tons	Year	Tons
1907	10,451	1912	18,818
1908	13,130	1913	19,287
1909	16,584	1914	17,297
1910	13,467	1915	10,780
1911	17,423	1916	9,030

In addition to the Ural deposits, there are partially worked occurrences in the governments of Irkutsk and Yenisei.—M.

ROUMANIAN PETROLEUM

A German oil authority lecturing recently at Bucharest stated that the fuel value of Roumanian oil was very high, *viz.*, 11,000 calories per kg., as against 8,000 calories for the best Welsh steam coal. Germany, hitherto, has obtained oil from her ally, Austria, which country in 1913 produced well over 1,000,000 tons of crude. The *Motor* suggests that Germany evidently expects an enormous development of the Diesel engine. Thus, it is to be expected that Germany will make an attempt to get a grip on all the oil sources she can and so render herself independent of coaling stations. An 8,000-ton ship with Diesel engines, it is estimated, can make a trip from England to Japan and back on 700 tons of oil only.—M.

A DEOXIDIZING ALLOY

The above alloy consists of manganese, aluminum and magnesium and is said to be particularly suitable for deoxidizing iron and other metals. The presence of aluminum, which is easily combined with magnesium and in which manganese is soluble, permits of the formation of a ternary alloy which can easily be obtained without impurity and without loss. It forms a very powerful oxidizing agent. In preparing this alloy the aluminum and magnesium are first combined, the manganese being then added.—M.

DYE FROM MAPLE LEAVES

The British Consul at Seoul has forwarded a report dealing with the so-called "Shinnamu" dye, obtained from the leaves of a species of maple tree. As the result of investigation conducted at the Central Laboratory of the Government, it is stated that the dye is looked upon as a superior one and that it has attracted the attention of people in various districts where the leaves have been gathered and the manufacture of the dye has been entered upon. No success worth speaking about has, however, been obtained, owing to the lack of expert knowledge and the small scale on which operations have been conducted. In the vicinity of Kaijo (Song-do) a large quantity of leaves is available and the manufacture of the dye on an adequate scale is being planned. There has also been experimental planting of the species of maple tree referred to which is peculiar to Korea, being found almost everywhere in that country.—M.

INSTRUMENTS AND TOOLS FOR VENEZUELA

Venezuela, says the *Times Trade Supplement*, which is one of the South American States benefited by the war, is about to launch upon a modified but comprehensive campaign of new building construction. There will, therefore, be a demand before long for many kinds of small machines, engineering instruments, artisans' tools and contractors' machinery. The Government is also engaged upon a survey of a number of new highways and here again the usual appliances for road construction will be called for. Among the more urgent demands are the following: windmills, portable boilers, rock-crushers, carts, wagons, industrial railways, wood-working machinery, appliances used among mines and small industrial plants. Already a number of road-rolling machines have been imported. There is an opening for small stone crushers and split log drags, such as are used in the United States for the maintenance of roads having an earth surface. In 1914 the value of imports in the matter of instruments taken into the republic for the use of artisans and laborers alone, was about $80,000. Manufacturers would do well to get into touch with some of the larger importing firms in Caracas, of whom there are 17 who act as agents for foreign manufacturers. There are several important foundries, sawmills and lumber dealers at Caracas, Cagna, Puerta Cabello and Maracaibo. Communications should be addressed in Spanish, as English is little understood.—M.

SWISS ELECTROCHEMICAL INDUSTRIES

According to a report in the *Chemical Trade Journal*, 62 (1918), 184, on the commerce and industry of Switzerland, the calcium carbide production rose from 60,000 tons in 1915 to 70,000 in 1916. The exports to different countries in 1915 and 1916 were as follows:

	1915	1916
Germany	46,200 tons	46,200 tons
France	2,200 tons	20 tons
Belgium	3,900 tons	690 tons
Netherlands	2,200 tons	20 tons
Total exports	55,400 tons	58,000 tons
Value	$2,500,000	$3,860,000

The output of calcium cyanamide was doubled during 1916, the production being nearly 25,000 tons. The production of carborundum and other abrasives was also nearly doubled, rising from 800 to 1500 tons. Figures on the aluminum production are not given, but the exports increased from 9,400 tons in 1915 to 11,400 tons in 1916. The nitric acid works at Chippis and in Bodis produced sufficient acid from atmospheric nitrogen to cover the demand of the federation. The output of caustic soda from the works in Monthey has risen from 1000 tons in 1913 to 2,500 in 1916. New chemical works opened at Aaran for the manufacture of hydrogen peroxide and at Bex for electrolytic copper sulfate of ferrosilicon; the works in Visp and Bodis exported 20,000 tons, the whole of the production in the previous year amounting to only 14,000 tons.—M.

OIL-BREAK SWITCHGEAR

A descriptive list issued by the British Thompson, Houston Company, of Rugby, England, deals with a totally enclosed switch for circuits of small capacity up to 700 volts. The standard forms are non-automatic, double or triple pole for 60 amperes, and automatic double or triple pole with series trip coils for 3 to 60 amperes. The automatic switches can be fitted with time lags and low voltage releases, if required, the low voltage release coils being wound for 100 to 700 volts, as necessary. The switches are opened and closed by the single motion of the operating handle, with which a quick make-and-break action is obtained, and they cannot be left in any position but full on or off. The tripping mechanism is so designed that, if the switch opens automatically, the operating lever remains in the closed positions. The automatic trip is, therefore, of the free handle type, and an indicator, independent of the handle, shows when the switch has opened automatically. Large clearances are allowed between all live parts and there is no earthed metal in the neighborhood of the contacts. The switches can be arranged for mounting on a wall, or can be carried on pedestals, either plain or containing bus bars, isolating switches, cable boxes and starting rheostats. M.

BRITISH BOARD OF TRADE

During the month of February, the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

MACHINERY AND PLANT:

Can-making plant to produce the standard conical tins as used for corned beef

Wire enamelling plant

Brush-making machine, pulling system as opposed to filling system

Machinery for making toy marbles

Plant for caustic soda production, electrolytic process

Machinery for making manioc flour from cassava roots

Plant for manufacture of sealing wax

Badges, regimental letter, made of celluloid or celluloid and paper, not metal

Celluloid poultry rings

Flower bead necklets

Hair curlers and wavers

Levigated iron

Stoves suitable for burning wood fuel

Zirconia (firms holding stocks)

—M.

NOTES AND CORRESPONDENCE

PREPARATION FOR POST-WAR CONDITIONS IN GREAT BRITAIN

The British Ministry of Reconstruction has published a complete list of the various commissions and committees that have been set up, both within that ministry and within other ministries and departments of the British Government, to deal with questions which will arise at the close of the war. The commissions and committees, which have been appointed at various times since the war began, now number 87 and fall into 15 groups as follows:

1—Trade Development	8—Labor and Employment
2—Finance	9—Agriculture and Forestry
3—Raw Materials	10—Public Administration
4—Coal and Power	11—Housing
5—Intelligence	12—Education
6—Scientific and Industrial Research	13—Aliens
7—Demobilization and Disposal of Stores	14—Legal
	15—Miscellaneous

Some of the committees and commissions of these groups dealing with chemical questions are:

TRADE DEVELOPMENT—*Committee on the Chemical Trades*—To advise as to the procedure which should be adopted for dealing with the position of the chemical trades after the war, with a view to the creation of some organization which should be adequately representative of the trade as a whole and by means of which the trade may be enabled hereafter to continue to develop its own resources and to enlist the closest coöperation of all those engaged in the chemical industry.

Board of Trade Committees on the Coal, Electrical, Engineering, Iron and Steel, Nonferrous Metal, and Textile Trades—To consider the position of these trades and industries after the war, with special reference to international competition, and to report what measures, if any, are necessary or desirable to safeguard that position.

RAW MATERIALS—*Central Committee on Materials Supply*—To consider and report upon (1) the nature and amount of the supplies of materials and foodstuffs which, in the committee's opinion, will be required by the United Kingdom during the period which will elapse between the termination of the war and the restoration of a normal condition of trade; (2) the probable requirements of India, the Dominions, and Crown Colonies for such supplies at the close of hostilities; (3) the probable requirements of belligerents and neutrals for such supplies at the close of hostilities; (4) the sources from which and the conditions under which such supplies can be obtained and transported, and, in particular, the extent to which they might be obtained from the United Kingdom or within the Empire or from allied or neutral countries; (5) the question whether any measure of control will require to be exercised in regard to the nature and extent of any such control.

Committee on Edible and Oil-Producing Nuts and Seeds—To consider and report upon the present condition and the prospects of the West African trade in palm kernels and other edible and oil-producing nuts and seeds, and to make recommendations for the promotion in the United Kingdom of the industries dependent thereon.

Nitrogen Products Committee—(1) To consider the relative advantages for this country and for the Empire of the various methods for the fixation of atmospheric nitrogen from the point of view of both war and peace purposes, to ascertain their relative costs, and to advise on proposals relevant thereto which may be submitted to the department. (2) To examine into the supply of the raw materials required, *e. g.*, pure nitrogen and hydrogen, and into the utilization of the by-products obtained. (3) Since some of the processes employed depend for their success on the provision of large supplies of cheap power, to ascertain where and how this can best be obtained. (4) To consider what steps can with advantage be taken to conserve and increase the national resources of nitrogen-bearing compounds and to limit their wastage. (5) To carry out the experimental work necessary to arrive at definite conclusions as to the practicability and efficiency of such processes as may appear to the committee to be of value. (6) As a result of the foregoing steps, to advise as to starting operations on an industrial scale.

COAL AND POWER—*Coal Conservation Committee*—To consider and advise (1) what improvements can be effected in the present methods of mining coal with a view to prevent loss of coal in working and to minimize cost of production; (2) what improvements can be effected in the present methods of using coal for production of power, light and heat and of recovering by-products with a view to insure the greatest possible economy in production and the most advantageous use of coal substance; (3) whether with a view to our maintaining our industrial and commercial position, it is desirable that any steps should be taken in the near future, and if so, what steps, to secure the development of new coal fields or extensions of coal fields already being worked.

Mining, Power Generation and Transmission, Carbonization, and Geological Sub-Committees—The question of the application of carbonization to the preparation of fuel for industrial and commercial purposes.

Committee on Supply of Electricity—To consider and report what steps should be taken, whether by legislation or otherwise, to insure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of power for their development.

INTELLIGENCE—*Imperial Mineral Resources Bureau Committee*—To prepare a scheme for the establishment in London of an Imperial Mineral Resources Bureau (1) to collect information in regard to the mineral resources and metal requirements of the Empire; and (2) to advise what action, if any, may appear desirable to enable such resources to be developed and made available to meet requirements.

SCIENTIFIC AND INDUSTRIAL RESEARCH—*Fuel Research Board*—To investigate the nature, preparation and utilization of fuel of all kinds, both in the laboratory and, where necessary, on an industrial scale.

Cold Storage Research Board—Appointed to organize and control research into problems of the preservation of food products by cold storage and otherwise.

Standing Committees on Engineering, Metallurgy, Mining, and Glass and Optical Instruments—To advise the council on researches relating to the lines of activity named and on such matters as may be referred to the committee by the Advisory Council.

Joint Standing Committee on Illuminating Engineering—To survey the field for research on illumination and illuminating engineering, and to advise as to the directions in which research can be undertaken with advantage.

Mine Rescue Apparatus Research Committee—To inquire into the types of breathing apparatus used in coal mines, and by experiment to determine the advantages, limitations, and defects of the several types of apparatus, what improvements in them are possible, and whether it is advisable that the types used in mines should be standardized, and to collect evidence bearing on these points.

Abrasives and Polishing Powders Research Committee—(1) To conduct investigations on abrasives and polishing powders with a view to their preparation and use as one factor in accelerating the output of lenses and prisms for optical instruments, not only for peace requirements, but in connection with the war. (2) To investigate the preparation and properties of abrasives and polishing powders.

Food Research Committee—To direct research on problems in the cooking of vegetables and meat, and in bread making, to be undertaken by two scholars of the committee of council.

Electrical Research Committee—A committee of direction appointed in connection with certain researches affecting the electrical industry.

Committee for Research on Vitreous Compounds, and Cements for Lenses and Prisms—To conduct researches into the preparation, properties, and mode of employment of cements for lenses and prisms; to prepare a reference list of vitreous compounds, their composition, densities, refractive indices, and dispersive powers.

Tin and Tungsten Research Board—The Cornish Chamber of Mines has been invited to nominate a representative of the landlords and a representative of the mine owners to serve on the board. A committee of control appointed in connection with certain researches into tin and tungsten.

Lubricants and Lubrication Inquiry Committee—To prepare a memorandum on the field for research on lubricants and lubrication, which will contain an analysis of the problems involved, together with a suggested scheme of research, which would be most likely to lead to valuable results.

Chemistry of Lubricants Subcommittee—To collect and review the existing information relating to the chemistry of lubricants and lubricating oils.

Zinc and Copper Research and Inquiry Committee—To collect and review the existing information as to the copper and zinc industries upon which future research must be based, to formulate proposals for carrying out the research suggested by the Brass and Copper Tube Association of Great Britain into the best methods of making sound castings of copper and brass for tube making and to prepare an estimate of their cost; and to report to the Advisory Council.

AGRICULTURE AND FORESTRY—*Forestry Committee*—To consider and report upon the best means of conserving and developing the woodland and forestry resources of the United Kingdom, having regard to the experience gained during the war.

EDUCATION—*Committee on the Teaching of Science*—To inquire into the position occupied by natural science in the educational systems of Great Britain, especially in secondary schools and universities, and to advise what measures are needed to promote its study, regard being had to the requirements of a liberal education, to the advancement of pure science, and to the interests of the trades, industries, and professions which particularly depend upon applied science.

NOTE ON "THE FERTILIZING VALUE OF ACTIVATED SLUDGE" BY NASMITH AND McKAY

Editor of the Journal of Industrial and Engineering Chemistry:

We have reviewed with much pleasure the timely and interesting contribution by Messrs. Nasmith and McKay on the subject of "The Fertilizing Value of Activated Sludge" and feel that its publication would be of direct value. However, we wish to point out in particular two fallacies in this paper which should not be perpetuated by being quoted from one publication to another.

First is the result obtained by Bartow and Hatfield in which activated sludge gave a higher yield proportionately than dried blood in their fertilizer experiments. This is contrary to all experience and known facts regarding dried blood, which is considered the most valuable of commercial organic ammoniates. The explanation for this discrepancy is probably in the abnormal conditions under which the experiments were carried out as compared with actual agricultural conditions, namely, in the use of a sterilized soil or of washed sand in stiff clay soil, thus killing off or materially reducing the ammonifying and nitrifying organisms which are so necessary to the success of organic ammoniates. Dried blood cannot supply these organisms since it has also been sterilized in drying. Activated sludge, however, when used wet or air-dried,[1] teems with proteolytic and nitrifying organisms, thus possessing an advantage over commercial organic ammoniates which the latter cannot reasonably be expected to overcome quickly. If activated sludge were dried on a commercial scale in the same manner as commercial ammoniates now are, it would not possess this advantage. Furthermore, in actual agricultural practice the sterile soil would not be used, so that the nitrifying organisms in the soil would attack one organic ammoniate as well as the other.

Another fact developed in this respect lies in the so-called availability, as determined by the empirical methods in use in the New England States, the alkaline permanganate method, and the method in use in the Southeastern States, namely, the neutral permanganate method. While we do not believe that these methods can in all cases determine the true availability of organic nitrogen, the fact remains that they are law in these States and must therefore be applied in determining the value of any given form of organic nitrogen. Our tests have shown repeatedly that the nitrogen in activated sludge falls below the minimum limit of availability set by the authorities in these States, thus classing it as an "inferior organic ammoniate," while the nitrogen in dried blood, tankage, bone, etc., is classed as "highly available." These methods preclude the use of many organic ammoniates which are thus wasted. Dr. J. W. Turrentine, of the U. S. Bureau of Soils, has been studying this problem for some time.

Please do not misunderstand our attitude in this matter. We are vitally interested in the successful working out of the activated sludge problem, since it presents for the first time in the history of sewage disposal a hope of successful recovery of the sludge in a form commercially usable, thus repaying, at least in part, the cost of sewage purification, while heretofore the disposal of the sludge has been the feature on which all other processes of sewage purification have failed. It has not only been the expense of disposing of the sludge, but in many cases the actual impossibility of finding a place where it might be dumped without objection. The nitrogen content of activated sludge is from two to three times as high as that of any other sludge previously produced, thus placing it at once within the range of commercial ammoniates which will stand expense of transportation outside of the immediate locality in which they are produced. We must not, however, permit experimental conditions which will not obtain in actual practice to fool us as to the actual monetary value of activated sludge. The facts so far developed on this most interesting process have fully justified all the energy, time and money expended without making any unjustified assumptions as to the final value of the sludge.

CHEMICAL LABORATORY, ARMOUR & COMPANY PAUL RUDNICK
CHICAGO, ILLINOIS March 4, 1918

[1] Nasmith and McKay, page 339, and presumably also Bartow and Hatfield, THIS JOURNAL, 8 (1916), 17.

REGULATIONS UNDER THE POTASH LEASING ACT

The Department of the Interior has issued the following:

Secretary of the Interior Lane has approved working instructions and regulations under the Potash Leasing Act of October 2, 1917, a matter which has been given the most careful consideration, in view of the importance attached to this pioneer work in the development of a great national asset.

The act is liberal in its terms, authorizing the exploration for and disposition of potash deposits generally in the public lands of the United States, under a system that provides for a preliminary permit to the holder for the exclusive privilege of searching for deposits of potash for a period of not exceeding two years.

ONE PERMIT LIMITED TO 2,560 ACRES

The acreage embraced within one permit is limited to 2,560 acres, and the Secretary, upon a satisfactory showing that valuable deposits of potash have been found within the permit, is authorized to issue a patent to not exceed one-fourth of the amount covered by the permit, the remaining lands in the permit being subject to lease either by the permittee or others, after advertisement, competitive bidding, or such other methods as the Secretary may by general regulations adopt.

REGULATIONS BROAD IN OUTLINE

To the end, therefore, that the liberal purposes of the act may find the fullest scope of operation, the instructions and regulations now approved are broad in outline, simple in form, yet so directly addressed to the matter in hand that it is believed all applicants under the law will find but little difficulty in presenting their claims for consideration by the department.

Requests for copies of these instructions should be addressed to the Commissioner of the General Land Office, Washington, D. C.

NOTES ON "FREE CARBON" OF TAR

Editor of the Journal of Industrial and Engineering Chemistry:

Although rather extensive investigations are under way concerning the nature of the "free carbon" of pitch and tar, the work as yet is not in such form as to warrant publication. However, the conclusions of Monroe and Broderson[1] as drawn from

[1] THIS JOURNAL, 9 (1917), 1100

their results, on the effect of solvents on certain bodies in coal tar, should not be passed without comment. We, therefore, take this opportunity to discuss the results of these investigators in connection with their remarks concerning the article by Weiss[1] on "free carbon."

Weiss found that both chloroform and carbon bisulfide, when held in contact with coal tar over varying periods, formed insoluble compounds containing chlorine and sulfur, respectively. Chlorine was found qualitatively and sulfur was determined quantitatively by Weiss. Monroe and Broderson substantiated the qualitative tests for chlorine by quantitative methods but do not mention the fact that carbon bisulfide also precipitates insoluble materials containing sulfur. Weiss also found that, with benzene and toluene as solvents, the free carbon content of tar increased with the time of contact and concluded that this was also due to the reaction between the solvent and certain tar bodies. Monroe and Broderson claim that this does not happen in the case of benzol, but that the colloidal "free carbon" is merely precipitated by the action of the solvent with no actual chemical combination. Weiss noted[2] that when a solution of tar in toluol or in aniline was placed under the microscope in the form of a hanging drop, a gradual increase of insoluble matter took place with the toluol, but that the aniline solution remained clear for more than 24 hours. For this reason, it would appear that the toluene actually reacted chemically as there is no reason to believe that this would break the colloidal suspension any more easily than would aniline.

If we now consider the method and results, illustrated by graphs by which Monroe and Broderson attempt to prove that benzene as a solvent does not form insoluble compounds by chemical reaction and that chloroform does give insoluble compounds by chemical combination, we encounter one fallacy. They attempt to prove the formation of compounds of higher molecular weight through the reaction of the solvent on the tar, by a rise in the boiling point of the solvent, but the compounds that are formed and in which they are interested are insoluble. Insoluble materials could have no effect on the boiling point of the solvent.

The horizontal graphs representing the boiling points of the solvents, benzene and carbon bisulfide, could very well represent the results of actual chemical combination between the tar and the solvent, resulting in the formation of insoluble materials. If chemical combination took place, both a portion of the tar and of the solvent would be removed from the solution in the insoluble form, and hence the line would still remain horizontal. We do not know the molecular comparison between the amounts of tar and solvent removed, but the actual formation of insoluble compounds is rather small. Therefore, the probable variation in the temperature, due to the removal of more solvent than tar (or vice versa) entering the insoluble compound, could hardly be determined by a Beckmann thermometer.

There seems to be but one explanation of the peculiar graph for chloroform, the rise of which Monroe and Broderson explain is due to the formation of insoluble "free carbon," that is, that there may be a reaction between the chloroform and the coal tar to form *soluble* bodies that would increase the boiling point of the solvent. This is, however, merely speculative and not of direct bearing on the claims in the paper.

RESEARCH DEPARTMENT LABORATORY
THE BARRETT COMPANY, NEW YORK CITY
December 20, 1917

JOHN MORRIS WEISS
CHARLES R. DOWNS

THE GROWTH OF THE INDUSTRIAL FELLOWSHIP SYSTEM[3]

Twelve years ago, the late Robert Kennedy Duncan, while attending the Sixth International Congress of Applied Chemistry in Rome, conceived the idea of a practical method of bringing the science of the University—the new knowledge—to the service of industry. The idea called for the establishment, in the University, of Industrial Fellowships by individuals, companies or associations for the investigation of specific manufacturing problems involving the physical sciences.

The first Industrial Fellowship was founded in 1907 at the University of Kansas, where Dr. Duncan was then professor of industrial chemistry, by a company interested in the chemistry of laundering. In 1910, Dr. Duncan was called to the University of Pittsburgh to inaugurate the Industrial Fellowship System in the Department of Industrial Research, now known as the Mellon Institute of Industrial Research.

The first Industrial Fellowship at the University of Pittsburgh was founded in March 1911, through a grant from a baking company which desired to improve its product. In the seven years which have elapsed, seventy-five distinct concerns have endowed some one hundred eighty-nine one-year Industrial Fellowships for the study of specific manufacturing problems.

During the past year, the Mellon Institute, in common with all of the other research institutions of the country, has suffered a marked depletion in its staff. Twenty-one of its members, including the Director and an Assistant Director, have entered Government service in response to their country's call. The Institute, in most cases, has been able to fill the vacancies on the Industrial Fellowships. However, the shortage of research men, of the type demanded by the Industrial Fellowship System, has forced the Institute to decline to accept, temporarily, a number of very desirable research problems. It is gratifying to report that, notwithstanding the unsettled condition of the business world, an increasing number of industrialists are assigning problems on their processes and products to the Institute.

The following table shows the number of Industrial Fellowships which have been founded in the Institute from March to March of each year—1911 to 1918; the number of researchers or Industrial Fellows, as they are called, who have been employed on these Fellowships; and the total amounts of money contributed for their maintenance by industrial concerns:

March to March	Number of Fellowships	Number of Fellows	Amounts Contributed
1911–1912	11	24	$ 39,700
1912–1913	16	30	54,300
1913–1914	21	37	78,400
1914–1915	21	32	61,200
1915–1916	36	63	126,800
1916–1917	42	65	149,100
1917–1918	42	64	172,000

The total amount of money contributed by industrial firms to the Institute for the seven years ending March 1, 1918, was $681,500. In addition to this sum, over $400,000 was expended by these concerns in the construction of experimental plants. During the seven years, the Institute itself expended about $280,000 in taking care of the overhead expenses—salaries of members of permanent staff and office force, maintenance of building, apparatus, etc.—in connection with the operation of the Industrial Fellowships. Besides this amount, the building and permanent equipment of the Institute, which make it the most complete and modern industrial experiment station in the country, represent an investment of about $350,000. The money for the building, its equipment and the yearly allowance for overhead expenses is the gift of Andrew William Mellon and Richard Beatty Mellon, citizens of Pittsburgh.

It required the cataclysm of the Great War to bring men to realize fully the part which applied science is playing and, more particularly, will play in the life of nations. As men have come to know that everything in modern warfare is controlled in a large measure by science—no gun of large caliber is located or fired without its aid—so they have come to know that in the making of things—in the economy and progress of manu-

[1] THIS JOURNAL, 6 (1914), 279.
[2] *Loc. cit.*
[3] Reprint of report issued by Mellon Institute of Industrial Research.

facturing operations—science must have a place, an important place too. With this idea in mind, institutions of learning and industries in this country, but more especially abroad, are investigating and studying methods to bring about coöperation between science and industry. The Mellon Institute is proud that, while very young, it has been a pioneer in the field. Its principal claim to distinction, apart from its contributions to specific industries, is based on the service it has been able to render to other institutions in demonstrating the practicability of a system which brings together science and industry for the development of a future and more gracious civilization.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
UNIVERSITY OF PITTSBURGH
March 1, 1918

AMERICAN DYESTUFF MANUFACTURERS' ASSOCIATION

The Board of Governors of the American Dyestuff Manufacturers' Association met on April 5 at the office of its counsel, Benjamin M. Kaye, 149 Broadway, New York City, to elect officers, execute the certificate of incorporation, and adopt the constitution and by-laws.

According to the incorporation papers the objects of the Association are:

To promote the welfare and business interests of those engaged in the dyestuff manufacturing industry in the United States of America.

To promote and encourage the manufacture and use of American dyes; to coöperate with Congress, the Tariff Commission, the Federal Trade Commission, the Department of Commerce and all other governmental agencies in order to secure adequate protection against unfair competitive methods employed by foreign producers.

To coöperate with the United States Bureau of Standards and other similar bureaus and departments for the purpose of establishing proper trade standards of dyestuffs in the United States.

To collect and disseminate accurate information relating to the manufacture, sale and use of dyes, chemicals and kindred products in order that the statistics so gathered may be utilized in the effort to establish the manufacture of dyestuffs as one of the real industries of the United States.

In adopting its constitution, special consideration was given to eligibility to membership, and the first section adopted reads:

All persons, firms or corporations engaged in the business of manufacturing dyestuffs or intermediates in the United States shall be eligible for membership in the Association. No concerns having affiliations with concerns doing business in those countries now at war with the United States or its allies shall be eligible to membership.

Officers were elected as follows:

President: Morris R. Poucher, of E. I. du Pont de Nemours & Co., Wilmington, Del.

First Vice President: L. A. Ault, of Ault & Wiborg, Cincinnati, Ohio.

Second Vice President: Frank Hemingway, of Frank Hemingway, Inc., New York City.

Secretary: C. Cyril Bennett, Manager of the "Color Trade Journal," New York City.

Treasurer: Charles Jenkinson, of the National City Bank, New York City.

Executive Board: President Poucher; August Merz, of Heller and Merz, Newark, N. J.; Robert C. Jeffcott, of the Calco Chemical Co., New York City; J. Merritt Matthews, of the Grasselli Chemical Co., New York City; Robert P. Dicks, of the Dicks, David Co., Inc., New York City.

Within a short time the Association will issue propaganda in order to acquaint the American public with the enormous strides made in the dyestuff industry in this country since the start of the European war.

CHEMICALS DIVISION OF NATIONAL WAR SAVINGS COMMITTEE ORGANIZED

A Chemicals Division of the National War Savings Committee appointed by the Secretary of the Treasury has been organized with committee as follows:

Chairman: Ellwood Hendrick, Consulting Editor, "Metallurgical and Chemical Engineering;" *Vice Chairman:* J. R. de la Torre Bueno, Editor, "The General Chemical Bulletin;" *Treasurer:* Jerome Alexander, National Gum and Mica Co.; *Secretary:* T. E. Casey, The Barrett Co.; Charles F. Roth, Manager National Exposition of Chemical Industries; Geo. W. Nott, Advertising Manager, "The Journal of Industrial and Engineering Chemistry;" F. M. Turner, Technical Editor, "Chemical Engineering Catalog;" Wm. H. Nichols, Jr., President, General Chemical Co.; T. M. Rianhard, Vice President, The Barrett Co.; J. B. F. Herreshoff, Vice President, Nichols Copper Co.; Charles H. Herty, Editor, "The Journal of Industrial and Engineering Chemistry;" Franklin H. Warner, Secretary and Treasurer, Warner Chemical Co.; H. I. Moody, Treasurer, National Aniline and Chemical Co.; C. E. Sholes, Sales Manager, Grasselli Chemical Co.; C. P. Tolman, Manufacturing Manager, National Lead Co.; E. D. Kingsley, President Electro Bleaching Gas Co.; Charles F. Chandler, Emeritus Professor of Chemistry, Columbia University; J. M. Matthews, Editor, "Color Trade Journal."

The committee in a letter sent to all manufacturers of chemicals, dyestuffs, and chemical apparatus has requested each manufacturer to organize his establishment to forward the sale of Thrift Stamps among his employees. They ask that one or more individuals connected with each company be made a distributing agent, and suggest that each department of a large company have its accredited agent. The committee being advised of the appointments has a signed certificate bearing the name of the appointee sent from the Secretary of the Treasury. Each employee is privileged to purchase War Savings Stamps from the agent in his plant but because of the value placed upon them, the Government will allow no more than $1000 worth to be sold any one person.

The patriotic coöperation of all manufacturers with Uncle Sam is asked to make it easy for employees to purchase these stamps. The committee makes many suggestions as to methods of promoting thrift among employees, and the sale of stamps; it must be remembered that an employee who has learned thrift is always responsible. All who would coöperate with the Chemicals Division are requested to communicate with Mr. T. E. Casey, The Barrett Co., 17 Battery Place, New York City.

AMERICAN CERAMIC SOCIETY

The Northern Ohio Section of the American Ceramic Society met in Toledo, Saturday, April 6. The program was preceded by a visit to the plant of the Buckeye Clay Pot Company where an experimental humidity dryer was of special interest. At the afternoon session, Dr. A. F. Gorton, of the Buckeye Company, gave a very interesting account of the result of three months' operation of the dryer working on heavy blocks. A. S. Walden, foreman of the Furnace Department, of the National Carbon Company in Cleveland, presented a paper treating of the points to be considered in the choice of refractories for various furnace conditions. The material presented was directly based on a large experience in the construction and operation of furnaces of greatly varying types. The charter granted to the Local Section by the Trustees at the recent meeting of the National Society in Indianapolis was presented by Ex-President C. W. Parmelee, Department of Ceramics, University of Illinois. Prof. Parmelee's address of presentation touched on the history and tradition of the American Ceramic Society and the part the Local Sections are to take in the future development of the organization. A business session provided for a completion of the organization details of the section. Fol-

lowing the afternoon program the members dined together and the meeting adjourned.

This Local Section draws from a very active field of ceramics and a real live organization should develop from the present preliminary efforts. The officers of the section are as follows:

Chairman: E. P. Poste, The Elyria Enameled Products Company, Elyria, Ohio.

Secretary and Treasurer: Bryan A. Rice, The Elyria Enameled Products Company, Elyria, Ohio.

Councilor: Robert D. Landrum, Harshaw Fuller Goodwin Company, Cleveland, Ohio.

TECHNICAL ASSOCIATION OF PULP AND PAPER INDUSTRY

The Third Annual Spring Meeting of the Technical Association of the Pulp and Paper Industry will be held at Dayton, Ohio, on Thursday and Friday, May 16 and 17, 1918. Headquarters will be established at the Miami Hotel, Dayton, and the business meetings will take place in Community Hall. On the afternoon of the first day papers and discussions will be given on the subject of Coal Conservation. The second day of meeting, Friday, May 17, will be given up to visits to mills in Dayton and vicinity.

All pulp and paper manufacturers should be represented at this meeting by the technical men in their employment who are members, as they will gain a great advantage by meeting other technical workers for the discussion of new developments, methods and processes.

The Secretary, T. J. Keenan, 117 East 24th St., New York City, will be glad to assist in making reservations for members at the hotels. Details of the Program will be issued as soon as the Local Committee has completed arrangements.

CALENDAR OF MEETINGS

American Society of Mechanical Engineers—Worcester, Mass., June 4 to 7, 1918.

American Institute of Chemical Engineers—Annual Summer Meeting, Berlin, N. H., June 18 to 22, 1918.

American Society for Testing Materials—Atlantic City, N. J., June 25 to 28, 1918.

Technical Association of Pulp and Paper Industry—Third Annual Spring Meeting, Dayton, Ohio, May 16 and 17, 1918.

SYNTHETIC MATERIALS—CORRECTION

In the note printed under the above title in THIS JOURNAL, 10 (1918), 314, the following correction should be made:

Page 314, right-hand column, "Phenylmethyl" in the 6th line from the top should read "Phenylethyl."

WASHINGTON LETTER

By PAUL WOOTON, Metropolitan Bank Building, Washington, D. C.

Steps are being taken by the purchasing agencies of the Government to give advance notice of its requirements for drugs and chemicals. Since the United States entered the war, large government orders have been placed with little anticipation. This has had the effect of unsettling the market and has been objected to strenuously by other consumers. In numerous cases the reserve of certain drugs and chemicals has been wiped out entirely to fill an unexpectedly large order from the government. When other buyers found stocks exhausted, a flurry often resulted, causing prices to reach fictitious levels. Manufacturers, as well as consumers, have objected to this unnatural condition. Had advance knowledge of government requirements been had, there would have been no difficulty in having ample stocks to meet it and the needs of the regular demands of commerce as well.

Charges made in connection with the application of the California Trona Co., for patents covering certain lands in the Searles Lake region of San Bernardino County, California, have been disapproved by the Secretary of the Interior and the patents will be granted. The charges that were made are, substantially: that the claims do not contain a mineral deposit of the form and character contemplated by the mining laws as subject to entry; that all of the acts performed by the company on the properties were for the purpose of securing title in the interest of non-resident aliens; that at the date of the withdrawal of the lands, the company was not the *bona fide* owner of the claims and that at the time of application for patent, the company was not qualified to receive the patent because a large majority of its stock was controlled by aliens.

In the decision, which was made after extensive hearings and a full investigation, it was stated that the scientific information at the disposal of the department shows the commercial value of several substances found on these claims, and that, chemically, each and every one of them is a mineral. The rule laid down by the department is that whatever is recognized by the standard authorities as a mineral, whether metallic or non-metallic, when found in the public lands, comes within the purview of the mining laws. In view of these facts, the decision holds "that brine in a lake from which potash is procured in valuable and commercial quantities is subject to location and patent under the mining laws."

The alien ownership feature was disposed of quickly by the citation of a ruling in a previous case in which it was held that "a corporation organized under the laws of the United States or of any state or territory thereof, may, under Sections 2319 and 2321 of the revised statute, occupy and purchase mining claims from the government, irrespective of ownership of stock therein by persons, corporations, or associations not citizens of the United States."

Preparations for big troop movements to France have interfered importantly with the plans of the Chemical Service Section of the National Army and of Charles L. Parsons, the secretary of the A. C. S., for securing the return of chemists to the essential industries. In many cases, where troops were ready to go to France, permission for transfers could not be secured, as commanding officers did not want to interfere even slightly with their organizations. Dr. Parsons has held a number of conferences with officials in regard to the matter, which he believes is in a fair way to be straightened out.

By far the most drastic steps taken in the reduction of imports to release ships are those of the War Industries Board in establishing partial and complete embargoes on many imports. One list of articles, the importation of which is to be restricted, already has been issued and others are in the making. Among the articles on the first list are all acids; muriate of ammonia; all coal-tar distillates, except synthetic indigo; all salts of soda, except nitrate and cyanide of soda; graphite and pyrites. The embargo is not complete on pyrites and graphite. It permits the importation of 125,000 long tons, up to October 1. The imports are to come in on a graduated scale as follows: April, 40,000 tons; May, 30,000 tons; June, 20,000 tons; July, 15,000 tons; August, 10,000 tons; September, 10,000 tons.

A substantial cut in the imports of manganese ore from Brazil is understood to have been decided upon by the authorities in Washington. The exact figures have not been made public, but it is understood that the imports of Brazilian ore for 1918 do not exceed 350,000 tons. In 1917 they exceeded 500,000 tons.

It is understood that there will be no limitation on the importation of ammonia, antimony, arsenic, bismuth, kainite, mica, tin, tungsten and vanadium. Imports will be restricted or cut off in most of the other important minerals.

The Car Service Section of the Railroad Administration is on the point of taking drastic action to compel the loading of cars to their full capacity. The chemical industries have been offenders to some extent in this matter, it is reported. The Railroad Administration is keeping a record of light loading, and serious losses are likely to be caused shippers who fail to follow instructions in the matter of loading.

At the request of the War Industries Board, the Committee on Fertilizers has made a survey of stocks of nitrate of soda. Fertilizer manufacturers who operate sulfuric acid plants have been asked to keep on hand enough nitrates to insure operation for ninety days.

All plants engaged in the manufacture of chemicals, ferro-alloys, explosives, gas, insecticides, mineral and vegetable oils, soap, tanning extracts and fertilizers are among the plants and industries embodied in the War Industries Board's preference list No. 1. Those on this list are to receive preferential treatment in the matter of fuel supply. In giving out its statement in regard to this list, it was made clear that it is not an attempt to classify any industry as non-essential. In determining what industries or plants are entitled to be certified, the relative urgency of the uses for which the product of the plant is utilized and the per cent of the product of the plant which is utilized in war work or in other work of exceptional or national importance, will be considered.

Owing to the wide-spread interest among chemists in the announcement of the Federal Trade Commission with regard to licenses under German dye and drug patents, the official statement is reproduced herewith in its entirety:

After extensive experimenting, with approximately 600 German owned or controlled dye patents, the proper combinations of the patents for the quantity production of the dyes have been determined, and the Federal Trade Commission has granted 22 applications of the E. I. du Pont de Nemours and Co., of Wilmington, Del., for licenses under these patents to manufacture the dyes which have been unobtainable since 1914. Eight applications made by the National Aniline and Chemical Co., of Buffalo, N. Y., have been granted by the Commission also.

The licenses were not granted until careful research and investigation by the Trading with the Enemy Division of the Federal Trade Commission to determine the proper combinations of patents necessary to make particular dyes or groups of dyes. Examination of the patents disclosed the fact that in many instances insufficient descriptions were given to enable anyone to follow the correct formulas. In some cases where attempts to combine the ingredients were made, explosions or failure from other causes resulted. In other cases the formulas were followed without a hitch which tried in a laboratory, but when a factory scale of operation was made to produce the dyes in commercial quantities.

After the proper combinations of patents for the mercantile production of dyes were established, further careful experimentation was necessary to discover which patented formula or formulas it was necessary to follow in order to introduce the dyes into fabrics. It was not until these problems were solved satisfactorily that the licenses were approved.

The licenses for American use of the enemy patents in nearly all cases are for the entire life of the patents or "end of the war."

Additional licenses to American firms to manufacture drugs under enemy patents have been issued by the Federal Trade Commission, too. Licenses have been issued to the Antoine Chiris Company, of New York, to manufacture "barbital" (veronal); to the Calco Chemical Company to manufacture procaine [illegible] and to the Dearsenol Chemical Company, of Buffalo, to manufacture "arsphenamine" (salvarsan). Announcement has already been made of former licenses to manufacture these drugs under enemy-owned patents.

The first licenses for the manufacture under German patents of "neo-arsphenamine" (neo-salvarsan) have been issued by the Federal Trade Commission to the Farbwerke Hoechst Company, of New York, the Takamine Laboratory, Inc., of New York, the Dearsenol Chemical Company, of Buffalo, and the Dermatological Research Laboratories, of Philadelphia.

In granting applications for licenses to manufacture "barbital," which is regarded as one of the best and safest hypnotics and nerve calmatives, it is provided that the old name "veronal" may be used on packages in an explanatory sense. This drug has practically supplanted cocaine as a local anaesthetic having the effectiveness but none of the dangerous habit-forming qualities of cocaine. Before the first license was issued to make "procaine" it had sold in the United States as high as $7.20 a pound, but now can be obtained at less than $.900 a pound.

As in other licenses under enemy-owned or controlled patents, the concerns to benefit by the licenses will pay the Alien Property Custodian 5 per cent of their gross receipts from the sales of the articles involved, or 5 per cent of a valuation determined by the Federal Trade Commission.

PERSONAL NOTES

Mr. W. S. Dean, a graduate in textile engineering of the North Carolina State College of Agriculture and Engineering at Raleigh, N. C., who for some time has been connected with the cotton marketing division of the U. S. Department of Agriculture, has resigned that position to take up work for the Board of Vocational Education, under T. E. Browne, director of vocational education in North Carolina.

Dr. J. C. Olsen, head of the department of chemistry at Cooper Union, has accepted the position of professor of chemistry and head of the department of chemistry at the Polytechnic Institute of Brooklyn. A new chemical laboratory is to be equipped and installed at the Polytechnic Institute and more emphasis given to the course in chemical engineering, both day and evening. Considerably more space is available for the work in chemistry since the Institute has taken over the building formerly used by the preparatory department, in which new chemical laboratories will be built. This building has been thoroughly overhauled and put in first-class condition.

Mr. R. C. Bergen, assistant editor of *Metallurgical and Chemical Engineering*, has resigned his position to go into manufacturing work. He has been with the journal since its change to a semi-monthly publication in 1915 and was formerly with the Roessler and Hasslacher Chemical Company.

Dr. E. B. Spear, professor of chemistry of the Massachusetts Institute of Technology, has been appointed consulting chemist to the Bureau of Mines in connection with the gas warfare work.

Mr. Elwood P. Wenzelberger, formerly assistant chemist for the Victor Talking Machine Co., has been transferred from Camp Dix to the U. S. Army School of Military Aeronautics at Princeton, N. J., where he is pursuing a course of training for a commission in the aviation corps.

Prof. D. C. Dyer, of the State Experiment Station, Newark, Del., has been appointed by the chairman of the Delaware Section, A. C. S., as a committee of one to promote the use of garbage for feeding purposes, in response to a request for cooperation from the Garbage Utilization Division of the U. S. Food Administration.

Dr. L. C. Jones, chief chemist of the Semet-Solvay Company and Solvay Process Company, has been elected a vice president of the National Aniline and Chemical Company.

The Navy Department has designated the Stevens Institute of Technology, Hoboken, N. J., as the headquarters for the new United States Steam Engineering School for the training of engineer officers for the U. S. Naval Auxiliary Reserve. This school is the only one devoted to training engineer officers for steam-engine service, and is a branch of the large training school now located at Pelham Bay Park, N. Y. The education of engineer officers at Stevens is directed by Prof. F. L. Pryor who has been appointed by the Navy Department with the approval of President Humphreys, civilian director.

Dr. Samuel A. Tucker, of Columbia University, Dr. H. R. Moody, of the College of the City of New York, and Mr. J. M. Moorehead, of Chicago, have been added to the personnel of the chemical section of the War Industries Board.

From April 1 until June 15 the offices and laboratories of the Pittsburgh Testing Laboratory will be located at the B. F. Jones Law Building, 4th Avenue and Ross Street, Pittsburgh, Pa. After June 15 they will be located at 612 to 620 Grant Street, Pittsburgh.

Among the demonstrators in McGill University last year the following are now doing work in connection with the war: M. J. Marshall is with the Shawinigan Electro-Metals Company, Shawinigan Falls, Que.; C. F. Hamill is at the New York State College of Forestry, Syracuse, N. Y.; W. J. Geldard is engaged on war work for the American Government; G. L. Magoun is with the du Pont Powder Company, Wilmington, Delaware.

Prof. Lawrence J. Henderson is at present engaged in the Wolcott Gibbs Memorial Laboratory at Harvard University in research on the physical chemistry of breadmaking and the study of the use of substitutes in the making of bread. Assisting Professor Henderson in this work are Lieutenant Cohn, and Sergeants Cathgart and Wachmann.

Mr. W. B. D. Penniman, of the firm of Brown and Penniman of Baltimore, has accepted the position of chemist on the staff of the U. S. Shipping Board.

Dr. Elbert C. Lathrop has resigned his position as biochemist in the laboratory of soil fertility investigations, U. S. Department of Agriculture, to accept a research position with the Jackson laboratory of E. I. du Pont de Nemours and Company of Wilmington, Del.

Mr. Leighton M. Long, for the last two years with the Kawin Company of Toronto, Canada, is now assistant chemical engineer at the works of the Dominion Tar and Chemical Co., Sault Ste. Marie, Ontario.

Mr. A. McGill, chief chemist, Department of Inland Revenue, Canada, is in Pittsburgh, Pa., investigating questions relating to gasoline.

Dr. E. P. Wightman, formerly a research chemist for Parke, Davis and Co., Detroit, Mich., who enlisted in the 30th Engineers Regiment, U. S. N. A., and was later transferred to the Chemical Service Section, has been promoted to First Lieutenant and has been sent to the overseas laboratories.

Word has been received of the promotion of First Lieutenant Lawrence J. Fairhill, Ph.D., Harvard, 1918, to a Captaincy. Second Lieutenant Lee I. Smith has been made a First Lieutenant, and Private Alexander D. MacDonald has been commissioned a Second Lieutenant in the Chemical Service Corps.

Mr. G. O. Richardson, 22 Maple Ave., Andover, Mass., has been appointed Second Lieutenant, Chemical Service, National Army.

Mr. P. E. Sprague has been granted leave of absence for the period of the war from the position of Assistant Purchasing Agent, The Glidden Varnish Co., Cleveland, Ohio, and has enlisted as a private in the Chemical Service Section of the National Army. He is stationed at the American University in Washington and has been assigned to serve as chemical engineer in the Mechanical Research Department, War Gas Investigations.

Mr. Henry Mandle has resigned as chief of the technical staff of Herman and Herman, Inc., New York City, and has resumed his former practice as a consulting chemical engineer with offices at 220 West 42nd Street, New York. He is also acting in the capacity of technical adviser for the National Bronze and Chemical Works.

Mr. W. H. Beers, secretary of the Alabama Section of the A. C. S., has been appointed bacteriologist of the City of Birmingham, Ala., and will be located at the City Hall in that city. His duties begin May 1st.

Mr. Leo Stein, president of Stein, Hall and Co., 61 Broadway, New York, died on March 31. He was born in 1866 at Chicago, Ill., and had been engaged in the chemical trade for thirty years. He was a graduate of Yale University and became associated with his uncle, M. M. Hirsch in the firm of Stein, Hirsch and Co. Mr. Hirsch recently retired and was succeeded by Frank G. Hall.

The Powers-Weightman-Rosengarten Co., Philadelphia, celebrated its century mark as a producer of medicinal chemicals the early part of April.

Messrs. Ostenberg and Christiansen, consulting chemical engineers of San José, Cal., have both taken up war work. Dr. Ostenberg has entered the Naval Flying Station at San Diego, and Dr. Christiansen is a Lieutenant on the medical staff of the navy.

Captain G. L. Norris, chief metallurgist of the equipment division of the Signal Corps of the United States Army, will be in command of the general laboratories that have been established in Pittsburgh where all metals entering into the construction of aircraft are to be scientifically tested. The laboratories, manned by a force of 200 picked chemists, engineers, metallurgists and machinists, will occupy the best equipped testing plant in the district, which has been taken over by the Government for that purpose. Captain Norris will be assisted by Dr. H. T. Beans and Prof. J. F. Macgregor on leave of absence from Columbia University, as chief chemist and chief of physical tests, respectively.

Mr. V. V. Kelsey, Industrial Agent for the Carolina, Clinchfield and Ohio Railway, has severed his connection with the railroad to become resident manager for the American Wood Reduction Company at their plant now building at Kingsport, Tenn., for the distillation of hardwood. He is retained by the railway company in a consulting capacity.

Mr. Byron M. Hendrix, of the department of physiological chemistry of the medical school of the University of Pennsylvania, has been loaned by the University to the War Trade Board where he is acting as trade expert in the chemical division of the Bureau of Exports of the Board.

Mr. J. T. Janson of the Experimental Farm, Ottawa, Canada, a member of the A. C. S. for the past four years, has been at the front in France since July 1915. He is now a Lieutenant Colonel. He has been mentioned three times in dispatches, and in June last was given the Distinguished Service Order and since then has had a bar added to it.

Dr. Frederic Bonnet, Jr., professor of chemistry at Worcester Polytechnic Institute, has resigned to accept the position of chief chemist at the Perryville plant of the Atlas Powder Company.

Mr. F. K. Bezzenberger, who has been in charge of the Radcliffe Laboratories for the past few years, has entered the Government service, and is now stationed at Cleveland, Ohio.

Mr. John Diggs, State Water Chemist of Indiana, is a First Lieutenant in the Sanitary Corps, and is to serve in France.

Messrs. George B. Walden and Earl Roberts, both with Eli Lilly and Company, have enlisted in the Radio Division of the Signal Corps.

Mr. A. E. Roberts, of the department of chemistry, Yonkers High School, Yonkers, N. Y., is now connected with the research department of the Barrett Company at Philadelphia.

Mr. A. H. Putnam, formerly with the Warner-Klipstein Co., South Charleston, W. Va., is now assistant chief chemist, Inspection Section, Metallurgical Group, Ordnance Department, Washington, D. C.

Dr. Louis S. Munson, for eleven years associated with the Ault and Wiborg Company of Cincinnati as a chemist, and in recent years chief chemist, has resigned to take care of the production department of the new dye plant being erected by the du Pont Dye Works on the Delaware River, near Wilmington. The company is a subsidiary of the du Pont interests engaged in the manufacture of explosives. Employees of the Ault and Wiborg Company tendered Dr. Munson a dinner on the occasion of his departure.

Mr. R. E. Christman, formerly engineer of tests for the War Department at the plant of the Consolidated Car-Heating Company, has been appointed Supervising Engineer of Tests on metallurgical and testing work at the various plants in the vicinity of Detroit with headquarters at the American Car and Foundry Co., Detroit.

Mr. William Wallace Mein, of New York City, has been appointed assistant to the Secretary of Agriculture in regard to the licensing of the fertilizer industry as ordered by the Proclamation printed on page 323 of the April issue of THIS JOURNAL.

The United States Civil Service Commission announces an open competitive examination for assistant chemist in forest products, salary ranging from $1200 to $1800 a year, for men only. On account of the urgent needs of the service, applications will be received until further notice. Applicants should at once apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Dr. C. L. Reese, of E. I. du Pont de Nemours and Co., has been named Chairman of the Committee on Dyestuffs and Intermediates of the Chemical Alliance.

Dr. Robert C. White has just resigned as laboratory manager of the H. K. Mulford Company, after nearly fifteen years connection with that house. He has become associated with Joseph V. Little and Thomas A. Burrows in the manufacture of pharmaceutical specialties. The new concern will be known as the Burrows-Little-White Company and will have its principal laboratory in Philadelphia.

Mr. Philip S. Barnes, formerly with the Avery Chemical Company of Lowell, Mass., is now associated with the Sales Department of the Pfaudler Company of Rochester, N. Y., as consulting chemical engineer, with headquarters in the New York office.

Dr. William P. Wood, assistant professor of chemical engineering at the University of Michigan, has resigned to join the Signal Corps of the Army.

A fellowship in physiological chemistry has been established at the University of Chicago by the Fleischmann Company of Peekskill-on-Hudson, New York, for the purpose of investigating some of the scientific questions which have arisen in the course of the manufacture of compressed yeast under present war conditions. The university has appointed the first fellow on this foundation, who is now engaged in research upon the problems.

Dr. Ethel M. Terry, of the department of chemistry of the University of Chicago, has been appointed to an assistant professorship.

Mr. William J. Gross, formerly with the Sherwin-Williams Company at Chicago, is now chief chemist of the Nordyke and Marmon Co., Inc., of Indianapolis, manufacturers of automobiles and machinery. The Nordyke and Marmon Company is doing extensive war work for the Government.

Mr. J. M. Goetchius has resigned as vice president and director of the General Chemical Company in order to give his services to the Government. He has been succeeded both as vice president and director by Mr. A. W. Hawkes.

Captain J. R. Anderson, of the Geneva Experiment Station, and Lieutenants W. A. Perlzweig, Henry R. Cates and Charles N. Frey, are making a nutritional survey of the army camps situated in the southern states. The survey is part of the work at present conducted by the Surgeon General's Office to determine the character of the food supplied to the American soldiers.

Dr. W. B. Bentley, head of the department of chemistry of Ohio University, has been commissioned as captain by the War Department, and is stationed at Watertown, Massachusetts, in the department of inorganic chemistry, of the Watertown Arsenal.

Prof. Watson Bain, of the department of applied chemistry in the University of Toronto, has been granted leave of absence for the duration of the war. He is going to Washington, D. C., where he will be on the staff of the Canadian Mission.

Dr. John W. Kimball, instructor in chemistry and physics at the dental school of Western Reserve University, has been called to Washington to undertake chemical work for the Army. Dr. Kimball has been granted leave of absence from the university and will leave immediately to take up his new work.

Dr. Francis C. Frary, research chemist of the Aluminum Company of America, has been commissioned as captain in the Ordnance Reserve Corps and assigned to research work in the trench warfare section, Engineering Bureau, office of the chief of ordnance, Washington, D. C.

The death is announced of C. I. Istrati, professor of organic chemistry and dean at the University of Bucharest and president of the Roumanian Academy of Sciences.

Mr. F. L. Locke has resigned as superintendent of the chemical plant of the Chattanooga Chemical Company to join the technical staff of the British-American Chemical Co., Inc., of New York City, to assist in the design, and later superintend the operation of extensive additions now being made to their plant.

Dr. A. D. Brokaw, assistant professor of mineralogy and chemical geology at the University of Chicago, has been called to Washington to take charge of the oil production east of the Rocky Mountains.

Dr. H. H. King, associate professor of chemistry at the Kansas State Agricultural School, has been advanced to the head of the chemistry department. He is now at the University of Chicago completing the work for his Ph.D. degree.

Mr. A. V. DeLaporte, chemist in charge of the Provincial Board of Health of Ontario, has joined the overseas forces and is now in England qualifying as an officer in the Royal Engineers. He had formerly been attached to the Hydrological Corps with the rank of Captain and served at the Toronto Exhibition Camp last winter.

Dr. John E. Bucher, professor of chemistry in Brown University, has been granted leave of absence for the second semester of the academic year, in order to devote himself to experimentation in chemical processes in the industry. He will continue to direct the work of certain advanced students in the University laboratory, but will be relieved of all teaching during the remainder of the year. Dr. Robert F. Chambers, a Brown graduate, will be acting head of the department during the second semester.

Dr. E. V. McCollum, professor of chemistry in the school of hygiene and public health, Johns Hopkins University, gave the Cutter lectures on preventive medicine and hygiene at the Harvard Medical School on March 19, 20 and 21.

Mr. Henry A. Gardner, until recently assistant director of the Institute of Industrial Research, at Washington, D. C., has received a commission as Senior Lieutenant in the Naval Flying Corps. At present he is stationed in Washington.

Mr. William H. Barrett, president of Barrett and Barrett, vinegar manufacturers of Chicago, Minneapolis and Bangor, Maine, died recently in Jacksonville, Florida, at the age of sixty-eight.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANTS
1905	782,739	Emil Fischer, Berlin, Germany	E. Merck, Darmstadt, Germany	C-C-dialkylbarbituric acid and process of making same	Antoine Chiris Co., 18 Platt St., New York
1906	837,017	Carl Auer von Welsbach, Vienna, Austria	Treibacher Chemische Werke Gesellschaft, m. b. h., of Treibach Austria Hungary	Pyrophoric alloy	The Pfanstiehl Company, Inc., North Chicago, Ill.
1913	1,075,171	Albrecht Thiele and Georg Wichmann of Berlin, Germany	Chemische Fabrik auf Actien (vorm. E. Schering), of Berlin, Germany	Process for the manufacture of 2-phenylquinolin-4-carboxylic acid	Calco Chemical Co., Bound Brook, N. J.
1912	1,043,349	Heinrich Ostwald of Cologne, Germany		Ball mill	F. L. Smidth & Co., 50 Church St., New York

The Marden, Orth and Hastings Corporation has obtained control of the Calco Chemical Company, a $7,000,000 corporation of New Jersey. The Calco Company was incorporated in 1916, and since then has been engaged in manufacturing dyes, intermediates and other chemicals.

The American Cellulose and Chemical Co., Ltd., capitalized at $25,000,000, has filed application for a charter at Dover, Del., and will deal in cellulose and its products. The incorporators are Henry J. Bigham of New York City, Frank C. Williams, New Rochelle, N. Y., and Oscar R. Houston of Great Neck Station, N. Y.

An important private company has been registered in London, England, under the title of the British Cellulose and Chemical Manufacturing Parent Company with a capital of $17,500,000. The board of directors includes Herbert McGowan of Nobel's Explosives, Sir Trevor Dawson, of Vickers, Ltd., which company it is rumored is about to merge with the British Dyes, Ltd.

The Edible Cocoanut Oil Corporation of Wilmington, Delaware, has applied for a Delaware charter to manufacture perfumes and derivatives of cocoanut oil. It has a capital of $10,000,000. The incorporators are C. L. Rimbinger, M. M. Clancy and F. A. Armstrong.

Chemical industry in Japan is growing rapidly. A number of new companies have been organized to manufacture a variety of substances including ammonium sulfate, potassium chloride, potassium sulfate, bleaching powder, nitric acid and dyes. The manufacture of chlorate of potash is an important industry which has developed since the war, and it is reported that the quantity shipped to this country from Yokohama during this period exceeds 10,000 barrels. Another industry that has made remarkable progress is the extraction of vegetable wax, the output of which amounts to about $850,000 per year.

Chemicals for war purposes will be manufactured at Saltville, Virginia, in a $250,000 plant which the War Department has decided to build there for operation with the Mathieson Alkali Works. Preparations have begun for constructing the necessary buildings.

The recent action of the President in fixing the price of aluminum calls attention to the rapid growth of this industry in the United States. The great increase in our production in this line places the United States far in the lead among the aluminum-producing countries of the world. In fact, about one-half of the world's output of aluminum is now produced in the United States. Bauxite, the mineral from which most of the world's aluminum is produced, is found in many parts of this country, though the bulk of that now used in the industry is the product of the State of Arkansas.

Secretary of the Interior Lane has designated Bartlesville, Okla., as the location of the new experimental station of the Bureau of Mines for the investigation of problems relating to the petroleum and natural gas industries. The station is one of three new experimental stations for the establishment of which the sum of $75,000 was appropriated by the last Congress. The two other stations have been located at Minneapolis, Minn., for the study of iron and manganese problems, and at Columbus, Ohio, for research connected with the ceramic and clayworking industries.

In the April issue of THIS JOURNAL we printed a report, taken from *Drug and Chemical Markets* for March 13, that the Dow Chemical Company's plants at Midland and Mount Pleasant, Michigan, were to be commandeered by the Government. According to the *Oil, Paint and Drug Reporter* for March 18, and also for April 15, the Dow Chemical Company says that there is no foundation to the rumor.

We learn from *The Little Journal* for April that Mr. C. F. Eckart, a leading authority on sugar planting in Hawaii, has developed a process in the raising of sugar cane in Hawaii which reduces the cost of labor 50 to 70 per cent and increases the yield 28 per cent. His process consists in laying yard-wide strips of paper longitudinally over the rows, holding them in place by covering the edges with cane field trash. The paper must be strong enough to keep down the weeds but not strong enough to kill the young cane. Five or six weeks after applying the paper the weed seeds that could germinate have done so and their sprouts are smothered, while the shoots of the sugar cane, being stiff and sharp, have either come through the paper or show their presence by little tent-like elevation in the paper which can be slit with long knives by laborers passing between the rows. A pretty problem in industrial research was presented to the Arthur D. Little, Inc., laboratories when the question of making a paper from bagasse suitable for this purpose was put to them. Many sorts of paper have been made from bagasse but they have tended to be hard and tinny, whereas there was required here a paper which would be strong enough to withstand the Hawaiian rainfall and yet give way under constant, gentle pressure. Also it had to be dark in color and very, very cheap. This problem was solved and plans are being made for a paper mill to take care of Mr. Eckart's plantation. Some interesting pictures appear in *The Little Journal* comparing cane $4^1/_2$ months after planting, one showing cane which had received the Eckart treatment, another that which was cultivated and hoed in the usual manner.

According to the *Canadian Chemical Journal* another recent achievement of the American chemist is the perfecting of a process for treating cotton cloth for the making of a suitable gas mask for use in the second line trenches. A product has been found which withstands the effect of cold and hard usage. The aviation branch of the service presents many problems difficult to overcome, among the chief of which is the numbing effect upon the aviator of the cold, wind and rain at high altitudes. A Canadian chemist has perfected an invention whereby the inside of an outer garment can be kept at a comfortable temperature by means of a network of fine wires connected with a small electric generator in the machine. An American chemist has perfected a process of treating cotton cloth for garments so as to render it water-proof and unaffected by the low temperatures and high winds experienced at high altitudes.

Prof. A. W. Grabau, of Columbia University, addressing the New York Academy of Sciences recently at the American Museum of Natural History, commented on the world-wide need of potash, and said that "if Germany should lose Alsace a potash supply for many years would be assured to the rest of the world for a period long enough either to re-establish friendly relations, or, if that may not be, to bridge over the space of time which must elapse before the known non-German deposits can be made available or new deposits found by careful and systematic search."

Professor Grabau was speaking on "The Salt and Potash Deposits of Alsace-Lorraine and Their Significance in the Present Conflict." An exhaustive study which he has made of this subject shows that the potash deposits of Alsace consist of two beds of chloride of potassium which lie in an intercalated rock salt deposit nearly 800 feet thick. The total quantity of the impure potash salt is estimated at 1,500,000,000 tons, equivalent to 300,000,000 tons of pure potash.

Professor Grabau said in part:

"The world needs potash. In spite of arduous search no great potash deposits are known from accessible regions, and we must turn to the more expensive utilization of potash brines and potash-bearing minerals of refractory type. It is true that there are potash deposits in northeastern Spain, but they have not been made accessible, and it looks as if they would not be within reach for many years to come. There are potash salts in eastern Abyssinia and from them 20,000 tons a year have been obtained in recent times. But these are over fifty miles from the coast, and they must be transported on camel back across a country whose inhabitants are at best none too friendly. If Germany should lose Alsace, a potash supply for many years would be assured to the rest of the world."

The War Trade Board announces "List No. 1 of restricted imports," which establishes a prohibition against the bringing into this country, under certain conditions, of 82 commodities falling into the "less essential" category. Metals, foodstuffs, luxuries and other products not necessary to the war are placed under the ban, which became effective on April 15 and does not apply to rail shipments from Canada or Mexico of goods originating in these countries.

The list includes the following items of interest in the drug, chemical and dyestuff trade:

Asbestos, blacking, candle pitch, palm and other vegetable stearine.

All acids, muriate of ammonia, alcohol, tar distillates, except synthetic indigo, fusel oil or amylic alcohol, citrate of lime, all salts of soda except nitrate of soda and cyanide of soda.

Sumac, ground or unground, chicory root, raw or roasted, clocks, watches and parts thereof, cocoa and chocolate, prepared or manufactured.

Manufacturers of cotton, cryolite, except not to exceed 2,000 long tons for the year 1918.

Explosives, except fulminates and gunpowder, manure salts, fluorspar. All nuts except coconuts and products thereof. Gelatine and manufactures thereof, including all from Europe.

Sulfur oil or olive foots, grease, hay, honey, hops, infusorial and diatomaceous earth and tripoli.

Mantels for gas burners.

Matches, friction and lucifer.

Nickel.

Oilcake.

Oilcloth and linoleum for floors.

All expressed vegetable oils from Europe only.

Lemon oil.

Non-mineral paints and varnishes.

Photographic goods

Plumbago or graphite (until July 1, 1918, thereafter not exceeding 5,000 long tons for remainder of 1918).

Pyrites (except not exceeding 125,000 long tons to October 1, 1918).

Rennets, artificial silk and manufactures thereof.

Soap.

Tar and pitch of wood.

Vinegar.

Manufactures of wool.

Manufactures of hair of camel, goat and alpaca.

Zinc.

The United States consuls have been instructed not to issue consular invoices on and after April 15, 1918, for the articles mentioned in the list without first being furnished with the number of the import license or being given other evidence of the issuance of such license. Shipping agencies are also advised not to accept for shipment consignments of the articles mentioned in the list without similar evidence of the issuance of the import license. This applies only to the articles mentioned in the list.

A synthetic indigo plant now being erected by the National Aniline & Chemical Company, Inc., at Marcus Hook, Pa., is intended to cover at least half the requirements of the United States. Much of the equipment is now on the ground and is in course of erection. The buildings are now mainly completed. A few months hence it should be possible to undertake contracts for specific deliveries. The development of this important chemical industrial problem has been coördinated under the direction of Dr. E. S. Johnson of the Semet-Solvay Company, and Mr. Robert M. Strong, Chief Works Engineer of the Marcus Hook plant of the National Aniline & Chemical Company. When the European War broke out and the supply of indigo (an essential staple of the American textile colorist) was threatened with elimination, the General Chemical Company, The Barrett Manufacturing Company, and the Semet-Solvay Company, recognizing the chemical catastrophe represented by the lack of indigo, entered upon its coöperative development. Research men from each organization were delegated to conduct the necessary experimental investigations, and about eighteen months were consumed before, in the matter of quality and yields, the product of the great German plants had been equaled. A semi-commercial operation is now producing small quantities of indigo, in connection with the extensive installation now under way at Marcus Hook.

Recruits for poison gas offensive and defensive experimental work are being organized at the Case School of Applied Science in Cleveland. Interest in the work for the Government has been aroused by William Green, representative of the gas investigation department of the United States Bureau of Mines. He says the students who enlist will be placed in the Chemical Service Section of the Army. There are now about 150 members in this service and 750 are wanted.

Dr. S. W. McCallie, state geologist of Georgia, reports the discovery of an important deposit of organic asphaltum containing the organic matter from which certain grades of German dyes are made. The deposit was first discovered in a Georgia swamp, and Dr. McCallie says it is sufficiently large and easily accessible to justify an immediate commercial development to extract and market the dyes. It has been believed that the only deposit of this mineral in the United States was in Florida. The latest discovery is considered more extensive than the Florida deposit, in better position for mining, and it has easier access to the market.

The crushing of copra in New Orleans is becoming more and more extensive. The Southport Oil Mills, Ltd., have just taken over the large plant of the Orleans Cotton Oil Co., where they are crushing copra imported from the South Sea Islands through San Francisco. As a nucleus of a castor bean industry in Louisiana, a 3000-acre tract which was once a famous sugar-cane producing property, but idle for some time, is to be planted in castor beans.

Experiments were recently made in Sydney, at the instance of the Commonwealth Advisory Council of Science and Industry, as to the possibility of producing alcohol at a low cost from some natural products. A Sydney chemist has experimented with the Zamia palm, or, as it is popularly known, the Burrawong palm, which grows in great profusion along the Sea Coast of New South Wales. It is stated that the yield of alcohol from this plant is 45 gallons per ton of material.

Ault and Wiborg Company, Cincinnati, has increased its capital stock from $2,000,000 to $10,000,000 and is to materially enlarge its production of coal-tar dyes.

K. Arndt in the *Vossische Zeitung* for February 5, 1918, states that alcohol is being produced from calcium carbide. Acetylene is passed through acidified water, containing a mercury salt, whereby acetaldehyde is formed; the latter is vaporized, mixed with hydrogen and the mixture passed over a nickel catalyst, when alcohol results. Alternatively acetaldehyde is converted into acetic acid by passing the vapor, mixed with oxygen, over a nickel catalyst. It is stated that a plant is being built near Visp in Wallis, Switzerland, capable of an annual production of 100,000,000 kg. alcohol by this process, this being sufficient to cover the whole requirement of Switzerland.

Drug and Chemical Markets reports that a representative of the German War Committee for Oils and Fats recently addressed a meeting of the agriculturists and mill owners of the district of Solingen (Prussia) on the subject of the extraction of oil from the germ of grain. The speaker stated that although only 40 per cent of the German mills have so far made the necessary arrangements for the work, 1,321,000 gallons of oil have been obtained from this source in nine months. The germ contains 10 to 12 per cent of oil, which can be utilized for the production of margarine. After the extraction of the oil, the residue of the germ yields a valuable albuminous food. A still greater advantage resulting from the removal of the germ, said the speaker, is the impossibility of the flour obtained from the grain becoming musty. The flour is in no way inferior after the removal of the fatty substance; it bakes better and the bread does not so easily turn moldy.

According to *Drug and Chemical Markets*, a color which has not been obtainable in the United States since the war, and was formerly manufactured only in Germany, has made its appearance on the American market and is now made in this country. It is said that the American product cannot be differentiated from the German color formerly imported. The offer of Rhodamine B, the dye referred to, came as a surprise to the dye and textile trade and led to much speculation as to the source of the supply. Some incredulous dealers, who did not believe it could be made in America, suggested that the product was imported from Germany by way of Russia and Japan to the Pacific Coast. It is interesting to learn that the color is made by an expert who formerly made Rhodamine B in Europe, but his name and previous connections are kept secret for trade reasons.

Possibilities for increasing the supply of ferro-alloys were discussed in Washington on March 22 by makers of these products with representatives of the War Industries and War Trade Board. In the morning a group of chrome men met with Government officials and made a complete canvass of the situation. The aim of the conference was to devise measures of developing domestic production and eliminating dependence to the present extent on foreign sources. The manganese situation was discussed during the afternoon and tungsten also was taken up. L. L. Summers, head of the section on explosives and chemicals of the War Industries Board, was a leading figure at the manganese meeting, while that on chrome was in charge of Pope Yeatman of the raw material division.

A $5,000,000 plant, including a by-product coke oven and two blast furnaces, is to be erected for the St. Louis Coke and Chemical Company on a 300-acre tract of land in Madison County, Illinois. The location of the new plant was determined upon because of its nearness to coal supply and to numerous metal-consuming industries. An annual production of a million gallons of toluol will be among the products of the new plant.

The Allied Industries Corporation is a new undertaking launched for the purpose of permanently establishing American-made goods in seventy markets in foreign countries, the plan being to represent groups of manufacturers and sell their goods under their own trade-marks on a selling commission basis regulated by the amount of goods shipped and sold. The association is affiliated with the French-American Constructive Corporation which has secured business amounting to $140,000,000 for execution after the war. Included in the directorate of the new corporation are Alfred I., William and Francis I. du Pont of Wilmington, Delaware. The markets named by the company include the principal countries and colonies in Asia, Africa, Australia, eleven European countries, and South and Central America and the West Indies.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

CONGRESSIONAL COMMITTEES

Coal and Asphalt Deposits. Minutes of Senate Indian Affairs Committee hearing on the House Resolution 195 for the sale of coal and asphalt deposits on segregated mineral land in Choctaw and Chickasaw Nations, Okla. 64 pp. Dated January 10–17, 1918. The report of the committee to the Senate on this subject is Senate Report 207. Dated January 18. 4 pp.

Fuel in the United States. House Report 246. Submitted January 18. 2 pp. This is a Mines and Mining Committee report to the House of Representatives on House Resolution 7235 which relates to the uniform selection and purchase of fuel to be used in the United States.

PRESIDENTIAL PROCLAMATION

License of Ammonia Industry. 2 pp. Presidential Proclamation. Dated January 3. No. 1421.

SMITHSONIAN INSTITUTION

The Annual Report of the Board of Regents of the Smithsonian Institution. A volume of over 607 pp. which includes the following articles of chemical interest. The report is known as Publication 2449. Price, cloth $1.00.

(1) **Ideals of Chemical Investigation.** Theodore William Richards.

(2) **Molecular Structure and Life.** Amé Pictet.

(3) **The Earth, Its Figure, Dimensions, and Constitution of Its Interior.** T. C. Chamberlin, Harry Fielding Reid, John F. Hayford and Frank Schlesinger.

(4) **Petroleum Resources of United States.** Ralph Arnold.

(5) **Outlook for Iron** (with bibliography). James Furman Kemp.

(6) **On Origin of Meteorites.** Friedrich Berwerth.

(7) **Relation of Pure Science to Industrial Research.** J. J. Carty.

SUPERINTENDENT OF DOCUMENTS

Chemistry, Industrial Alcohol, and Preservatives. Pricelist 40, 9th Ed. 8 pp. This list covers the publications on these and related subjects which are for sale by the office of the Superintendent of Documents.

Mines, Explosives, Fuel, Gas, Gasoline and Petroleum. Pricelist 58, 5th Ed. 21 pp. This list covers the publications for sale by the Superintendent of Documents.

FEDERAL TRADE COMMISSION

Hide and Leather Situation. House Document 357. 5 pp. Issued January 24, 1918.

NATIONAL MUSEUM

Mineral Industries of United States: Coal, Resource and Its Full Utilization. CHESTER G. GILBERT AND J. E. POGUE. Bulletin 102. 4 pp.

PUBLIC HEALTH SERVICE

Stream Pollution. Public Health Bulletin 87. A digest of Judicial Decisions and a Compilation of Legislation Relating to the Subject.

Investigation of the Pollution of Certain Tidal Waters of New Jersey, New York, and Delaware, with Special Reference to Bathing Beaches and Shellfish-Bearing Areas. H. S. CUMMING. Public Health Bulletin 86. Issued December 1917.

Disinfectants, Their Use and Application in Prevention of Communicable Diseases. T. W. MCCLINTIC; revision by G. W. MCCOY, A. M. STIMSON AND H. E. HASSELTINE. Public Health Bulletin 42. 71 pp. Paper, 10 cents. Issued January 1918.

The Application of Ozone to the Purification of Swimming Pools. W. A. MANHEIMER. Public Health Reports, 33. 7 pp. Issued March 1.

Ozone when properly applied to the water of a swimming pool effectively purifies the water. When one part of ozone per million parts of water is used, the result is sterile water. When half part ozone per million parts of water is used, a bacterial reduction of 99.8 per cent results, except when too great an excess of air is introduced with the ozone.

A study of the cost of operation of the ozonator has shown that a current consumption of 2 kw. per day with alternating current and of 4 kw. per day with direct current, plus 1 cent a day for calcium chloride, represents the total operating cost for a 60,000-gal. pool. This amounts to 11 to 15 cents a day for alternating current (at 5 to 7 cents per kw.) and to 21 to 29 cents a day with direct current. The cost of refilling the pool is at least $30. The use of the ozonator decreases the number of times the pool must be emptied to such an extent that the cost of the installation is soon paid for.

The application of ozone to the purification of swimming pools is automatic in control, reliable in action, and inexpensive in application. Accordingly, we recommend the consideration of this chemical as a standard procedure in the sanitary control of swimming pools.

GEOLOGICAL SURVEY

The Flaxville Gravel and Its Relation to Other Terrace Gravels of the Northern Great Plains. A. J. COLLIER AND W. T. THOM. Professional Paper 108-J, from Shorter Contributions to General Geology, 1917. 6 pp. Published January 26, 1918.

Ore Deposits of the Northwestern Part of the Garnet Range, Montana. J. T. PARDEE. Bulletin 660-F, from Contributions to Economic Geology, 1917, Part 1. 81 pp. Published January 10, 1918.

The Dunkleberg Mining District, Granite County, Montana. J. T. PARDEE. Bulletin 660-G, from Contributions to Economic Geology, 1917, Part 1. 7 pp. Published December 27, 1917.

Strontianite Deposits near Barstow, California. A. KNOPF. Bulletin 660-I, from Contributions to Economic Geology, 1917, Part 1. 24 pp. Published January 18, 1918.

Possibilities for Manganese Ore on Certain Undeveloped Tracts in Shenandoah Valley, Virginia. D. F. HEWETT, G. W. STOSE, F. J. KATZ AND H. D. MISER. Bulletin 660-J. Prepared in coöperation with the Geological Survey of Virginia. From Contributions to Economic Geology, 1917, Part 1. 26 pp. Published January 21, 1918.

Phosphatic Oil Shales near Dell and Dillon, Beaver Head County, Montana. C. F. BOWEN. Bulletin 661-I, from Contributions to Economic Geology, 1917, Part 2. 6 pp. Published January 12, 1918.

Lode and Placer Mining on Seward Peninsula, Alaska. J. B. MERTIE, JR. Bulletin 662-I, from Mineral Resources of Alaska, 1916–I. 32 pp.

Geologic Structure of the Northwestern Part of the Pawhuska Quadrangle, Oklahoma. K. C. HEALD. Bulletin 691-C, from Contributions to Economic Geology, 1918, Part 2. 44 pp. Published February 7, 1918.

Gold, Silver, Copper, Lead, and Zinc in Colorado in 1916. Mines Report. C. W. HENDERSON. Separate from Mineral Resources of the United States, 1916, Part I. 58 pp. Published February 5.

Gold, Silver, Copper, Lead and Zinc in Utah in 1916. Mines Report. V. C. HEIKES. Separate from Mineral Resources of the United States, 1916, Part I. 35 pp. Published January 24.

Gold, Silver, Copper, Lead and Zinc in Nevada in 1916. Mines Report. V. C. HEIKES. Separate from Mineral Resources of the United States, 1916, Part I. 44 pp. Published January 19.

Arsenic, Bismuth, Selenium and Tellurium in 1916. J. B. UMPLEBY. Separate from Mineral Resources of the United States, 1916, Part I. 5 pp. Published February 2.

The production of arsenic in the United States in 1916, as in 1915, exceeded that of any previous year, amounting to 5,986 short tons, valued at $555,187, an increase over 1915 of less than 9 per cent in quantity and of nearly 84 per cent in value.

Imports of white arsenic and arsenic sulfide, or orpiment, decreased from 3,183 short tons to 2,163 short tons, or 32 per cent. Thus the total supply in 1916, as compared with 1915, fell from 8,681 short tons to 8,149 short tons.

Only two companies produced bismuth in 1916, the United Metals Refining Co. and the American Smelting & Refining Co., from plants located, respectively, at Grasselli, Ind., and Omaha, Neb. So far as known to the Geological Survey, ores from Tintic, Utah, supplied most of the metal, although some was also produced from flue dust shipped to Omaha by the Garfield, Utah, copper smelter. Only one carload of bismuth ore is known to have been shipped and this contained considerable gold, silver, and copper.

As in recent years, details of production cannot be given, although from data available it seems that the total output is not very different from that in 1915.

The New York price, as quoted in the *Engineering and Mining Journal*, ranged in 1916 from $3.15 to $4 a pound, or from 15 cents to $1.25 higher than during 1915.

The imports during the year were greater than in 1915, although lower than for several years previous thereto.

No new developments in the selenium industry came to the attention of the Geological Survey during 1916. It should be borne in mind, however, that this element has very exceptional photo-electric properties and may at any time be made the basis of some war or industrial invention which would greatly increase the demand for it. Selenium is obtained as a by-product in the refining of copper, and it is the opinion of copper metallurgists

that if market conditions warranted, its production in this country might be greatly increased.

The value of imports for consumption of selenium and salts of selenium rose from $59 in 1915 to $302 in 1916.

During 1916 the American Smelting & Refining Co was the only producer of selenium, as against two producers in 1915. The total output was somewhat greater, however, than in 1915.

Prices at the refinery averaged approximately $1.35 a pound, and on the New York market, according to the *Engineering and Mining Journal*, prices ranged from $2.50 to $5 a pound, largely depending on the quantity purchased.

No production of tellurium in 1916 was reported to the Geological Survey.

Borax in 1916. C. G. YALE AND H. S. GALE. Separate from Mineral Resources of the United States, 1916, Part II. 3 pp. Published January 7, 1918.

In 1916 the production of crude borate material in the United States was 103,525 short tons, valued at $2,409,459, compared with 67,003 short tons, valued at $1,677,099 in 1915, and 62,400 short tons, valued at $1,464,400 in 1914. All the crude borate material now used in this country is the mineral colemanite (calcium borate), and the output in 1916 came from a few mines in southern and southeastern California. The value of the product given is the value of the ore at the point of shipment estimated on a basis of $1 per unit (per cent) of anhydrous boric acid (boron trioxide, B_2O_3) in the raw material. All the ore shipped from California, however, was calcined or concentrated before being put on the cars at the mines.

Price quotations given in the trade journals show a gradual rise in the price of borax and boric acid, reaching about 7 or 8 cents a pound for borax and about 12 cents a pound for boric acid toward the close of 1916. It is understood that contracts for large quantities of borax were placed during the year at $5^3/_4$ cents a pound and that contracts for 1917 delivery were at $6^3/_4$ cents a pound.

Sulfur, Pyrite, and Sulfuric Acid in 1916. P. S. SMITH. Separate from Mineral Resources of the United States, 1916, Part II. 30 pp. Published January 23, 1918.

Some sulfur is imported by the United States, but usually it is less than 10 per cent of the quantity consumed, and during 1916 the great expansion in consumption made the imports relatively still less significant. More than 95 per cent of the sulfur imported is crude, and although it is the least expensive of the various forms of sulfur received, its value in 1916 was about 88 per cent of the combined value of all the sulfur imported in that year.

In 1913 the United States exported 89,221 long tons of sulfur, valued at $1,599,761; in 1914 the exports were 98,163 long tons, valued at $1,807,324; in 1915 they declined greatly and were only 37,312 long tons, valued at $724,679; in 1916, however, the exports increased to 128,755 long tons, valued at $2,505,857, or an increase of approximately 250 per cent in both quantity and value. From these figures it will be seen that in 1916 the exports exceeded the imports by 106,520 long tons and $2,101,073. The exports in 1916 were about 45 per cent greater than the exports in 1913, which may be taken as fairly representative of the normal conditions immediately before the war. The large quantity of sulfur exported was used chiefly for the manufacture of munitions and undoubtedly could be transported more advantageously in the form of sulfur than as explosives or sulfuric acid.

The demand in 1916 for pyrite to meet the unusual consumption of sulfuric acid created by the war increased notably over the demand in 1915. Never before was so much pyrite produced or imported by the United States, and prices increased throughout the year. Even with the stimulus of an increased demand and good prices, however, the number of pyrite mines in operation in the United States showed practically no increase. Six new producers were operating in 1916, but their plants were all small, several of them recovering the pyrite from coal, and their total yield was only about 2,000 tons. On the other hand, three mines that were in operation in 1915 and during that year yielded over 7,000 tons of pyrite, were idle in 1916, and at one of the former larger producers almost the entire year was spent in repairing the damage from the caving of the mine shaft, so that it produced much less than its normal output of pyrite.

The increase in production is therefore to be attributed to the greater yield from the old mines rather than to the opening of new deposits. This condition is believed to be due to the lack of initiative in attempting to find suitable deposits rather than to absence of undeveloped deposits of commercial value. The low cost of foreign pyrite, under normal conditions, has deterred the pyrite users from seeking a domestic supply and from encouraging the expenditure of the money necessary to prospect and develop properties that appear to promise success.

The domestic production of pyrite in 1916 was 423,556 long tons, valued at $1,965,702, an increase of about 30,000 long tons in quantity and of about $290,000 in value, as compared with the production in 1915. The consumption of pyrite ore in 1916—that is, the domestic production plus imports—amounted to about 1,670,000 long tons and was about 310,000 long tons greater than the consumption in 1915. This increase was largely attributable to the greater demand for sulfur in industries connected with the war and was made possible mainly because of increased imports.

Cement in 1916. E. F. BURCHARD. Separate from Mineral Resources of the United States, 1916, Part II. 35 pp. Published January 26, 1918.

The year 1916 proved a busy period for the cement industry in most parts of the United States. Labor troubles caused the temporary suspension of operations at a few Portland cement plants in the Mississippi Valley, but no plants were embarrassed by lack of business. In 1914 and 1915 there was a decrease in the production of cement, consumers having exercised strict economy in its use, but the year 1916 showed a reaction, it having opened with a demand unprecedented for a midwinter season. Prices of Portland cement, which averaged only 86 cents a barrel for the entire year 1915, began to rise toward the end of that year and continued to do so until well toward the close of 1916, so that the average price per barrel in bulk at the mills for the year was $1.103, an increase of 24.3 cents, or 28.3 per cent. The increased prices, of course, did not mean an equivalent net increase in returns to the manufacturers, because the cost of fuel, explosives, machinery parts, bags, labor, and in fact the costs of all the items that enter into the manufactured product rose considerably during the year. The comparatively high prices did not, however, check the demand for cement. Many manufacturers sold all they could produce and others drew heavily on stocks. The net decrease in stocks for the country at large was more than 3,000,000 barrels, or 27.1 per cent, as compared with the quantity on hand at the close of 1915. Every commercial district but one showed a decrease in stocks on hand.

The total quantity of Portland, natural, and puzzolan cements marketed or shipped from the mills in the United States in 1916 was 95,394,433 barrels, valued at $104,689,090, as compared with 87,685,222 barrels, valued at $75,155,102 in 1915. This represents an increase in quantity of 7,709,211 barrels, or 8.8 per cent, and an increase in value of $29,533,988, or 39.3 per cent.

Tin in 1916. A. KNOPF. Separate from Mineral Resources of the United States, 1916, Part I. 6 pp. Published February 6. The production of metallic tin of domestic origin in 1916 was approximately 140 short tons. As in recent years, this output

was derived almost wholly from Alaska. The main part of the Alaskan output was won by dredges operating in the York district, in the western part of Seward Peninsula, and the remainder was recovered incidentally to gold placer mining in the Hot Springs district, in the sector between Yukon and Tanana rivers. The bulk of the concentrate was shipped to Singapore to be smelted, but a part was sent to the recently completed tin-smelting plant at Perth Amboy, N. J.

The total importation of tin in 1916 was 74,619 short tons. Tin recovered from drosses and waste metals amounted to 17,400 tons. The total supply of primary and secondary tin in the United States, exclusive of a small quantity reduced from Alaskan concentrate, therefore amounted in 1916 to 92,019 tons.

The world's production of tin in 1916 was roundly 136,000 short tons, or slightly less than it has been in the preceding two years. The output of the various tin-producing regions is shown in the accompanying table. The figures given are based in the main on official reports, except those for Banca, Billiton, and Nigeria, which are taken from "Mineral Industry."

WORLD'S PRODUCTION OF TIN, 1914–1916, IN SHORT TONS

	1914	1915	1916
Federated Malay States	54,927	52,378	49,134
British Protected Malay States	4,000(*a*)	4,600	5,000
Bolivia	25,039	24,409	23,508
Banca	15,650	15,426	16,294
Billiton	4,480	6,440	5,600
China(*b*)	9,000	9,000	9,000
Siam(*c*)	7,600	8,700	9,400
Nigeria	5,059	5,102	5,684
Australia	5,400	5,400	5,400
Cornwall	5,663	5,564	4,200(*a*)
Union of South Africa	2,200	2,260	2,100
Other Countries	1,500	1,000	1,500
	140,518	140,279	136,320

(*a*) Estimate.
(*b*) Based on the estimate of the production of China for 1915 given by V. K. Ting ("China's Mineral Resources," *Far Eastern Rev.*, **13** (1917), 569.)
(*c*) Shipments to Straits Settlements.

Iron Ore, Pig Iron and Steel in 1916. E. F. BURCHARD. Separate from Mineral Resources of the United States, 1916, Part I. 58 pp. Published February 13. The iron ore, exclusive of that containing 5 per cent or more of manganese, mined in the United States in 1916 amounted to 75,167,672 gross tons, as compared with 55,526,490 gross tons mined in 1915, an increase of 19,641,182 gross tons, or 35 per cent. Beneficiated ore, instead of crude ore mined, is included, if the ore is treated in any way. The quantity of iron ore shipped from the mines in the United States in 1916 amounted to 77,870,553 gross tons, valued at $181,902,277, as compared with 55,493,100 gross tons, valued at $101,288,984, shipped in 1915. This represents an increase in quantity of 22,377,453 gross tons, or 40 per cent, and in value of $80,613,293, or 80 per cent. The average price of ore per ton for the whole country in 1916 was $2.34 as compared with $1.83 in 1915. These quantities of ore, both mined and shipped, include the iron ore used for fluxing other metallic ores at smelters in the Western States, but the shipments do not include the iron ore sold for the manufacture of paint. The quantity of iron ore sold for the manufacture of paint in 1916 amounted to 16,968 gross tons, valued at $45,256 or $2.67 per ton. In Arkansas one producer shipped 5 tons of loadstone, averaging 70.5 per cent of metallic iron, which was sold at a high price to manufacturing druggists. This shipment is not included in the tabulated statistics of iron ore. The ore reported as sold for fluxing other than in the manufacture of pig iron amounted to 88,601 gross tons, valued at $288,089 in 1916, as compared with 17,213 gross tons, valued at $27,456 in 1915. The domestic iron ore actually sold for the manufacture of pig iron amounted in 1916 to 77,781,952 gross tons, valued at $181,614,188 as compared with 55,475,887 gross tons, valued at $101,261,528 in 1915.

According to reports to the United States Geological Survey by the manufacturers, the shipments of pig iron, exclusive of ferro-alloys, in 1916 amounted to 39,126,324 gross tons, valued f. o. b. at the furnaces at $663,478,118, as compared with 30,384,486 tons, valued at $401,409,604 in 1915, an increase in quantity of 8,741,838 tons, or 29 per cent, and in value of $262,068,514, or 65 per cent. The average price per ton in 1916 was $16.96, and in 1915 it was $13.21, an increase in 1916 of $3.75 a ton, or 28 per cent. These values represent the approximate price per ton f. o. b. at the furnaces; this approximate price eliminates freight costs, selling commissions, and other items, which are included in the market prices of certain grades of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Africa, Canada, Chile, Cuba, Nova Scotia, Spain, and Sweden, although it constitutes a very small percentage of the total production, is considerable, as it is calculated that the shipments derived from foreign ore in 1916 amounted to 764,850 gross tons, valued at $15,996,756, as compared with 945,022 tons, valued at $13,011,950 in 1915. In the manufacture in 1916 of 727,550 gross tons of pig iron, 1,295,518 gross tons of foreign iron ore were reported to have been used, thus indicating an average pig-iron yield of 56.16 per cent, as compared with the quantity of imported ore. Domestic ore, including 4,036,022 tons of cinder, scale, scrap, etc., and amounting to 74,805,359 gross tons, was reported in 1916 as used in the manufacture of 37,974,413 tons of pig iron, thus indicating a yield of 50.76 per cent in pig iron from the domestic materials.

The statistics of production of the principal grades of pig iron have been published by the American Iron and Steel Institute for 1916, as follows:

GRADE	GROSS TONS
Bessemer and low phosphorus	14,422,457
Basic (mineral fuel)	17,684,087
Forge pig iron	348,344
Foundry and ferrosilicon	5,553,644
Malleable	921,486
Spiegeleisen	194,002
Ferromanganese	221,532
White, mottled, direct castings, etc.	89,245
TOTAL	39,434,797

In the following table are given the statistics of the American Iron and Steel Institute showing the production of pig iron, according to the fuel used for 1916. The charcoal figures include small quantities of pig iron made with charcoal and electricity. The total includes small quantities of ferro-alloys made with electricity, coke and electricity, etc.

FUEL USED	PIG IRON PRODUCED GROSS TONS
Bituminous, chiefly coke	38,844,598
Anthracite and coke	217,788
Anthracite alone	...
Charcoal	372,411
TOTAL	39,434,797

The following table gives an incomplete outline of the sales of ferro-alloys in the United States in 1914, 1915 and 1916:

FERRO ALLOYS OF DOMESTIC MANUFACTURE SOLD IN 1914, 1915 AND 1916

VARIETY OF ALLOY	1914 Quantity Gross Tons	1914 Value	1915 Quantity Gross Tons	1915 Value	1916 Quantity Gross Tons	1916 Value
Ferromanganese	100,731	$4,440,283	144,260	$9,283,443	224,103	$30,123,493
Spiegeleisen	76,625	1,586,139	114,556	2,403,580	182,837	6,188,202
Ferrosilicon					166,308	
Ferrophosphorus	77,182	1,621,830	128,263	2,595,265	1,966	5,273,088
Ferrochrome(*a*)						
Ferromolybdenum						
Ferrovanadium	986	1,702,033	1,565	3,198,137	3,574	8,226,989
Ferrotungsten (80 per cent or more tungsten)						
TOTALS	255,524	$9,350,285	388,644	$17,480,385	580,788	$50,281,992

(*a*) No ferrochrome reported for 1914 or 1915.

FERRO ALLOYS IMPORTED FOR CONSUMPTION IN THE UNITED STATES IN 1914, 1915 AND 1916

VARIETY OF ALLOY	1914 Quantity Gross Tons	1914 Value	1915 Quantity Gross Tons	1915 Value	1916 Quantity Gross Tons	1916 Value
Chrome or chromium and ferrochrome	200	$21,553	32	$1,662	16	$1,998
Ferrophosphorus	26	1,136	12	617	.	.
Ferrosilicon	6,249	341,925	5,128	311,249	6,740	384,384
Molybdenum and ferromolybdenum	0 10	59	.	203	....	. .
Titanium and ferrotitanium	18	8,356	....	....	100	8,126
Tungsten and ferrotungsten	195	222,447	7	9,588	38	157,711
Ferromanganese	82,997	3,619,607	55,263	3,333,699	90,928	9,240,528
Spiegeleisen	2,870	71,147	200	5,110	....	....
TOTALS	92,555.10	$4,286,230	60,642	$3,662,098	97,816	$9,792,747

BUREAU OF THE CENSUS

Census of Manufactures, 1914: Petroleum Refining. 13 pp. One of a series of bulletins being issued by the Bureau, presenting statistics of industries concerning which inquiries were made at the quinquennial census of manufactures in 1914. Statistics are presented in three sections: Summary and analysis giving general data compiled for industry; special statistics, relating to materials, products, and methods of manufacture; and State tables giving comparative summary, by States, for 1904, 1909 and 1914, and detailed statistics for industry, by States, 1914.

BUREAU OF EDUCATION

Higher Technical Education in Foreign Countries, Standards and Scope. A. TOLMAN SMITH AND W. S. JESIEN. Bulletin 11, 1917. 121 pp. Paper, 20 cents.

BUREAU OF LABOR STATISTICS

Trend of Accident Frequency Rates in Iron and Steel Industry during the War Period, by Causes. L. W. CHANEY. From Monthly Review of Bureau of Labor Statistics, December 1917. 5 pp.

BUREAU OF MINES

Suggestions for the Safe Operation of Gasoline Engines in Mines. R. H. KUDLICH AND E. HIGGINS. Technical Paper 174. 19 pp. Paper, 5 cents.

Blast-Furnace Breakouts, Explosions, and Slips, and Methods of Prevention. F. H. WILLCOX. Bulletin 130. 267 pp. Paper, 30 cents.

The Mining Industry in the Territory of Alaska During the Calendar Year 1916. S. S. SMITH. Bulletin 153. 85 pp. Paper, 15 cents.

Cost Accounting for Oil Producers. C. G. SMITH. Bulletin 158. 117 pp. Price, 15 cents.

Occupational Hazards at Blast-Furnace Plants and Accident Prevention Based on Records of Accidents at Blast Furnaces in Pennsylvania in 1915. F. H. WILLCOX. Bulletin 140. 145 pp. Paper, 30 cents. This report was prepared under a cooperative agreement with the Pennsylvania Department of Labor and Industry.

Firing Bituminous Coals in Large House-Heating Boilers. S. B. FLAGG. Technical Paper 180. 15 pp. Paper, 5 cents.

Combustion of Coal and Design of Furnaces. H. KREISINGER, C. E. AUGUSTINE AND F. K. OVITZ. Bulletin 135. 138 pp. Paper, 20 cents. The material presented consists mainly of the description of about 100 tests made in the special furnace having a long combustion space, tabulated and plotted results of these tests, and the discussion of these results with deductions furnishing the basis for rational furnace design. The tests were made with three kinds of coal, namely, Pocohontas, Pittsburgh, and Illinois coal. The coals were burned at five rates—20, 30, 40, 50, and 60 lbs. per sq. ft. of grate per hour. Several tests were made with each coal at each rate of combustion, each test being run with a different percentage of excess air.

The material is arranged in four parts: the first part contains the description of the apparatus and the methods of conducting the experiments; the second part gives the results of the experiments, explains their meaning and points out their practical application; the third part consists of discussions of miscellaneous observations; and the fourth part contains a discussion of the process of combustion in the combustion space and of the laws that govern it.

Determination of Unsaturated Hydrocarbons in Gasoline. E. W. DEAN AND H. H. HILL. Technical Paper 181. 20 pp. Paper, 5 cents. The experiments described herein have dealt chiefly with the estimation of unsaturated constituents in mixtures which also contain paraffin or paraffin and aromatic hydrocarbons. Allowance has been made for the presence of aromatics in only the moderate proportion usual with petroleum products. The problem of estimating aromatic constituents is not considered, as none of the experiments recently performed has shown any method to be better than that described in a recent paper by Rittman, Twomey and Egloff.[1]

Flotation of Chalcopyrite in Chalcopyrite-Pyrrhotite Ores of Southern Oregon. W. H. COGHILL. Technical Paper 182. 7 pp. Paper, 5 cents. "Gravitation methods of concentrating the copper-bearing mineral cannot be applied, because the gangue sulfides have practically the same density as chalcopyrite. Magnetic separation does not seem practicable—assuming that the gangue sulfides can be made to respond naturally or by a preliminary treatment to an electromagnet—because fine grinding is required to liberate the mineral grains. The methods of concentration now in vogue are hand sorting and jigging which eliminate some of the siliceous gangue. An inspection of the smelter returns in the possession of mine operators gives the impression that the average grade of ore shipped runs 10 per cent copper.

"The experiments on separating the chalcopyrite from the gangue by flotation have been carried through the preliminary laboratory stage with flattering results."

New Views of the Combustion of the Volatile Matter in Coal. S. H. KATZ. Technical Paper 183. 9 pp. Paper, 5 cents.

Accidents at Metallurgical Works in the United States During the Calendar Year 1916. Compiled by A. H. FAY. Technical Paper 201. 16 pp. Paper, 5 cents.

Concentration Experiments with the Siliceous Red Hematite of the Birmingham District, Alabama. J. T. SINGEWALD, JR. Bulletin 110. 68 pp. Paper, 15 cents.

BUREAU OF ORDNANCE

Microscopic Examination of Steel. Reprint. 47 pp. Paper 15 cents.

BUREAU OF STANDARDS

Wave-Length Measurements in Spectra from 5600 Å. to 9600 Å. W. F. MEGGERS. Scientific Paper 312. 25 pp. Paper, 10 cents. Published January 16, 1918.

Specific Heat of Liquid Ammonia. N. S. OSBORNE AND M. S. VAN DUSEN. Scientific Paper 313. 36 pp. Paper, 5 cents. Published December 13, 1917. "The results of the determinations by the two independent methods have been expressed by the following two empirical equations:

$$\text{First method } \sigma = 5.0931 - 0.00864\,\theta + \frac{17.329}{\sqrt{133 - \theta}} \qquad (A)$$

$$\text{Second method } \sigma = 5.1858 - 0.00850\,\theta + \frac{16.350}{\sqrt{133 - \theta}} \qquad (B)$$

[1] W. F. Rittman, T. J. Twomey and Gustav Egloff, "The Estimation of Aromatic Hydrocarbons in Cracked Petroleum Mixtures," *Met. and Chem. Eng.*, **13** (1915), 682–686.

where the positive value of the square root is to be used. * * * The greatest difference between the mean results by both methods and the results of either method as represented by empirical equations is seen to be less than 1 part in 1000."

Latent Heat of Vaporization of Ammonia. N. S. OSBORNE AND M. S. VAN DUSEN. Scientific Paper 315. 34 pp. Paper, 10 cents. Published December 21, 1917. "As a final result the latent heat of vaporization of ammonia, that is, the heat in joules per gram required to convert saturated liquid into saturated vapor at constant temperature is expressed in the range —42 to 52° C. by the equation: $L = 137.91\sqrt{133 - \theta} - 2.466\,(133 - \theta)$. If the latent heat of vaporization be expressed in calories per gram, taking 1 calorie = 4.183 joules, the equation becomes $L = 32.968\sqrt{133 - \theta} - 0.5895\,(133 - \theta)$.

Gas Interferometer Calibration. J. D. EDWARDS. Scientific Paper 316. 5 pp. Paper, 5 cents. Published December 8, 1917. "The method here proposed requires no special apparatus and only a knowledge of the refractive indices of the gases which are to be used. The calibration is accomplished by filling both chambers of the interferometer with dry air free from carbon dioxide, and determining the scale reading when the pressure in one chamber is reduced by known amounts."

Wire Gauges. ANONYMOUS. Circular 67. 5 pp. Paper, 5 cents. Published January 17, 1918.

Paint and Varnish. ANONYMOUS. Circular 69. 82 pp. Paper, 15 cents. Published November 17, 1917. "This publication is intended to give in a general way, without unnecessary detail, such information as would be valuable to various people who desire information upon this subject. While the composition and methods of manufacture of paint may not in every case be essential, it is believed that a broad knowledge of these subjects will, in general, lead to a more intelligent selection and application of paints. On the other hand, little reference will be made in this Circular to methods of analysis, which would be useful only to persons engaged in the manufacture or testing of paints." For varnishes, the raw materials, methods of manufacture and of testing, and the procedure of application are described. Similar information is given for paints but with most attention to the nature, sources, and characteristics of the paint pigments. Various whites, blacks, reds, yellows, browns, blues, greens, and bronzes are discussed.

Materials for the Household. ANONYMOUS. Circular 70. 254 pp. Paper, 25 cents. Published December 5, 1917. "This circular describes the more common materials, other than foods and drugs, used in the home. A previous circular in this series described household measurements and a third circular (now in preparation) treats of household safety. The present circular relates to the quality and use of materials. While written primarily for the household, it may incidentally interest dealers in materials for the household, who should be in close touch with its needs, and teachers of home economics who are training future home makers in scientific home management.

"The purpose of the circular is practical: (1) To stimulate the interest in household materials, (2) to explain the nature of their desirable properties, (3) to aid in their intelligent selection, and (4) to promote their effective use and preservation. A better utilization of materials will aid the efficient administration of the home and promote the health and comfort of the household. Home economics is of growing interest at this time. The subject is of universal and permanent concern, and when its importance is realized it must become a factor of primary importance to national well-being. The excellent instruction in the subject now given in high schools and colleges begins a new era in home management."

The following is a list of the most important subjects discussed: Clay products, wood, metals, lime, cement, plasters and stucco, paints, paint oils, and varnishes, bituminous roofing, rubber, leather, textiles, paper, inks, adhesives, water, soap, miscellaneous cleansing agents, bluing and starch, materials for fireproofing cotton fabrics, polishes, disinfectants, preservatives, fuels, illuminants and lubricants, and quantity in the purchase and use of materials.

Table of Equivalents—Millimeters to Inches. ANONYMOUS. Supplement to Bureau of Standards Circular 47. 10 pp. Paper, 5 cents. Published October 27, 1917.

Properties of Portland Cement Having a High Magnesia Content. P. H. BATES. Technologic Paper 102. 42 pp. Paper, 15 cents. Published January 19, 1918. "It is not to be thought that this investigation was intended to show the desirability of increasing the amount of magnesia now allowed by the standard specifications. Its primary purpose was to determine what new constituents, if any, were produced in clinker by increasing the magnesia content, also how this latter increase affects the constituents already present, and, finally, to correlate the quantitative changes in the amounts of the various constituents with the changes which would be produced in the general physical properties of the cement.

"Portland cement with a magnesia content of about 9.50 per cent may be burned in a rotary kiln without producing a clinker materially different from one containing less than 4 per cent. The clinkering temperature will be reduced somewhat, however. With greater amounts of magnesia present the resulting clinker is very vitreous and dusts more or less slowly, the rapidity and amount of dusting increasing with the magnesia content.

"The strengths developed, either by the neat cement or 1 : 3 sand mortar or $1 : 1^1/_2 : 4^1/_2$ gravel concrete, show that cements containing as much as 7.5 per cent of magnesia are satisfactory. It would be impossible to predict from the strength tests at the end of one and one-half years which were the cements containing low magnesia or magnesia up to 7.5 per cent. With higher amounts the strengths developed decreased with increased magnesia, but even with the high-magnesia cements there is a noticeable increase of strength with age."

Typical Case of the Deterioration of Muntz Metal (60 : 40 Brass) by Selective Corrosion. H. S. RAWDON. Technologic Paper 103, 28 pp. Paper, 10 cents. Published December 15, 1917. "One very common type of deterioration of metal of this composition, particularly when exposed to some electrolyte (*e. g.*, sea water), is selective corrosion or 'dezincification,' the term 'selective corrosion' being used to signify a corrosive attack of certain of the microstructural constituents of the alloy rather than a general uniform action upon the metal as a whole. Though this type of deterioration of brass has been known for years and numerous references on this subject have appeared in the technical literature, the description of the various forms in which it may occur and of the changes produced in the metal by which it may be detected are very meager. The numerous samples illustrative of this type of metal failure submitted to this Bureau for examination, together with the inquiries received on this subject, suggested the utility of a description of typical cases of metal affected by this type of nonferrous corrosion as an aid in the detection and identification of similar cases of this type of deterioration of metals. A study of the various forms in which this type of corrosion may occur, together with the resulting structural changes within the metal, also aids in defining the conditions which are most favorable for such deterioration to occur."

Safety for the Household. Circular 75. 127 pp. Paper, 15 cents. This is a popularized description of hazards commonly occurring in the home from fire, electricity, lightning, gas, chemicals, etc.; suggested precautions and rules for emergencies are given.

COMMERCE REPORTS, FEBRUARY, 1918

Exports of **pulp** and **paper** from Canada have increased from about $8,000,000 in 1910 to $43,000,000 in 1917, and are expected to reach $60,000,000 in 1918. (P. 419)

Hardened **whale fat** has been used in margarine in Denmark for three years, and is now being introduced into Norway. (P. 439)

Salt is produced by solar evaporation at Aden under particularly favorable conditions, owing to the low rainfall and humidity. (P. 456)

New deposits of **manganese ore** being developed in Brazil contain over 300,000 tons of ore with 45 to 50 per cent manganese. (P. 522)

Production of **lignite** in Italy shows a marked increase. (P. 550)

The annual mineral output of the Rio Jinto district in Spain has increased to 6,000,000 tons, principally of **copper-iron ores.** The ore is roasted in McDougal furnaces, and then smelted to blister copper, of which the output is 15,000 to 20,000 tons. Only a small part of the sulfur is recovered as **sulfuric acid** of which nearly 14,000 tons were made in 1914. **Antimony graphite** and **manganese ores** are also obtained in this district. (Pp. 568–573)

The reported securing of 257 **dye recipes** from Germany is treated lightly in England, since it is recognized that much more than a knowledge of "recipes" is necessary for a successful dye industry. Progress in the British dye industry has been very great, but the problem of providing adequate plant facilities and material and labor has not yet been solved. (Pp. 580–2)

The **zinc industry** of Japan has made great progress since 1914, so that Japan is now exporting large quantities of zinc, instead of importing. (P. 600)

Exports of **tungsten ore** and **antimony** from China show marked increases. (P. 602)

Salt is obtained in India from rock salt mines, brine lakes, and sea water. The latter method is not very successful, owing to the high humidity. (P. 638)

Tungsten deposits in Hongkong include several outcrops with as much as 18 per cent. (P. 663)

Plans are being made to increase the **quinine** output of India, especially by the cultivation of cinchona plants of high quinine content. (P. 726)

Both total output and output per acre of **sugar beets** in Canada show a marked increase. (P. 729)

An enormous increase has been made in Germany in the output of **vegetable drying plants,** especially dried potatoes, cabbage and turnips.

SPECIAL SUPPLEMENTS ISSUED IN FEBRUARY

Italy Sup. 84; Dominican Republic Sup. 262; Venezuela Sup. 480; British India Sup. 504; Ceylon Sup. 514; Zanzibar Sup. 786

STATISTICS OF EXPORTS TO THE UNITED STATES

JAPAN (P. 363): Copper, Antimony, Manganese ore, Ferromanganese, Molybdenum ore, Ferrosilicon, Tungsten ore, Ferrotungsten, Zinc dust, Indium ore

PALERMO (P. 664): Citric acid, Mannite, Olive oil soap stock, Sumac, Tartar

VENEZUELA Sup. 482: Bones, Copaiba, Divi-divi, Hides, Sugar, Fustic

BORDEAUX (P. 676): Alcohol, Tartar, Rubber, Olive oil, Paper, Rags, Hides, Cream

RUSSIA (P. 788): Hides, Licorice root, Potassium carbonate, Sugar beet seed

DOMINICAN REPUBLIC Sup. 266: Dividivi, Logwood, Hides, Sugar, Fustic, Mangrove, Glycerine, Copra

TURIN, ITALY Sup. 80: Glue, Hides, Reclaimed rubber, Artificial silk, Talc, Asbestos yarn

BRITISH INDIA Sup. 505: Hides, Indigo, Jute, Lac, Linseed, Castor beans

CEYLON Sup. 514: Citronella oil, Coconut oil, Paprin, Croton seeds, Graphite, Rubber

COMMERCE REPORTS, MARCH, 1918

Efforts are being made to arrange for increased exports of **graphite** from Madagascar to the United States. (P. 788)

Exports of **soya-bean oil** from Manchuria to the United States increased from about 45,000,000 pounds in 1916 to nearly 200,000,000 pounds in 1917. (P. 806)

A factory for the manufacture of **caffeine** from tea is being erected in Formosa. (P. 841)

Early in the war, the British government bought up the available supply of **natural indigo,** *viz.*, 267 tons, which has since been sold, thus preventing a shortage. (P. 853)

A substitute for **absorbent cotton** for surgical dressings is being made in Sweden from **wood pulp.** (P. 867)

Use of **gas for motor traction** is increasing greatly in England, where it is predicted that its use will become permanent, using later, however, compressed gas instead of as now gas at nearly atmospheric pressure in flexible holders. (P. 946)

One British private firm of **dyestuff** manufacturers is producing more dyes than all other British companies combined, including the government-controlled British Dyes, Ltd. (P. 1000)

Investigation by the Bureau of Standards upon **anti-freezing solutions** for automobile radiators led to the conclusion that (1) calcium chloride solutions should be used with caution if at all, on account of their corrosive action; (2) kerosene or similar oils should not be used on account of their inflammability, high boiling point, and effect on rubber; (3) mixtures of alcohol and glycerine, though satisfactory, are precluded by the need for glycerine for munitions; and (4) aqueous solutions of wood alcohol or denatured alcohol form the most desirable anti-freezing solutions. (P. 1042)

A new **oil seed** of a species of strephonema found in Belgian Congo yields about 40 per cent of a soft, yellow fat, probably edible. The residual meal contains appreciable tannin and is hence not suitable for cattle food. (P. 1092)

Efforts are being made in South Africa to develop the manufacture of **potash** from sea-weed, of a variety known as "seabamboo," which is lower in potash content than American seaweed. (P. 1107)

Although there are a number of **manganese** properties in Eastern Cuba, only a few can be operated at a profit. **Production is,** however, increasing. (P. 1146)

Large amounts of **orchid liquor,** obtained from the lichen *Roccella tinctoria,* are imported into the United States from the Cape Verde Islands. (P. 1163)

The British Government has contracted for the entire **copper** output of Australia up to June 30, 1918, estimated at from 15,000 to 20,000 tons. (P. 1197)

SPECIAL SUPPLEMENTS ISSUED IN MARCH

France Sup. 84; Cuba Sup. 84; French West Indies Sup. 84; Argentine Sup. 84; Hongkong Sup. 524; Australia Sup. 604; French East Africa Sup. 704; Portuguese East Africa Sup. 704

STATISTICS OF EXPORTS TO THE UNITED STATES

SINGAPORE (P. 1026): Gambier, Gum copal, Gum damar, Gutta gelotong, Gutta percha, Gutta siak, Hide, Mangrove bark, Rubber, Tin

PANAMA (P. 893): Balata, Copra, Gold, Hides, Ipecac, Maguey fiber, Rubber, Tallow

CUBA Sup. 584: Beeswax, Potassium carbonate, Hides, Molasses, Sugar, Asphalt, Alcohol

LONDON (P. 838): Rubber, Tin, Hides, Indigo, Platinum

HONGKONG Sup. 524: Chemicals, Hides, Peanut oil, Aniseed, Castor oil, Straw, Tin, Tungsten ore

AUSTRALIA Sup. 604: Casein, Hides, Manganese ore, Concentrates, Eucalyptus oil, Tin, Zinc ore

MADAGASCAR Sup. 704: Beeswax, Graphite, Hides

ARGENTINE Sup. 884: Beeswax, Bones, Casein, Glycerine, Ipecac, Tartar, Copper, Tankage, Glue stock, Grease, Guano, Hides, Leather, Linseed, Mica, Castor oil, Petitgrain oil, Stearin, Tungsten ore, Quebracho, Rubber, Tallow, Zinc

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Alcohol: Practical Handbook on the Distillation of Alcohol from Farm Products and Denaturing. F. B. WRIGHT. 271 pp. Price, $1.50. Spon & Chamberlain, New York.

Analysis: A Manual of Qualitative Chemical Analysis. J. R. MORTON. 12mo. 189 pp. Price, $1.25. Sir Isaac Pitman & Sons, New York.

Artificial Dyestuffs, Their Nature, Manufacture and Uses. A. R. RAMSEY AND H. C. WESTON. 8vo. 212 pp. Price, $1.60. E. P. Dutton & Co., New York.

Carbon and Its Allies. R. M. CRAVEN. 8vo. 489 pp Price, 15s. Charles Griffin & Co., London

Chemical Industry in France: L'Avenir de l'industrie chimique en France. A. KLING. 8vo. Chaix, Paris.

Chemical Physiology: Directions for a Practical Course in Chemical Physiology. W. CRAMER. 3rd Ed. 12mo. 119 pp. Price, $1.00. Longmans, Green & Co., New York.

Chemistry: Cours expérimental de chimie. M. GRANDMONTAGNE. 8vo. 250 pp. Price, 2 fr. 25. Larousse, Paris.

Chemistry: The Laboratory Study of Chemistry. H. R. SMITH AND H. M. MESS. 8vo. 256 pp. Price, $1.20. Henry Holt & Co., New York.

Chemistry: Treatise on Applied Analytical Chemistry. V. VILLAVECCHIA. 8vo. Price, 21s. J. and A. Churchill, London.

Coal: Chemistry of Coal. MYLES BROWN. 8vo. 75 pp. Price, 1s. 6d. Thomas Wall & Sons, London.

Coal Distillation, Gasification and By-Products. J. E. CHRISTOPHER. 8vo. 90 pp. Price, 2s. 6d. Science and Art of Mining, London.

Coal Gas Residuals. F. H. WAGNER. 2nd Ed. 8vo 214 pp. Price, $2.50. McGraw-Hill Book Co., New York.

Coal Tar: The Treasure of Coal Tar. ALEX. FINDLAY. 8vo. 151 pp. Price, 4s. 6d. G. Allen & Unwin, London.

Coal Tar Distillation. A. R WARNER. 8vo. 314 pp. Price, $3.50. D. Van Nostrand Co., New York.

Colliery Sinking. JAMES KEEN. 8vo. 48 pp. Price, 1s. Thomas Wall & Sons, London.

Dyeing and Cleaning. F. J. FARRELL. 4th Ed. 8vo. 263 pp. Price, 5s. Charles Griffin & Co., London.

Economic Geology: The Principles of Economic Geology. W. H. EMMONS. 8vo. 606 pp. Price, $4.00. McGraw-Hill Book Co., New York.

Electrodynamic Wave Theory of Physical Forces. T. J. J. SEE. 4to. 170 pp. Price, $5.00. T. P. Nichols & Son, Lynn, Mass.

Engineering: Applied Mechanics. H. AUGHTIE. 8vo. 227 pp. Price, 2s. 6d. G. Routledge & Sons, London.

Engineering: Elements of Sanitary Engineering. MANSFIELD MERRIMAN. 4th Ed. 8vo. 250 pp. Price, $2.00. John Wiley & Sons, Inc., New York.

Flour Milling: A Theoretical and Practical Handbook. P. A. KOSMIN. 8vo. 584 pp. Price, $7.50. D. Van Nostrand Co., New York.

Geologic Handbook of the Miami Mining District. E. S. PERRY. 30 pp. Price, $1.00. The Author, Miami, Okla.

Glass and Glass Manufacture. PERCIVAL MARSON. 8vo. 138 pp. Price, 2s. Sir Isaac Pitman & Sons, London and New York.

Heat Engines: Elementary Manual on Heat Engines: Steam, Gas and Oil. ANDREW JAMIESON. 15th Ed. 8vo. 390 pp. Price, 3s. 6d. Charles Griffin & Co., London.

Liquid Fuels for Internal Combustion Engines. H. MOORE. 8vo. 215 pp. Price, 12s. 6d. Crosby Lockwood & Son, London.

Materials: An Elementary Outline of Mechanical Processes Giving a Brief Account of the Materials Used in Engineering Construction. G. W. DANFORTH 8vo 423 pp. Price, $3.75. U. S Naval Institute, Annapolis.

Mechanical Engineer's Pocket Book of Tables, Formulae, Etc. D. K. CLARKE. 10th Ed. 18mo. 768 pp. Price, 6s. Crosby Lockwood & Son, London.

Mechanical Laboratory Methods. J C SMALLWOOD. 2nd Ed 12mo 399 pp. Price, $3.00 D Van Nostrand Co , New York.

Metallurgy: La Situation de notre métallurgie. R. MANDUIT. 8vo 88 pp Price, 3 francs Recueil Sirey, Paris.

Mine Gases and Gas Testing. J. W. MCTRUSTY. 2nd Ed 8vo 174 pp. Price, 2s 6d Science and Art of Mining, London

Powdered Coal as Fuel. C. F. HERINGTON. 8vo. 211 pp Price, $3.00. D. Van Nostrand Co., New York.

Proteins: The Physical Chemistry of the Proteins. T B. ROBERTSON 8vo 483 pp Price, $5.00 Longmans, Green & Co , New York

Rubber: Its Production, Chemistry and Synthesis. A. DUBOSC AND A. LETTRINGER 8vo 394 pp. Price, 21s. Charles Griffin & Co., London.

Rubber: A Wonder Book of Rubber. B. F GOODRICH RUBBER CO 12mo 72 pp Gratis The Company, Akron, Ohio

Salt: A History and Description of the Manufacture and Mining of Salt in New York State. C J. WERNER 8vo. 144 pp Price, $7.60 The Author, Huntington, N. Y.

Science and Industry. R. T. GLAZEBROOK. 12mo. 51 pp. Price, $0.50. G. P. Putnam's Sons, New York

Soil Physics and Management. J. G. MOSIER AND A. F. GUSTAFSON. 8vo. 442 pp. Price, $2.00. J. B. Lippincott Co., Philadelphia.

Sugar: Manual de fabricantes de azucar de cana y guimicos azucareros. G. L. SPENCER. 16mo. 617 pp. Price, $5.00. John Wiley & Sons, Inc., New York.

Tables: A. B. C. Five-Figure Logarithms and Tables for Chemists. C. J. WOODWARD. 18mo. 76 pp. Price, 3s. E. and F. N. Spon, London, and Spon & Chamberlain, New York

Waste in Modern Boiler Rooms, Finding and Stopping. G. H. GIBSON AND P. S LYON. 12mo. 274 pp. Price, $1.00. Harrison Safety Boiler Works, Philadelphia.

RECENT JOURNAL ARTICLES

Acetone and Lime. M E. FREUDENHEIM. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 3, pp. 184–193.

Alcohol and Soda-Lime. B. H. CARROLL. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 2, pp. 128–149.

Alcohol from Sulfite-Pulp Waste Liquor. ELLWOOD HENDRICK. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 7, pp. 360–362.

Alundum Manufacture and Use. M. A. WILLIAMSON. *The Metal Industry*, Vol. 16 (1918), No. 3, pp. 128–129.

Ammonia: Recovering Ammonia at Tar-Distilling Plants. C. R. WOODWARD. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 6, pp. 299–301.

Black Dyes. C. S. WEHRLY. *Color Trade Journal*, Vol. 2 (1918), No. 3, pp. 118–120.

Burning Slack Containing Excessive Moisture. J. F. MCCALL. *Power*, Vol. 47 (1918), No. 14, pp. 472–473.

By-Product Oven—A Paradox. W. H. BLAUVELT. *The Iron Trade Review*, Vol. 62 (1918), No. 11, pp. 659–664.

Caffeine: About Caffeine-Free Coffee. C. W TRIGG. *The Tea and Coffee Trade Journal*, Vol. 34 (1918), No. 3, pp. 233–235.

Chrome Production and Distribution. S. H. DOLBEAR. *Engineering and Mining Journal*, Vol. 105 (1918), No. 14, pp. 634–635.

Coal: Combustion Characteristics of Coals. J. G. WORKER. *The Electric Journal*, Vol 15 (1918), No. 4, pp. 120–123.

Coke as a Fuel for the Blast Furnace. G. W. HEWSON. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 4, pp. 60–63.

Coke Breeze: Development in Burning Coke Breeze. JOHN VAN BRUNT. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 4, pp. 179–180.

Colloidal Chemistry in Papermaking. W. M. BOYARD *Paper*, Vol. 22 (1918), No. 3, pp. 11–16.

Copper: Determination of Non-Sulfide Copper. C. E. VAN BARNEVELD AND E. S. LEAVER. *Mining and Scientific Press*, Vol. 116 (1918), No. 10, pp. 339–340.

Copper: The Physical Properties of Copper and the Factors by Which They are Affected. P D MERICA *Metallurgical and Chemical Engineering*, Vol 18 (1918), No 7, pp 357–360

Dyestuff Testing in the Textile Industry. E W. PILRGE. *Textile World Journal*, Vol. 53 (1918), No. 39, pp. 29–31.

Electricity in Beet-Sugar Factories. E. M. ELLIS. *General Electric Review*, Vol 21 (1918), No. 3, pp. 188–195.

Electroplating Engineering. C B WILLMORE *The Metal Industry*, Vol 16 (1918), No. 3, pp. 117–119.

Fats and Fatty Acids from Petroleum. R J MOORE AND G. EGLOFF. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 6, pp. 308–311.

Fatty Acids: Determination of Fatty Acids in Butter Fat. E. B HOLLAND AND J P BUCKLEY, JR *Journal of Agricultural Research*, Vol 12 (1918), No 11, pp 719–732

Fuel: Methods for More Efficiently Utilizing Our Fuel Resources. ESKIL BERG. *General Electric Review*, Vol 21 (1918), No. 3, pp. 216–221

Fuel Resources of Canada with Reference to the Pulp and Paper Industry. B F HANSEL *Pulp and Paper Magazine*, Vol 16 (1918), No 10, pp. 225–228

Gas: Making Substitutions for Natural Gas. F DENK *The Blast Furnace and Steel Plant*, Vol 6 (1918), No 4, pp 186–188

Nitric Acid and Copper Ore. C. C. WESTBY. *Metallurgical and Chemical Engineering*, Vol 18 (1918), No 6 pp 290–296

Nitric and Mixed Acids. W E BURKHARD *The General Chemical Bulletin*, Vol 4 (1918) No 5, pp 224–226

Nitro Dyes. J M MATTHEWS *Color Trade Journal*, Vol 2 (1918), No. 4, pp 157–162

Oil Shale of Colorado. R L CHASE *Mining and Scientific Press*, Vol. 116 (1918), No 13, pp 445–446

Ore and Coal Bridges. H D JAMES *The Electric Journal*, Vol 15 (1918), No 4, pp 110–114

Pyrometry and Its Several Limitations. C B TIRING *The American Drop Forger*, Vol 4 (1918), No 5, pp 108–112

MARKET REPORT—APRIL, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON APRIL 10, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lb.	4.00	@	4.50
Aluminum Sulfate, iron free	Lb.	3 1/4	@	3 1/2
Ammonium Carbonate, domestic	Lb.	nominal		
Ammonium Chloride, white	Lb.	18	@	19
Aqua Ammonia, 26° drums	Lb.	25	@	26
Arsenic, white	Lb.	16 3/4	@	17
Barium Chloride	Ton	65.00	@	85.00
Barium Nitrate	Lb.	9 1/2	@	11
Barytes, prime white, foreign	Ton	40.00	@	45.00
Bleaching Powder, 35 per cent	100 Lbs.	2.25	@	2.50
Blue Vitriol	Lb.	9	@	9 1/4
Borax, crystals, in bags	Lb.	7 3/4	@	8 3/4
Boric Acid, powdered crystals	Lb.	13 3/4	@	15
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	85
Calcium Chloride, lump, 70 to 75% fused	Ton	27.50	@	30.00
Caustic Soda, 76 per cent	100 Lbs.	5.00	@	5.25
Chalk, light precipitated	Lb.	4 3/4	@	5
China Clay, imported	Ton	18.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	1.75	@	3.00
Green Vitriol, bulk	100 Lbs.	1.15	@	1.25
Hydrochloric Acid, commercial, 20°	Lb.	2 3/4	@	2 3/4
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	18
Lead Nitrate	Lb.	nominal		
Litharge, American	Lb.	9 1/2	@	11
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	22
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	8 1/2	@	9
Nitric Acid, 42°	Lb.	9	@	10
Phosphoric Acid, 48/50%	Lb.	8	@	10
Phosphorus, yellow	Lb.	1.50	@	1.60
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate, casks	Lb.	45	@	47
Potassium Bromide, granular	Lb.	1.35	@	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	40	@	50
Potassium Chlorate, crystals, spot	Lb.	37	@	38
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	83 1/2	@	84
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	28	@	30
Potassium Permanganate, bulk	Lb.	4.00	@	4.10
Quicksilver, flask	75 Lbs.	123.00	@	125.00
Red Lead, American, dry	Lb.	10	@	10 1/2
Salt Cake, glass makers'	Ton	22.00	@	25.00
Silver Nitrate	Oz.	61	@	63
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.55	@	2.65
Sodium Acetate	Lb.	23	@	24
Sodium Bicarbonate, domestic	100 Lbs.	2.80	@	3.00
Sodium Bichromate	Lb.	22	@	23
Sodium Chlorate	Lb.	24	@	25
Sodium Cyanide	Lb.	40	@	43
Sodium Fluoride, commercial	Lb.	18	@	19
Sodium Hyposulfite	100 Lbs.	2.25	@	2.50
Sodium Nitrate, 95 per cent, spot	100 Lbs.	nominal		
Sodium Silicate, liquid, 40° Bé	100 Lbs.	2.25	@	2.50
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal		
Sodium Bisulfite, powdered	Lb.	5 1/2	@	6
Strontium Nitrate	Lb.	22	@	28
Sulfur, flowers, sublimed	100 Lbs.	4.05	@	4.50
Sulfur, roll	100 Lbs.	3.70	@	4.10
Sulfuric Acid, chamber 66° Bé	Ton	37.50	@	40.00
Sulfuric Acid, oleum (fuming)	Ton	65.00	@	75.00
Talc, American white	Ton	15.00	@	18.00
Terra Alba, American, No. 1	100 Lbs.	1.17 1/2		
Tin Bichloride, 50°	Lb.	23 1/4	@	24
Tin Oxide	Lb.	78	@	80
White Lead, American, dry	Lb.	9	@	9 1/2
Zinc Carbonate	Lb.	28	@	30
Zinc Chloride, commercial	Lb.	12 1/2	@	14
Zinc Oxide, American process XX	Lb.	14	@	15

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	75	@	79
Acetic Acid, 56 per cent, in bbls	Lb.	nominal		
Acetic Acid, glacial, 99 1/4%, in carboys	Lb.	nominal		
Acetone, drums	Lb.	nominal		
Alcohol, denatured, 180 proof	Gal.	68	@	69
Alcohol, grain, 188 proof	Gal.	4.85	@	4.90
Alcohol, wood, 95 per cent, refined	Gal.	91	@	92
Amyl Acetate	Gal.	5.00	@	5.50
Aniline Oil, drums extra	Lb.	26	@	28
Benzoic Acid, ex-toluol	Lb.	4.25	@	4.50
Benzol, pure	Gal.	30	@	35
Camphor, refined in bulk, bbls	Lb.	98 1/2	@	99
Carbolic Acid, U. S. P., crystals, drums	Lb.	53	@	55
Carbon Bisulfide	Lb.	8	@	8 1/2
Carbon Tetrachloride, drums extra	Lb.	15 1/2	@	16
Chloroform	Lb.	65	@	65
Citric Acid, domestic, crystals	Lb.	90	@	91
Creosote, beechwood	Lb.	1.90	@	2.00
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	7 1/2	@	8 1/2
Dextrine, imported potato	Lb.	19	@	20
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde 40 per cent	Lb.	19 1/2	@	20
Glycerine, dynamite, drums included	Lb.	65	@	66
Oxalic Acid, in casks	Lb.	43	@	45
Pyrogallic Acid, resublimed, bulk	Lb.	3.15	@	3.25
Salicylic Acid, U. S. P.	Lb.	90	@	1.00
Starch, cassava	Lb.	—		
Starch, corn (carloads, less pearl)	100 Lbs.	6.30	@	6.45
Starch, potato, Japanese	Lb.	10 1/2	@	11
Starch, rice	Lb.	8	@	10
Starch, sago flour	Lb.	8 1/2	@	9
Starch, wheat	Lb.	5	@	6
Tannic Acid, commercial	Lb.	50	@	60
Tartaric Acid, crystals	Lb.	77	@	80

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	59	@	63
Black Mineral Oil, 29 gravity	Gal.	21	@	22
Castor Oil, No. 3	Lb.	33	@	34
Ceresin, yellow	Lb.	15	@	18
Corn Oil, crude	100 Lbs.	18.70	@	18.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17 1/2	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.40	@	20.50
Menhaden Oil, crude (southern)	Gal.	1.00	@	1.02
Neat's-foot Oil, 20°	Gal.	3.15	@	3.20
Paraffin, crude, 118 to 120 m. p.	Lb.	10	@	10 1/4
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs	Bbl.	6.20		
Rosin Oil, first run	Gal.	41	@	—
Shellac, T. N.	Lb.	62	@	64
Spermaceti, cake	Lb.	31	@	33
Sperm Oil, bleached winter, 38°	Gal.	2.18	@	2.20
Spindle Oil, No. 200	Gal.	36	@	37
Stearic Acid, double-pressed	Lb.	23	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	32	@	33
Turpentine, spirits of	Gal.	40 1/2	@	42

METALS

Aluminum, No. 1 ingots	Lb.	32	@	33
Antimony, ordinary	Lb.	12 1/4	@	12 1/2
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	23 1/2	@	—
Copper, lake	Lb.	23 1/2	@	—
Lead, N. Y.	Lb.	7	@	7 1/4
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	93 3/4	@	94
Tin, Straits	Lb.	nominal		
Tungsten WO_3	Per Unit	20.00	@	26.00
Zinc, N. Y.	Lb.	7 3/4	@	8

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.75		
Blood, dried, f. o. b. Chicago	Unit	6.70	@	6.75
Bone, 3 and 50, ground, raw	Ton	35.00	@	40.00
Calcium Cyanamid	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	nominal		
Phosphate Acid, 16 per cent	Ton	16.00	@	17.00
Phosphate rock, f. o. b. mine:	Ton	nominal		
Florida land pebble, 68 per cent	Ton	3.25	@	3.50
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	310.00	@	335.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high grade, f. o. b. Chicago	Unit	6.50		

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | JUNE 1, 1918 | No. 6

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- America in Safe Hands ... 418
- Washington Notes ... 418
- An Inglorious Rout ... 419
- Prophecy and Fulfilment ... 419
- The Great Gamble ... 419
- Typical German Pronouncements ... 420c
- Research and the Tar Baby ... 420d

SOCIÉTÉ DE CHIMIE INDUSTRIELLE:
- Conditions of the French Chemical Industries during 1916. F. J. LeMaistre ... 421
- The Great Effort of the French Industries. Marcel Knecht ... 423

ORIGINAL PAPERS:
- The Quantitative Estimation of Anthraquinone. Harry F. Lewis ... 425
- Critical Elaboration of Quantitative Precipitation Methods. H. Heidenhain ... 426
- Improved Methods for the Estimation of Sodium and Potassium. S. N. Rhue ... 429
- A Comparative Study of the Thermal Decomposition of Coal and of Some of the Products of Its Carbonization. M. C. Whitaker and John Richard Suydam, Jr. ... 431
- The Influence of Cold Shock in the Sterilization of Canned Foods. L. D. Bushnell ... 432
- Detection of Added Color in Butter or Oleomargarine. Herbert A. Lubs ... 436
- An Accurate Loss-on-Ignition Method for the Determination of Organic Matter in Soils. J. B. Rather. 439
- The Agricultural Availability of Raw Ground Phosphate Rock. William H. Waggaman and C. R. Wagner ... 442
- Upon the Action of Tetrazodi-*o*-Tolylmethane Chloride upon Naphthol and Naphthylamine Sulfo Acids. James H. Stebbins, Jr. ... 445
- Method of Calculating Comparative Strength and Efficiency of High Explosives from Their Composition and Apparent Densities. Charles E. Waller ... 448
- Para Cymene. I—Nitration. Mononitrocymene, 1-CH_3, 2-NO_2, 4-$CH(CH_3)_2$. C. E. Andrews ... 453
- Effect of Acetylene on Oxidation of Ammonia to Nitric Acid. Guy B. Taylor and Julian H. Capps ... 457

LABORATORY AND PLANT:
- A Rocking Electric Brass Furnace. H. W. Gillett and A. E. Rhoads ... 459
- A Summary of the Proposals for the Utilization of Niter Cake. John Johnston ... 468
- Chemical Tests for the Detection of Rancidity. Robert H. Kerr ... 471
- Notes on the Color Designation of Oil Varnishes. F. A. Wertz ... 475

ADDRESSES:
- Planning a Research Laboratory for an Industry. C. E. K. Mees ... 476
- The Ammonia Program for 1918. Charles W. Merrill. 480
- American Chemists Welcomed by the Cercle de la Chimie ... 482

WILLARD GIBBS MEDAL AWARD:
- Introductory Address. L. M. Tolman ... 483
- Medal Address. Chemistry in the Petroleum Industry. William M. Burton ... 484

CURRENT INDUSTRIAL NEWS:
- A New Copper Area; Electric Zinc Furnace; Electrical Energy from the Volterra "Soffioni;" Utilization of Fish Oil; Australian Gelatine, Glue and Size; Pure Cyanamide; Indigo Crop of India; Gypsum Deposit in a Boiler; Reactions of Acetylene; Magnesites; Water Lubrication of Gas Exhausters; Utilization of Waste Sulfite Lye; Coal Saving; British Board of Trade ... 487

SCIENTIFIC SOCIETIES:
- Annual Meeting of the Chemists' Club; American Electrochemical Society; Sixth National Textile Exposition; New York Section, American Chemical Society; North Carolina Academy of Science and North Carolina Section of the American Chemical Society; National Fertilizer Association; Alabama Technical Association and the Alabama Section of the American Chemical Society; American Leather Chemists' Association; American Institute of Chemical Engineers; Research as an Aid to Industrial Efficiency; Calendar of Meetings; Annual Meeting of the American Chemical Society ... 489

NOTES AND CORRESPONDENCE:
- Women's National League for the Conservation of Platinum; Searles Lake Open to Lease Application; A Letter from France; The Association of British Chemical Manufacturers; Conservation of Alcohol, Glycerin, and Sugar as Used in Medicines; High-Grade Technical Men and Skilled Operatives Wanted for United States Army Ordnance ... 494

WASHINGTON LETTER ... 496

OBITUARIES ... 498

PERSONAL NOTES ... 499

INDUSTRIAL NOTES ... 501

GOVERNMENT PUBLICATIONS ... 503

BOOK REVIEWS ... 504

NEW PUBLICATIONS ... 505

MARKET REPORT ... 506

EDITORIALS

AMERICA IN SAFE HANDS

As Chairman of the Committee of the AMERICAN CHEMICAL SOCIETY advisory to the United States Bureau of Mines it was our fortunate privilege, through the courteous invitation of Director Van. H. Manning, to be present at the opening conference between the leaders of the various lines of work at the Bureau of Mines Experiment Station located at American University and the National Committee advisory to that Experiment Station. In the afternoon an inspection was made of the entire Experiment Station plant, where field demonstrations were given of the various products there evolved.

Utmost secrecy was enjoined as to every feature of the day's program, but permission has been given to speak editorially of the impressions gathered on that most memorable day. Permission was sought because it was desired to share with the chemists of the country some of the inspiration, confidence, and enthusiasm gained.

These feelings were begot primarily by the sight of the men gathered around the conference table. Without attempting a complete enumeration we would mention the presence of Director Manning, the following members of the Advisory Committee: Doctors Nichols, Venable, Talbot, Franklin, Hoskins and Parsons (Dr. T. W. Richards joined the group the following day), and representative leaders of the Experiment Station work, among whom were Burrell, Bancroft, Norris, W. K. Lewis, Cottrell, Hulett, Jennings, Kohler, Richter, Reid, Frazier, Fieldner, Cheney, Henderson, Rowland, Winternitz, Underhill, Hunt, Marshall. The Chemical Service was represented by Lieutenant Colonel Bogert, and there were present distinguished members of the War and Navy Departments.

A glance over this group of more than fifty men thrilled us with the thought of how great an asset America possesses in her chemists, men who with characteristic American agility have changed their whole train of thought from the accustomed subjects of research to those pressing problems of modern warfare upon whose prompt and efficient solution depends so much the success of our fighting forces.

That this thought transference has already borne much fruit, despite the brief period of activity, was shown at the Experiment Station grounds, where every phase of the work was under full headway. In these days of difficulty in procuring material and equipment it was amazing to see how rapidly the work has grown since its inception by a few foresighted men in the Bureau of Mines, immediately upon our entrance into the war. Financed during the early months solely from the funds of that Bureau, its resources have now been greatly increased by large appropriations from the War and Navy Departments. In spite of the necessity of constant expansion there was evidenced no slightest sacrifice of the painstaking accuracy of the most careful research.

The field demonstrations constituted an eye-opener to all of the uninitiated, and yet as we look back, that which impressed us most was the fine *esprit de corps* which has been developed, the harmonious coöperation of all divisions of the work and the complete sinking of self in the spirit of service to the cause in which we are enlisted.

Some day when these buildings are dismantled and when the men return to their peaceful pursuit of science, the full story of this work must be written and published to the world. It will prove one of the most striking narratives of these stirring days and constitute one of the most glorious tributes to the genius of the American chemist.

WASHINGTON NOTES

A three-day sojourn in Washington furnished so many topics for editorial discussion that limited space necessitates brevity. Hence the following condensed notes:

1—A Spring Meeting of the AMERICAN CHEMICAL SOCIETY was unnecessary. Go to Washington any old day—you couldn't tell the difference.

2—The colors of the Society, cobalt-blue and golden yellow, have changed their function from the decorative feature of banquet menu cards to the more appropriate rôle of the distinctive hat-cord now worn by the enlisted men of the Chemical Service Section under due authorization from the Secretary of War. Stand by the colors!

3—Lieutenant Colonel Bogert, head of the Chemical Service Section in this country, is no longer with the National Research Council or the War Industries Board, but is quartered in Unit F, Corridor 5, Floor 3, 7th and B Streets, N. W., Washington, D. C.

4—The authorized quota for the Chemical Service Section has been increased to a total personnel of something over 1300.

5—Organization is sufficiently perfected and the needs of the situation are so clearly understood that the assignment of all chemists in the present draft to chemical work is assured. The stock of perforated filters for such assignment has fortunately been exhausted.

6—There is an error somewhere. Major G. F. Tyler, of the office of Assistant Secretary of War Crowell stated that it was the conviction of the War Department that chemists in camps must be transferred to chemical work because of the scarcity of chemists. In answer to our suggestion that there were still some three hundred chemists in camps he stated that the records had been carefully gone over and that not more than fourteen or fifteen remained. A return visit to Secretary Parsons' office confirmed the three hundred idea, gained originally from the careful records which the Secretary has kept since the census of sixteen thousand chemists was compiled. Get together Messrs. Major and Secretary and compare notes. Perhaps it would simplify matters if the Major would adopt the method of the chemist and refilter the solution

7—Serious thought is being given to the matter of the training of chemical reserves. With so many professors engaged upon war research and no instructors exempted in the draft because of the character of their work, the possibility of such reserves is very slight. Yet in various other ways we are preparing for a long war.

8—The Mineral and Ore Control Bill, already passed by the House and now before the Senate, embodies two important principles: the release of shipping for transport of men and supplies to France, and the furtherance of national self-containedness. Why not extend its scope to products other than minerals?

9—With the passage of this bill in sight, the Railroad Administration, in the interest of economy, discharges the industrial agents, among them the very men who last September at the Chemical Exposition brought the undeveloped mineral resources of the South to the attention of the country and particularly of the chemists who best understood the rational methods for their development. Think again, Mr. McAdoo. An automobile would be an inefficient means of progress were it not provided with reverse gear as well as forward gears.

10—We heard that the "Garabed" had too much juice turned on and the machine broke down, necessitating extensive repairs before its exhibition to the committee of eminent scientists. Meanwhile the matter of winning the war continues to be prosecuted vigorously by the usual methods, which, though perhaps to be rendered obsolete by the use of "Garabed," nevertheless impart at the present time a greater feeling of confidence.

AN INGLORIOUS ROUT

Among the many difficulties the new American dyestuff industry has had to overcome, none has been more nagging, more malicious, and less founded on fact than the prejudice engendered by the oft-heard phrase "American dyes are not fast." That this propaganda has been quietly and subtly promoted by those who wished to preserve for post-bellum days the American market for German dyestuffs has been understood by those who knew the facts. But the propagandists capitalized our national weakness for the "imported" brand, and the one-time prevalent belief that the Germans possessed certain magical secrets which enabled them alone to make dyes worthy of confidence. Our good people of the trade fostered their designs by placarding their goods with such statements as "The color of these goods cannot be guaranteed."

It was the old story of "giving a good dog a bad name," and against this propaganda counterstatements have proved of little avail. However, the poisonous slander received its effective antidote during the recent Textile Exposition in New York City, in the clear, legitimate, and efficient demonstration by the National Aniline and Chemical Co., Inc., of the relative qualities of American and German dyestuffs. Comparative exhibits were made of fabrics dyed with foreign and domestic products, and subsequently subjected to similar conditions approximating those of daily use. In this contest the American products fully held their own. To meet the possible criticism that the tests may not have been genuine, a dyestuff laboratory was installed, and there, upon request, comparative experiments were carried out before the eyes of the skeptical. Here, too, the results substantiated all that the most ardent advocate of the American industry had claimed. Now the press is doing its part in publishing these facts to the world. Another German drive has been stopped, and as the exhibit and laboratory travel to various cities it is safe to predict that the drive will be turned into an inglorious rout.

PROPHECY AND FULFILMENT

We received a letter recently from a former member of the chemistry staff of the Medical School of the University of Minnesota. The heading reads "Somewhere in France, March 24, 1918," and the concluding paragraph follows:

> As the Regimental Gas Officer I find plenty to do and also find my chemical training and experience most valuable assets both when at the front and when in training. While *en repos* I conduct a Gas School for the Officers and N. C. O's. * * My lecture room is the rear room of a French café; our campus, the great outdoors of untilled fields; our laboratories, the battlefield and gas-shelled areas; and our source of demonstration material is No Man's Land where the only cost of material is the nerve to go after and the energy necessary to carry away what is found and desired. * * *
>
> Sincerely,
> (Signed) ROBERT A. HALL,
> Lt. Inft., N. A.,
> Regimental Gas Officer,
> 18th Infantry, A. E. F.

The following excerpt from "General Orders No. 15," dated one week later than the above letter, gives a prophetic coloring to the reference to the "source of demonstration material."

> Headquarters First Division
> American Expeditionary Forces
> France, March 31, 1918
>
> General Orders No. 15
>
> The Division Commander cites the gallant conduct of the following officers and men:
>
> * * * * 2nd Lieut. Robert A. Hall, N. A., 18th Infantry, "voluntarily went into No Man's Land on two occasions: once to bring back the body of an American soldier, again to secure equipment left by the enemy."
>
> By command of Major General Bullard,
> (Signed) H. K. LOUGHRY,
> Major, F. A., N. A.,
> Division Adjutant.
>
> [Seal]
> "*Official:*
> *First Division American Expeditionary Forces.*"

Here's to Dr. Hall! And here's to his comrades in the Service! Keep up the good work.

THE GREAT GAMBLE

> "Of course, the first duty, the duty that we must keep in the foreground of our thought until it is accomplished, is to win the war. I have heard gentlemen say recently that we must get five million men ready. Why limit it to five million?"
> —*The New York Times*, May 19, 1918

Thus spoke the President of the United States at the great Red Cross meeting in New York City on the

evening of May 18, 1918. Our answer to the President's question is that, should a limitation of the size of our armed forces ever become necessary, it will not be due to lack of determination on the part of the American people to win the war, nor to unwillingness to sacrifice their lives, nor to any disposition to withhold the smallest fraction of the Nation's wealth; but a limitation may be forced upon us by inability to manufacture sufficient ammunition, and this matter depends directly upon our output of sulfuric and nitric acids, and the extent of manufacture of these two fundamental war necessities is indissolubly bound up in the matter of our available supplies of platinum.

But, it may be argued, platinum was commandeered on March 1, 1918. So it was; and on May 15 the press throughout the country carried the announcement that platinum had again been commandeered. Why this duplication of commandeering orders? The answer is simple. In the preparation of the original order someone blundered in two regards—first, in failing to include iridium within the scope of the order; second, in assuming that manufacturing jewelers would comply with the spirit and intent of the order and hold hands off, which some did not, as set forth by excerpts from the jewelers' own publications in the May issue of THIS JOURNAL, in an editorial entitled "Platinum Scraps." Those charged with building a dam across the platinum stream to store up its waters extended the dam two-thirds of its needed length (the importers and refiners) whereupon through the remaining open space (the manufacturing jewelers) platinum flowed into the already green fields of non-essential adornment of the *nouveau riche*, while the builders of the dam rested contentedly upon their labors, oblivious to the possibility of a drought and to the important rôle of this rare metal in the winning of the war.

A VISIT TO MR. CONNER

On Tuesday, May 14, we called at the offices of the War Industries Board in Washington and received a copy of the latest commandeering order from Mr. C. H. Conner, in charge of platinum for that Board. Iridium and palladium were included in the order but, *mirabile dictu*, the dam had not yet reached the opposite shore, for while jewelers were this time specifically mentioned, nevertheless twenty-five per cent of the stocks thus commandeered was released for commercial usage, on condition that the holders waive any liability of the Government for the remaining seventy-five per cent. Some bargain that! And the dam had been purposely built short of completion, for, in reply to our remonstrances, Mr. Conner asserted his conviction that the present measure would furnish adequate supplies for ammunition manufacture (though President Wilson asks why the number of men to be equipped should be limited to five million, and though the estimated sufficiency of the seventy-five per cent to be held was determined in advance of the inventory of stocks, forms for which inventory were sent out along with the commandeering order). In support of the wisdom and justice of the new order Mr. Conner gave all of the stock arguments of the jewelers: Theirs is a great industry which should not be suddenly shut off from its supplies (as if the jewelers were dependent largely upon platinum for a livelihood); ten thousand skilled workmen and their families would be deprived of a living wage (as if there was not work, and crying work to-day for every able-bodied man in America); it may be possible still to get some platinum from Russia in exchange for food and clothing (as if conditions in Russia could be depended upon for anything); and we will get some from Colombia (as if German money and plotting could never possibly cripple our supplies from that source). Holding such views it was only natural that Mr. Conner should take strong exception to the patriotic and unceasingly vigorous campaign being conducted by the Women's National League for the Conservation of Platinum, under the able and fearless leadership of its chairman, Mrs. Ellwood B. Spear, of Cambridge, Mass. Thus is begun the great gamble, under official authorization, between the paltry profits of the jewelers and the limitation of the number of men in our army—unless some of the future drafts fight without ammunition and without supporting artillery, depending for their offense and defense upon the bayonet alone.

SOME AUTHORITATIVE STATEMENTS

Feeling that we might possibly be unduly apprehensive, at the same time clearly mindful that there had already been several other woeful miscalculations in Washington by those clothed with direct authority, we sought the views of those in best position in other Government circles to give authoritative statements. Such statements were promptly furnished and are reproduced here, fully confirming our apprehension.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
Washington

May 16, 1918

Office of the Director

DR. CHARLES H. HERTY, Editor,
Journal of Industrial & Engineering Chemistry,
35 East 41st St., New York, N. Y.

My dear Dr. Herty:

The facts of serious shortage in platinum supply are beyond question: The largest source, Russia, cut off, our domestic production only a fraction of 1 per cent of our needs, and our military requirements increasing at a rate that no one can foresee, the remedy, and the only remedy is to cut out non-essential uses one hundred per cent, not at some future date, but now, and of these non-essential uses jewelry is first and greatest.

What meaning is there in a national thrift campaign when any luxury maker is allowed to make and sell his wares, the material of which is absolutely needed in the processes of manufacture of munitions needed by our Army in France? What less patriotic use can be made of excess profits than buying platinum rings and platinum cigarette cases and platinum mesh bags? A Hoover is needed to conserve platinum lest our military program halt simply because our acid works cannot meet their demands.

Of course, Mr. Editor, I endorse your protest against a half-way or a seventy-five per cent or even a ninety-nine per cent restriction of non-essential use of platinum. No American with his eyes open to the facts can do less than stand behind you.

Yours very cordially,

(Signed) GEO. OTIS SMITH,
Director

DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
Washington

May 16, 1918

Office of the Director

DR. CHAS. H. HERTY,
Editor, Journal of Industrial & Engineering Chemistry,
New York City

Dear Dr. Herty:

Replying to your request for my opinion regarding the Country's need of platinum and the use to which, in my opinion, platinum should be put, I have no hesitancy in stating that in my belief the present high price of platinum is due to the artificial value which it has been given for use in jewelry, an entirely unessential use even in time of peace and one which in my opinion should be discouraged at all times, especially in time of war when the metal is so greatly needed for the production of munitions and other essential materials.

I believe that the use of platinum in jewelry is due to an entirely false conception, as there are other white metals equally valuable for the setting of gems and the production of jewelry which would be used for that purpose to-day, except for the fact that they are not so costly as platinum. When the price of platinum was less than that of gold, there was practically no demand for it in jewelry, with the possible exception of a slight use as a setting for gems. Over fifty per cent of the Country's supply of platinum is now used annually for jewelry. No metal is more easily imitated than platinum and there is much white metal now on the market which cannot be told from platinum by the uninitiated.

I have stated to others that it is inconceivable to me that any woman would wear a lead-colored ring or bracelet or adorn herself with lead-colored jewelry except that its artificially produced high price has been made to give it a false value in her eyes. With the platinum of Russia now under German control and barely enough platinum in sight for this year's needs, with no prospect of increased American supplies, I certainly cannot consider the purchase of platinum in jewelry patriotic now, and it appears to me, since it is worn almost solely on account of its high price, to be in doubtful taste at any time.

Very truly yours,
(Signed) VAN. H. MANNING
Director

.....

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
Washington

May 15, 1918

Division of Mineral Resources

DR. CHARLES H. HERTY, Editor,
The Journal of Industrial & Engineering Chemistry,
35 East 41st St., New York, N. Y.

Dear Dr. Herty:

In reply to your letter of May 14:

It is my impression, based on such information as is available to the U. S. Geological Survey, that the platinum situation is not better at present but is far worse than it was six months ago. At that time a shortage of platinum metals for war purposes was indicated. Many plans made at that time have been enlarged and still further extensions of the war program are indicated by Secretary Baker's statements to Congress.

In view of these facts, it seems most unwise to permit the use of these metals in non-essentials, such as jewelry. To permit the continued utilization of 25 per cent of the stocks held by manufacturing jewelers at the present time appears to me to be the height of folly, since our stocks are low, demands for war purposes increasing with each addition to our army, and our source of new materials strictly limited.

Yours very truly,
(Signed) J. M. HILL
Geologist in Charge, Platinum Statistics

As a further contribution to the literature of this subject there are added excerpts from an able editorial in the *Scientific American*, May 18, 1918.

"We have within the past two months received a quantity of circular mail from an association of manufacturing jewelers, the general content of which has been a consistent minimizing of the platinum shortage and a persistent decrying of the suggestion that while the war lasts jewelry of this metal is out of order. We have taken the trouble to look into the facts so far as we are able to do so; and as a result we arise to brand this propaganda as a most vicious one, conceived and carried out from motives wholly selfish and unworthy of American business men. * * * In doubtful taste at any time, surely now, when our basic war needs for platinum are to be met only with the greatest difficulty, the purchasing of jewelry made from this unattractive metal cannot be considered as anything other than the height of unpatriotism. It is surpassed, in its class, by but one act—that of deliberately, and for the sake of profit, urging those ignorant of the true state of affairs to buy such jewelry."

THE JEWELERS' POINT OF VIEW

In striking contrast to the above official letters from Directors Smith and Manning and Mr. Hill is the interview attributed to Mr. William E. Eisenhower of the firm of J. E. Caldwell and Company and printed in the Philadelphia *Public Ledger* of May 16, 1918. According to the *Ledger*, Mr. Eisenhower said:

"About six weeks ago the Government requested us to submit a report of the amount of platinum owned and what percentage we could reserve in case of a shortage later. Out of the reserve stock the Government requisitioned 25 per cent, which was a very small proportion of the whole and which never may be needed. *This 25 per cent of the total reserve stock, however, is enough to fill all war needs five years, even under a much larger war program than outlined now.*" (Italics are ours.)

We know nothing of the 25 per cent requisition referred to, but the statement is absurd in itself, as evidenced by the latest commandeering order requiring the holding of 75 per cent subject to the call of the Government, and if based upon supposedly official statistics, then Mr. Eisenhower has access to some mysterious source of information, for we have never yet found anyone connected with the munitions program who was willing even to admit that any such information existed. How could it exist, with the war program constantly expanding? The effort to create the impression that war needs of platinum for five years are provided for in the present reserves is so seditious in character that it deserves the serious consideration of Government officials.

The jewelers, however, do not have to depend solely upon interviews in the daily papers for their propaganda. Some magazines (whether knowingly or not, we cannot say) are lending their aid. For instance *Vogue*, May 1, 1918, pp. 74 and 75, contains these items:

"There has been designed another engagement ring that is meant especially for the war bride to-be, a ring which is patriotic without being conspicuous about it, when it is worn, one would never think, by merely looking at its light and graceful platinum setting, that if the ring were slipped off and held up for scrutiny one would see that there are, on each side, wrought shields bearing stars and stripes, and that the two small diamonds on either side of the large one twinkle in star-shaped settings. A wedding ring is designed to go with this engagement ring—a ring engraved all around its platinum circle with stars. * * *

"One other jewel that belongs to her of the uniformed fiance is the service pin. Of course, service pins, whether they are of enamel on gold or precious stones set in platinum, are all alike in design—a red border, a white center, and a blue star in the middle; but when they are made of rubies, diamonds and sapphire, set in platinum, they are very beautiful."

What an impudent parading of our old friend "the slacker wedding ring" under a patriotic guise! What a hollow mockery is thus sought to be imposed upon the young womanhood of America and the men who are prepared to offer their lives as a sacrifice for democracy! Why should these lives be needlessly jeopardized? And for what? From the aesthetic standpoint, such platinum can be replaced by "white metal." No words from Director Manning are needed to confirm this statement. Let the jewelers add their own testimony on this point.

"A resolution recommending the discontinuance of the use of white gold in place of platinum in the manufacture of jewelry embodying precious stones was passed yesterday at a meeting of jewelry manufacturers and retailers at the Hotel Biltmore. The meeting, which grew out of the commandeering of platinum, iridium and palladium by the Government for war uses, was called by the Jewelers' Vigilance Committee, and was attended by representative retail jewelers from Chicago, Cincinnati, St. Louis, Pittsburgh, Boston and this city. A second resolution passed recommended the inclusion in the karat designation stamped on articles such as watch chains, cigarette cases, etc., of the letter 'w' or the words 'white' or 'white gold' in cases where they are made of this metal instead of platinum. The purpose is to protect the public from the selling, by unscrupulous dealers, of articles of white gold as platinum. While this metal resembles platinum more or less in appearance, it does not resemble platinum so far as 'workability,' value, and wearing qualities are concerned."—*The New York Times*, May 16, 1918.

The eye cannot tell the difference; the letter "w" or the words "white" or "white gold" must be stamped on the article to protect the young soldier from imposition in the purchase of a "patriotic" engagement ring!

SIDE-LIGHTS

Interesting side-lights are thrown upon this whole platinum situation from another source. Again we prefer to let the story be told in the words of the jewelers themselves and of the publication devoted to the interests of the jewelry trade. On page 55 of *The Jewelers' Circular*, April 10, 1918, an account is given of the annual meeting of the Jewelers' Vigilance Committee. This account contains the report of Chairman Harry Larter, three paragraphs of which are herewith reproduced:

"While the platinum matter, in so far as its connection with the Government is concerned, is now out of the hands of this platinum committee, the Jewelers' Vigilance Committee is still interested in the adverse propaganda, started afresh with new vigor because of the acute situation now existing throughout the world in regard to this precious metal.

"The commodity tax, in which jewelry is a factor, developed in Congress just about a year ago in the War Revenue Bill, which, as you know, has since become a law. Again, our committee called a mass meeting, and at it another powerful, representative committee was appointed, headed by the former very able and efficient chairman, Mr. Rothschild, and ever since then, committees large and small in number—sometimes only the chairman have been in Washington and in constant telephonic or telegraphic touch with the Internal Revenue Commissioner's Department.

"* * * While other things have been accomplished and plans for the future discussed, because of existing conditions, they have been temporarily postponed. All of the above work has, naturally, imposed a large expense, and through the energetic and persevering work of the chairman of the finance committee has been met by contributions of large and small amounts by the generosity of over 400 persons and firms connected with our industry. We still have left a nucleus for a fighting fund which can and will be used in the interest of every branch of the jewelry trade."

Following this report the account of the meeting (again page 55) gives some interesting statistics.

"An idea of some of the work done by the committee during the year was given in the report of Secretary Dickinson, which showed that during the year there have been 61 meetings of the directors and committees, divided as follows: Directors, 17; executive committee, 14; platinum committee, 16; legislative committee, 2; tax committee, 12. * * *

"There have been sent out 17,472 letters, circulars, announcements, etc., through the mail, and 445 telegrams, the shortest of which was 42 words and the longest consisting of 708 words, this latter having been sent to 11 firms.

"There had been 18 trips made by committees on various matters, 14 to Washington, two to Albany, one to Searsdale and one to Boston. In all 115 members of the Jewelers' Vigilance Committee, and delegates from the trade at large making the trips."

How some of these activities impressed a distinguished member of Congress is best set forth by the following letter from the Hon. Henry T. Rainey of Illinois to Mrs. Ellwood B. Spear, which is reproduced here by the consent of Mrs. Spear and Congressman Rainey:

HOUSE OF REPRESENTATIVES U. S.
Washington, D. C.

May 9, 1918

MRS. ELLWOOD B. SPEAR,
Chairman, Woman's Nat'l League
for Conservation of Platinum,
27 Walker St., Cambridge, Mass.

Dear Madam:

I am in receipt of an editorial which was released May 1, 1918, in INDUSTRIAL AND ENGINEERING CHEMISTRY, with reference to the conservation of platinum.

I am quite familiar with the subject. I am a member of the committee which draws war tax measures, and on the Floor of the House I made a speech in favor of amending the bill so as to tax platinum used in the manufacture of jewelry 250 per cent. The matter is serious indeed, and your organization is rendering a splendid war service. I know of no profiteers in the United States who have more justly earned all criticism and condemnation that can be phrased against them than the jewelers who organized a lobby and sent it here to Washington and maintained it here for a considerable period of time in order to enable them to continue their profitable business in the use of platinum for jewelry. They came here and infested the Capitol building, and stood around the committee rooms, pledging themselves to conserve platinum, and pointing with pride to the fact that they had passed a resolution discouraging the use of platinum in jewelry, and also produced on every occasion the statement of Secretary of Commerce Redfield, commending their action as wise and patriotic. There was absolutely nothing in their position. The platinum supply could not be conserved in that way and the promises and pledges they made at that time they have failed to keep, and I knew they would not keep their promises or even attempt to keep them.

They pointed to the fact that platinum came from Russia and that Russia was at war with Germany, and that we could get all the platinum we wanted while Germany could get none. The arguments some of us used in our interviews with the members of their lobby, calling attention to the unstable conditions in Russia, and the possibility that Germany might soon control Russia, had not the slightest effect upon them.

The organization which maintained a lobby here in Washington ought to be held up to the contempt of patriotic citizens of the United States. Although I am a Democratic member of the committee which prepares the revenue bills, I did the unusual thing from a standpoint of a Democratic supporter of the measures which come from the committee, and joined with Representative Longworth in his attempt to amend the bill, which failed on account of the efforts of the jewelers' lobby.

May I call attention to my speech made on May 21, 1917, which you can find as of that date on page 2862 of the Congressional Record, which you can of course find in your library.

Very truly yours,

(Signed) HENRY T. RAINEY

Further comment is unnecessary, except that we recommend the reading of this section of this editorial to Congressman Nicholas Longworth, who sought about a year ago to build a one hundred per cent dam across the platinum stream by placing a prohibitive tax upon platinum jewelry, which patriotic effort, however, was defeated.

THE JEWELERS AGAIN

What the jewelers' publication would have to say regarding the most recent commandeering order, was a matter of interest to us. In *The Jewelers' Circular* of May 15, 1918, we found what we sought. On page 102 it is stated

"In speaking of this platinum order, the Jewelers' War Service Committee, *which has been in close touch with Mr. Conner in the preparation of all details in connection therewith*, made a full statement through its secretary, in explanation of the way the order will work out." (Italics are ours.)

and on the following page (103) the "Statement by the Jewelers' War Service Committee, Regarding the Government's Most Recent Order, Commandeering Platinum, Iridium and Palladium" contains this illuminating paragraph:

"The order has been sent from Washington to approximately 1,000 manufacturing and retail jewelers and refiners. *Our committee has been in constant touch with the officials, advising them as to the necessary steps, and the manner and form in which they should be taken.* It was our function to assist the government and to protect the interest of our trade in every way possible. The committee, therefore, urged that the order be drawn up in a different and simpler manner than that which the trade has just received, but it was impossible to do this on account of the legal restrictions placed upon the officials issuing the order. *The representatives of the Government were very solicitous of the welfare of the jewelry trade*, and we are pleased to state that every question was given careful and courteous consideration. However, the objects to be attained could not be reached in any other way. The result was that all platinum, iridium, and palladium in the hands of those receiving the order, no matter in what form, has been commandeered; but releases or waivers of delivery to the Government have been arranged in order not to disturb the industry unnecessarily." (Italics are ours.)

One final quotation from the same issue (page 105, editorial page) gives the jewelers' view-point:

"The men and women in the factories and workshops who to-day are making large wages for the first time in their lives, can obtain the necessaries of life by working half time and if their purchases are confined to the necessaries of life they will work only half time. What they are striving for—the incentive that makes them work the full day and even overtime is the opportunity to buy the luxuries of life which are for the first time within their reach.

"Take from these people the opportunity to buy jewelry, to dress well, to go to the theatres or indulge in luxurious eating or living and you take away the real reason that 90 per cent of them are willing to start in their work early and go home late. They do not want money as money; they want the money for what it will buy. It is the luxury that they have craved for years and one they could not get, that they demand now as a compensation for their work."

In the name of the factory and workshop men and women who have just bought so widely Third Liberty Loan Bonds, whose every thought now is to help win this war, and whose effective labor is to-day so largely responsible for the speeding up of the great national production machine, we protest against any such aspersions upon the motives which lead them to their daily toil.

PATRIOTIC SERVICE BY WOMEN

Fortunately there is a strong popular movement, growing stronger each day, which will eventually offset such sordid activities; the full story of Mrs. Spear's untiring and patriotic personal activities must some day be told; Mrs. Alfred S. Weill's letter, mailed to ten thousand women of Pennsylvania, and reprinted on page 494 of this issue, constitutes another phase of this movement; so too the war pledge cards for platinum conservation will have their decided effect, and finally the stirring words of the wife of the Governor of Massachusetts, Mrs. Samuel McCall, will surely find a ready response in the hearts of all American women. We quote from an interview reported in the *Boston American* of May 4, 1918.

"The giving up of little things like jewels—luxuries—and things that have no value as necessities, does not entail a great sacrifice.

'And even if it did, the women of America would not hesitate. They have given their sons, their fathers and their husbands. They have given all that they value most, the people that make life for them. Are they going to hang back when it is a question of mere bauble?

"The women of the country aren't lacking in the spirit that has to go behind a country in war times. They can give without a murmur, and jewelry is a small concern when it is considered in connection with life.

"It seems to me that any woman who orders any jewelry in platinum settings at a time like this either cannot understand or feel deeply the love of country. And if she has any of the material on hand she ought to be entirely willing to surrender it—such a small thing to do, when others are giving their lives."

That interview must have taken place at the base of the Bunker Hill monument.

FURTHER LOSS POSSIBLE

In conclusion, attention is called to paragraph 5 of the letter signed by Mr. Conner and sent out by him along with the commandeering order to approximately one thousand jewelers. The paragraph is as follows:

"The undersigned will consider applications, on forms which will be supplied upon request, for further releases of platinum, iridium and palladium."

Is there to be still further dissipation of our limited supplies of these vitally important metals?

Finish that dam!

TYPICAL GERMAN PRONOUNCEMENTS

A correspondent has forwarded by mail to this office a newspaper clipping containing a dispatch from Amsterdam, dated April 18. The article announces the conferring of the Bunsen medal upon Professor Haber, head of the Chemical Research Institute of Berlin, for his lecture on "The Relation of the Exact Sciences to Militarism."

Professor Haber is quoted as having said in the course of his lecture, "Gas attacks arose on both sides out of the requirements of the situation." Why did he not follow more closely the example of German statesmen and say, "Gas attacks were inaugurated by our enemies while we were defending in Belgium the invasion of the Fatherland," despite the awful memories of the British in connection with that first wave of chlorine at Ypres? When international

amenities are again the order of the day it may be well to take under careful consideration the question of readmission to good fellowship in the world-body of chemists of those German chemists who were responsible for the plans which started the armies of the world upon this frightful medium of attack.

Again Professor Haber is quoted as having said, "The reason why the use of gas is disliked by our enemies is that the use of protections against gas attack calls for a special measure of discipline and intelligence in the common soldier."

How typical of the German mind!

RESEARCH AND THE TAR BABY

There is one product on the market which is too cheap, and this through the natural working of the law of supply and demand. That is a rather startling statement in these days when prices of all commodities are soaring. Still more startling does that statement become when it is revealed that this product is composed solely of organic compounds, for these seem to be adapted particularly to spectacular price elevation. Nevertheless, the statement is true, for in a recent number of the *Weekly Naval Stores Review* the editor remarks (and market quotations seem to sustain his contention) that "spirits of turpentine is the only cheap raw product in the world to-day, rosins being the next cheapest."

The explanation of this anomalous situation is easily found in war conditions which have largely decreased building operations, made difficult the securing of shipping space, and shut off from the producers of naval stores the hitherto extensive markets of Germany and Austria, particularly the former. Certain increased uses of these products for war purposes can not compensate in any measure for these unfavorable influences and the net result is financial distress for the producer.

Three remedies have been suggested. The first, most natural, and usually applied in industry, was the curtailment of production; but with an industry so loosely organized as this one, success in such an effort cannot always be safely predicted. The second was a proposal by a correspondent of the *Review* to "divide the territory into zones and have an agent for each zone, whose duty it would be to visit each still and ship the turpentine for the operator." If we were overproducing, it would be the duty of this zone agent "*to dump the surplus spirits on the ground.*" The reference to the ground rather than the gutter is good, in view of the extra-urban character of the industry, but we cannot refrain from a surmise as to what would happen to those zone agents, as a result of the physical activities of the individual operators, about the time the aforesaid dumping process began. Such a test of the value of the anti-dumping clause enacted by the last Congress would scarcely be fair because of its unexpected character. The third remedy was suggested at a conference last September between representatives of the producers and officials of the Bureau of Chemistry, when the Government chemists were urged to find new uses for turpentine. This would be a step in the right direction. That Bureau exists to serve the people; but herein lies a real difficulty—there are so many people interested in so many different lines of industry that no particular industry ought to expect everything in the way of salvation from this source, especially in view of the restricted appropriations available to the Chief of the Bureau and his able associates.

None of these measures adequately meets the situation. May we, therefore, venture to call the attention of our friends in the naval stores industry to a development of the past few years in many lines of industry, namely, the creation of well-equipped and well-manned industrial research laboratories, in which by scientific procedure, seemingly slow at the outset, real industrial progress is being made through improvements in methods of manufacture, resulting in increased yields and more efficient plant operation in general, through the discovery of new possibilities of raw material and through the development of new uses for the manufactured products. Millions of dollars have been invested in these laboratories and the end is not yet. No surer safeguard of the industrial future of this country exists.

If, however, it be argued that the output of the plant of any naval stores operator is too small to justify large expenditures for research, we would urge careful consideration of the movement in many industries toward coöperation in such endeavor. A typical case is that of the research laboratory of the National Canners' Association in Washington. Proving no severe tax upon any individual concern, this laboratory has solved a multitude of problems, has had at its disposal material from all sections for test and study, and through the tact of its Director has brought all elements of the canning industry into more harmonious relationship. Following this example, the oil men of the West have united in a coöperative research laboratory at the University of Oklahoma, and still more recently the leather trade has determined upon a similar coöperative effort and its research laboratory is now being equipped in New York City. The growth of the idea has been rapid and its roots have struck deep into the industrial life of the Nation. Its latest manifestation is the appointment of Dr. John Johnston as Secretary of the National Research Council with the understanding that his energies are to be directed largely to the development of coöperative industrial research, an opportunity for fine service by a man preëminently qualified for the undertaking.

If the turpentine operators are soon to gather in annual assemblage, may we suggest that Dr. Johnston be invited to address the convention on the subject which he has so deeply at heart, along which line will be found the real and permanent cure for low prices and the future advance of the naval stores industry.

One thing we know: the turpentine operators are somewhat slow to take hold of a new idea, but when they do, they take hold hard. There was genuine foundation for Uncle Remus' story about the tar baby.

SOCIÉTÉ DE CHIMIE INDUSTRIELLE

On April 24, 1918, the first meeting of the recently formed New York Section of the Société de Chimie Industrielle was held at the Chemists Club, New York City, Dr. L. H. Baekeland, president of the Section, presiding. The deep interest felt in the relations between France and America were clearly reflected in the spirit and enthusiasm of the large and representative assemblage. Dr. Wm. H. Nichols, president of the AMERICAN CHEMICAL SOCIETY, addressed the meeting, welcoming the new association to its place among the chemical societies of America. Prof. George A. Hulett, a member of the first special War Commission sent to France and England from this country, spoke on "Some of the Chemical War Problems," and was followed by Mr. Frederick J. LeMaistre and Mr. Marcel Knecht whose addresses appear below.—EDITOR.

CONDITIONS OF THE FRENCH CHEMICAL INDUSTRIES DURING 1916

By F. J. LEMAISTRE

Member of the American Industrial Commission to France

I have been requested by Dr. Baekeland to present to you this evening a few remarks on the "Conditions of the French Chemical Industries during 1916." I presume the only justification I have for appearing before the Société this evening is that I have had the good fortune of making a visit to France during war times, an experience which I shall not soon forget, and it is my sincere hope that I shall never be insensible to the responsibilities which go with such privileges.

The American Industrial Commission to France, of which I was a member, has issued a very full report of its findings entitled "Franco-American Trade," a volume of over 250 pages. The twelve Commissioners were all representatives of important industrial and technical associations; the speaker was the official representative of the AMERICAN CHEMICAL SOCIETY and The Franklin Institute. It is extremely interesting to look back upon the efforts of this group of men, representatives from a country which was then neutral. A repetition of this visit under present conditions with America on the side of the Allies would, undoubtedly, be of added interest.

It must be remembered that my remarks this evening are not of present conditions, but of conditions as we found them in the fall of 1916. Some supplementary material has been added, and consists of information general in character, which for various reasons it was thought inexpedient to publish at that time. I have also been assisted in selecting material for this paper by statements made to me personally by Professor Grignard and Lieutenant Engel on the occasion of their visit to this country some months ago.

With the latitude Dr. Baekeland has kindly granted, I have gone somewhat afield of the topic selected for my address, and for convenience my remarks are grouped in two general divisions:

1—Subjects of interest, in France, to the American chemical industry.

2—Subjects of interest, in America, to the French chemical industry.

Before proper consideration can be given to these two subjects, we must presuppose that a state of mind exists regarding the meaning of the word "reciprocity," as no true progress can be made by the industries in these two countries without a full knowledge of what this term implies, and in this connection I think Mr. Frank Hemingway's statement, made at the St. Louis Meeting of the American Institute of Chemical Engineers, is pertinent, that "frequently wrong-minded public action is based on ill-informed public opinion." True reciprocity cannot be had without a knowledge of the facts in the case.

It is important to remember that on such a hurried trip as this—45 days' travel through France—no complete survey can be made of any one industry under normal conditions, let alone during war time, and this was our experience even though the Commission was granted very many unusual privileges by the French Government. I am giving you to-night, therefore, but a few impressions made during a hurried trip under expert guidance. We, of course, heard much from people in authority, and had many privileges not granted the ordinary traveler, such as discussions with Chambers of Commerce, economic associations, special Government commissions, and business organizations.

SUBJECTS OF INTEREST, IN FRANCE, TO THE AMERICAN CHEMICAL INDUSTRY

Any group of American chemical manufacturers seeking trade with France should have a thorough knowledge of the French language, and this is furthermore imperative if we are to be of any permanent help to this country in their period of reconstruction. It was the terse expression of opinion of the foremost American business men in France that "the export of American men should follow the export of American goods," and that these men should be representative and better qualified than those ordinarily assigned to such duties.

Knowledge of France and its people is also essential. Adventures have been undertaken and money lost, due to the lack of appreciation on the part of American concerns of the characteristics of the French people. The French are essentially artistic, are naturally opposed to production in quantity, which they call "series." It must not be overlooked that on account of their love of home, they often lack a knowledge of the possibilities of their own country. The banking system and the thrift of the French people should be common knowledge to all those seeking trade in this country.

The number of French technical schools is surprisingly small. One of the foremost educationalists advised us that there is a great need at the present time, by the French nation, for higher education. In 1914, the total number of students in Government universities was approximately 42,000 and of these about 15 per cent represented the foreign element. The above number of students could be grouped as follows:

	Per cent
Law	18
Medicine	30
Science	18
Arts, etc.	34

In this connection, it is of interest to note that on a basis of unit population, Switzerland has 300 chemists, Germany 250, while France has only 7.

It is commonly accepted that, pending the development of more technical schools in France, the young men will be forced to obtain their technical education elsewhere, and the United States has been preferred. It has been thought that the intercourse of the French and British soldiers has afforded the Frenchmen an opportunity to learn the English language, so that on this account such a step will be entirely practical. It is, therefore, our duty to prepare now for such a contingency. It seems to me that we should see to it that the rank and file of the French people know what educational facilities we have to offer.

As in our country, there has not been in France sufficient intercourse between the college professor and the technologist. I personally had a subject up for consideration with one of the prominent college professors in France, and failed to obtain an interview with the professor, as he sent back the report through his commercial representative that he was busy on other subjects and could not arrange to visit Paris for two or three weeks, and that on no account could he or his assistants take time to consider the commercial application of this work.

I think it is of interest to all American chemists to know of the work done by the Commercial Attaché of the American Embassy. An inspection of the list of subject matters passing through this office clearly shows how often are the attempts to embark on absolutely worthless projects. These ventures usually represent a serious money loss both at home and abroad.

My own experience permits me to endorse heartily the efforts of Lieutenant Engel and his confrères to have a French chemical publication of special interest to the technologists, as a gulf at present separates the college professors from those in direct charge of chemical plants. Lacking this intercourse, antiquated methods of manufacture are followed in certain branches of the chemical industry, which it is hard to believe can still be in use.

It is of interest for the American chemist to know that the French chemists are generally at a loss to account for our lethargy and slowness in adopting the metric system in America. It is to be hoped that one of the beneficial effects of the war will be the more active study of this problem by the authorities in Washington. We surely ought to look for some accomplishment shortly.

SUBJECTS OF INTEREST, IN AMERICA, TO THE FRENCH CHEMICAL INDUSTRY

Much profit would be obtained by the annual visit of a group of men interested in the French chemical industry to this country, probably at the time of the annual chemical exhibition in New York. This character of legitimate advertisement is much needed and, in my opinion, would fill a very direct need. I consider that such a delegation should be made up of representatives from the industrial sections of France.

It is the duty of the French chemist visiting this country to acquaint himself with the many important associations interested in foreign trade. Such permanent exhibits as the Commercial Museum in Philadelphia and similar institutions should be visited.

It seems to me that much progress could be made by a study of standardization of chemical equipment in America, as well as in France. The manufacturers of both countries should seek counsel together. There is no real reason why prices of this class of equipment should maintain at the present high level, when in many cases the selection of three sizes—large, medium, and small—and the manufacture of these in quantities would satisfy all demands. The French chemical industry, however, is greatly influenced by the general tendency of the French people to have variety rather than quantity.

In the future development of the chemical industry in France, liberal use will, undoubtedly, be made of woman labor, as very gratifying results have been obtained in this direction during the past three years. Those best qualified to judge are emphatic in their statements that a return to old conditions cannot be made if competition is to be met and the quality of German goods equaled.

Raw materials from America is a subject which has received very active study by many companies throughout France. Much work still remains to be done before specifications are clearly understood by both parties. In many cases misunderstandings arise, due to poor translation. The present facilities for the translation of technical French in this country are wholly inadequate. Could not our universities profitably take over this work?

It was the consensus of opinion of all the Commissioners that the French people were more favorably disposed than ever before to American products. In certain factories making munitions of war, as high as 60 per cent of the mechanical equipment came from America. This surely affords a wonderful opportunity for follow-up trade.

It was our general observation that an arduous task will devolve upon the French manufacturer upon the return to normal conditions. Under stress of war-time manufacture, chemical control is not always

possible of attainment. It is generally conceded that the maximum efficiency can be secured only by the entire regrouping of many industrial sections, as a number of the chemical plants are illogically located. The majority of the more active chemical manufacturers fully appreciate the importance of increasing efficiency, but hesitate in branching out on new methods of manufacture on account of the enormous expenditures such a change involves. It is believed that the necessary encouragement from this side would enable them in future to compete with the efficiency of the German chemical manufacturers.

It would, no doubt, be of interest to give a few specific statements which may indicate the view-point taken by some members of the affiliated chemical industries of France.

PERFUMES—The French manufacturers were warned by some of their own trade specialists of the inroads that might be made by the synthetic perfume manufacturers of Germany. They did not take heed, however, maintaining that these artificial compounds could not approach the true perfumes of France. They have, however, recently decided to embark on the artificial perfume industry and to develop this trade in a logical way.

PETROLEUM—It was also acknowledged by a number of manufacturers that many changes will be needed in the factories now refining crude petroleums. They acknowledge that this industry before the war was conducted on altogether too small a scale to be profitable.

CELLULOID—This old established industry of France was inactive during our visit, owing to the fact that most of these factories have been commandeered by the War Department for the manufacture of nitrocellulose. The love of the French for the artistic is well illustrated in this case. The French manufacturers in recent years have purchased large quantities of sheet celluloid from Germany and have manufactured this stock material into miscellaneous artistic articles.

ELECTROCHEMICAL INDUSTRY—This industry appears to receive very active study by both chemists and engineers. Extensive programs have been outlined and are now in process of development which will undoubtedly bring about many economies which were not formerly enjoyed by the French manufacturers. We heard of a number of cases where the Field Commanders were requested to release men from the front who were specialists along this line. These men were assigned to three to four months' study of this special problem.

RECOVERY OF SULFURIC ACID—We had the pleasure of meeting Mr. Kessler of the company by this name. He informed us that since the war began they had sold, up to November 1916, some 300 Kessler apparatus of varying sizes, and that their apparatus alone installed in France was equivalent to a daily capacity of 4,000 metric tons of sulfuric acid, 66° Bé.

DYES—The manufacture of dyes was receiving in 1916 the same attention in France as elsewhere. It is unfortunate that many are rushing into this industry wholly ignorant of the difficulties of this line of manufacture. It seemed to the Commission that the tendency in France was towards Government supervision and ownership of the dye industry.

PHARMACEUTICAL CHEMICALS—Few pharmaceuticals were manufactured in France prior to the war. Plans are now on foot to return to this manufacture, which, due to the special trade agreements with Germany, had entirely passed into their hands.

DENATURED ALCOHOL—The laws regarding denatured alcohol and its uses are being gradually revised. The same problem exists in France as we find in this country. On several occasions the writer had an opportunity to recommend a liberal extension of privileges for the use of this valuable solvent. As in many other cases, the Germans have been the leaders in this direction. There is no real reason why much of the Government red tape now required should not be eliminated.

It is of interest to note that, in 1913, 70 per cent of the denatured alcohol sold in France was used for heating and lighting, the balance representing that consumed in the manufacture of ether and explosives. It is also of commercial interest to note that some of the leading French economists have recommended to the Government fixing the price of denatured alcohol for a period of five years.

I cannot close my remarks this evening in a more fitting way than to voice the impression of all the Commissioners that the present industrial effort of France commanded our fullest admiration and to quote the following from our official report:

There is a striking resemblance between many of the social, industrial and commercial problems of the two sister republics, and there is evident a tendency to solve them on similar lines. Nothing could be more profitable than a joint comparative study of them.

THE GREAT EFFORT OF THE FRENCH INDUSTRIES

By MARCEL KNECHT

Member of the French High Commission to this Country

France has been invaded; France has suffered terribly. But France is in no way bled to death as the propaganda of the German emperor has tried to make you believe.

The French army—and I give you these, not my figures, but the official figures given recently to your War Secretary, Mr. Baker, by the French Commissioner, Mr. André Tardieu—the French army at the beginning of the war sent 1,500,000 fighters, and you know with what heroism those soldiers have been fighting, and you know how many of those have been wounded and disabled. Yet, still, through the energy of our soldiers, through the energy especially and the great spirit and sacrifice of the mothers of France who have sent all their sons to the front, we now have a fighting force of 2,600,000 men ready to keep up the conflict.

Do you know the loans which the French people have given to their government? Do you know this little nation of 30,000,000 people at the beginning of the war, which has been so terribly reduced since the north and east parts of France were invaded, do you know the amount of money loaned by the people of France, by the peasants and by the workmen of France—for we have 20,000,000 peasants in France—we have loaned to our Government since the beginning of the war $18,000,000,000.

Do you know—and it is always M. Tardieu who speaks—do you know how many shells for guns of 75 millimeters we could shoot every day in August of 1914? The French light artillery, the field artillery—for we hardly had any big artillery, the French light artillery could shoot 15,000 shells every day; and now, with the wonderful effort of our business men of the Chambers and Associations of Commerce—and I insist on that fact to prove to you that you have in France brothers in business who are quite worthy of your admiration and sympathy—for the men of industry in France before the war were considered too old-fashioned, were considered small business men in a country where we had lost 60 per cent of our iron ore, and 60 per cent of our coal mines, and 50 per cent of all the best mechanics of France who were taken prisoners from the invaded districts—now, we can give to the French army 250,000 shells of 75 millimeters every day.

And at the beginning of the war we had only 300 big guns against those huge guns of Germany which had been destroying so many cities in Belgium and in France—we had only 300 guns and a very small quantity of shells, and now we have 6,000 huge guns from the best factories of France, and we also have 100,000 big shells every day to shoot in those big guns.

France lost the best of her industries, of her mines, of her heart in the beginning of the war. You know, perhaps, that in the east of France, in my district, there were enormous mineral resources, but some years before the war those resources were very little known, even in France; for France was too much interested in literature and in her theatres; and though we had fine people, though we had people who were working hard, we did not interest ourselves enough in industry and in business.

You did not know it at all. And there is only one nation who knew better than we knew, and knew exactly what was in France, in the east of France, what was going on in France, and that was Germany.

It is in Lorraine that your boys will show that they are brave soldiers of America. If Germany had not taken, in 1871, and, also recently in 1914, the two parts of Lorraine, Germany could never have declared war on France or any other nation in Europe. And I will prove to you why.

In 1913 the annexed part of Lorraine, which was under German domination, produced 21,000,000 tons of the best iron ore ever known. And the French part, which had not been taken by Germany in 1871, the part which has been occupied, nearly all of it, since 1914—produced in 1914, 19,000,000 tons of iron ore. Then you can understand how, in 1871, Germany was able, with those 21,000,000 tons of Lorraine iron ore to make her big guns and shells, and prepare for this war.

In the same year, 1913, the whole German territory, excepting the annexed Lorraine part, produced only 6,000,000 tons of iron ore. If Germany had not taken in 1871 those 20,000,000 tons she had in 1913, and if she had not occupied in 1914 this wonderful district to the north of Nancy, where we produced 19,000,000 tons, Germany could not have declared war on the world because she would have had only 6,000,000 tons of iron ore, and with this it is impossible to go into a war where steel is the one great strength.

Then, if you know of the wonderful richness of the Lorraine district which was French before 1871, the annexed part and the French part, you know that we produced in 1914, 48,000,000 tons of iron ore, and in your Lake Superior district in the same year there was a production of 52,000,000 tons. That is a very slight difference, and you can understand how this district of Lorraine, by the blood of your sons and by the richness of its soil, compares to the Lake Superior district, is extremely important for you Americans, because it means many things for the future.

Another figure which is also instructive is the figure that in Lorraine, in the annexed part, in the French part, and in the Luxemburg part, there are resources of iron ore which will exist when there will be no more iron ore left in the Lake Superior district. We have resources amounting to 5,000,000,000 tons of iron ore in those two little spots on the map of Europe.

And another great factor is this, that if we leave in the hands of German militarism, German autocracy, not only annexed Lorraine—if we leave in the hands of German militarism those 19,000,000 tons of iron ore, and the 2,000,000,000 tons in reserve which there are in the district of French Lorraine, invaded only since 1914, the business men of Germany can see that they not only want to keep annexed Lorraine, but they want to occupy the districts which they took in 1914.

If we leave 19,000,000 and 21,000,000 tons of iron ore, and this 6,000,000 tons, and all their resources to German autocracy and militarism, even if peace comes, we will see, in the next ten years, in the next fifteen years, a new, big war; because when a nation with a militaristic spirit and an autocratic spirit has in her possession the best of the iron ore of Europe, equal to your iron ore in America, then she must make war again.

At the conclusion of the speaking, moving pictures, loaned by the Ministry of War of France, were exhibited, showing:

1—A great munitions works.

2—A war port.

3—The armies of the Marne, Verdun, and the Somme.

ORIGINAL PAPERS

THE QUANTITATIVE ESTIMATION OF ANTHRAQUINONE

By Harry F. Lewis

Received April 29, 1918

In the analysis of anthracene by the method of Luck,[1] an impure anthraquinone is formed. Various methods for the purification of this anthraquinone have been proposed. The most popular common modification is the one which goes by the name of the "Hochst Test,"[2] which prescribes a solution of the product in pure fuming sulfuric acid and the resultant separation of a pure crystalline anthraquinone by dilution with water. This is a long process and with certain types of anthracene it may be very inaccurate. Basset[3] suggests boiling the impure anthraquinone, obtained according to Luck's method, for some time with a solution of mixed chromic and nitric acids, for the reason that the pure anthraquinone does not lose weight by this treatment, while that obtained from commercial anthracene may lose from 1 to 2 per cent.

If it is desired to accurately determine the amount of anthraquinone present in samples contaminated with either large amounts of anthracene or phenanthraquinone, the above methods leave much to be desired.

Quantitative determination of anthraquinone based upon the formation of the oxime by the methods described by Goldschmidt,[4] Schunck and Marchlewski[5] and Musenheimer[6] have not been found practical for the reason that the manipulation is long and difficult and the yield of oxime could not be made quantitative.

A method for the estimation and purification of anthraquinone has been developed based upon the susceptibility of the carbonyl radicals to reducing agents.

Grabe and Liebermann[7] described the preparation of a compound, which they call oxanthranol or anthrahydroquinone, formed by the reduction of anthraquinone by an alkaline suspension of zinc dust. This compound is quite soluble in hot alkaline solution but in that solution is easily reoxidized to anthraquinone. They recommend the use of 2 parts of zinc dust and 30 parts of a 50 per cent sodium hydroxide solution to 1 part of anthraquinone. The anthraquinone is suspended in a small amount of 50 per cent alcohol and the hot alkaline solution and zinc dust added. This mixture is heated for half an hour and filtered. On the filter paper are found the unchanged portion of the anthraquinone and the zinc dust; the oxanthranol in the filtrate may be oxidized with air, and the anthraquinone formed filtered and weighed.

Following out the above directions, a dark green, alkaline solution is obtained instead of the cherry-red solution described by Grabe and Liebermann. The red color is formed on dilution, so it seems possible that a typographical error in regard to the concentration of alkali employed was made in the original paper. When the concentration of the sodium hydroxide solution is about 5 per cent or less it has been found that the reduction and subsequent reformation of anthraquinone can be made quantitative.

Johann Walter[1] has made use of this process for the separation of anthraquinone from anthracene and phenanthraquinone. He gives no detailed description of the method.

The following procedure, if carefully followed, has been found to give very accurate results. In addition to the factor of increased accuracy this method has the added advantage of a substantial saving of time.

One part of anthraquinone is wet with a small quantity of alcohol, mixed with 2 parts of zinc dust, and about 50 parts of a hot 5 per cent sodium hydroxide solution added. The mixture is heated just below the boiling point for 5 min., and then rapidly filtered by suction, and washed once with water. The filter paper with the residue is heated with another equal portion of the sodium hydroxide solution and rapidly filtered into the same flask. A third heating with alkali is sufficient to effect the solution of any residue of anthraquinone that may remain unreduced. The combined filtrates are cooled and reoxidized by shaking in the presence of air. A practical procedure is to shake the suction flask under a stream of cold water until the red color disappears. The resulting anthraquinone is filtered upon a weighed Gooch crucible, washed with water, dried at 110° and weighed.

The following precautions must be observed:

If the mixture is boiled for too long a period, there is some formation of the next reduction step, the compound called by Liebermann and Gimel,[2] anthranol, which contains one less oxygen atom than does the oxanthranol and does not reoxidize to anthraquinone by the action of air. The presence of this compound is easily shown by any yellow color in the filtrate from the final reoxidation.

There is danger that all the anthraquinone may not go into solution through the reduction. This is readily determined. If the residue on the third filter paper imparts no red color to the liquid when boiled again with hot alkaline solution, the reduction is complete.

A green color showing in the reoxidized anthraquinone indicates the presence of a reduced compound of phenanthraquinone, the structure of which has not been determined. Phenanthraquinone in the original substance causes high results, but when present in amounts less than 10 per cent the error is not sufficient to vitiate the practical value of the method.

It is necessary that the hot solution of the reduced anthraquinone be filtered rapidly in order to prevent reoxidation on the filter.

[1] *Z. anal. Chem.*, **12** (1873), 34; **13** (1874), 25.
[2] *Ibid.*, **16** (1877), 61.
[3] *Chem. News*, **73** (1896), 178.
[4] *Ber.*, **16** (1883), 2179.
[5] *Ibid.*, **27** (1894), 2125.
[6] *Ann.*, **323** (1902), 207.
[7] *Ibid.*, **160** (1871), 126.

[1] D. R. P. No. 168,291 (1904).
[2] *Ber.*, **20** (1887), 1854.

It has been found that certain grades of asbestos are affected by alkali and it is necessary that the asbestos, before use, should be freed from alkali-soluble constituents.

For analytical purposes a very good sample of anthraquinone was obtained from a so-called chemically pure commercial sample by recrystallizing several times from hot toluene. This commercial sample was analyzed by the above method and gave the following result:

Anthraquinone taken	0.2000 g.
Anthraquinone recovered	0.1992 g.
Loss	0.008 g. = 0.40 per cent

After purification the sample was analyzed as follows:

TABLE I—ANALYSIS OF PURE ANTHRAQUINONE

Sample Gram	Zinc Dust Gram	Sodium Hydroxide Cc of 5% Soln	Recovered Alcohol	Recovered Gram	Per cent
0.2000	0.4	15	To	0.2003	100.15
0.3002	0.6	20	wet	0.2997	99.83
0.2003	0.4	15	sample	0.2007	100.19

This method of purification and estimation seems to be especially adapted to supplant the "Hochst Test" in the estimation of anthracene because of its greater speed and accuracy. It may also be used with excellent results in estimating the purity of anthraquinone which is contaminated with anthracene and less than 10 per cent of phenanthraquinone.

The examples given in Table II illustrate the degree of accuracy to be expected when no special precautions are taken. Some of these analyses were completed in less than 2 hours.

TABLE II—ANALYSES OF MIXTURES

Composition of Mixtures: Anthraquinone Gram	Anthracene Gram	Phenanthraquinone Gram	Anthraquinone Recovered Gram	Per cent
0.1803	0.0297	0.0000	0.1805	100.09
0.1982	0.2000	0.0000	0.1975	99.65
0.1782	0.0000	0.0228	0.1805	101.28
0.2018	0.0747	0.0000	0.2020	100.10
0.2005	0.1342	0.0098	0.2000	99.75
0.2004	0.0000	0.0100	0.1999	99.75

A single analysis may be easily completed in 1½ hrs., exclusive of the drying of the final product to constant weight. If analyses must be completed in a short time the drying of the sample may be hastened by washing with alcohol and ether. The sacrifice in accuracy may be as little as 1 per cent.

A modification of this method is being worked out to increase the accuracy in the presence of large amounts of phenanthraquinone.

COLOR INVESTIGATION LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

CRITICAL ELABORATION OF QUANTITATIVE PRECIPITATION METHODS

EXEMPLIFIED BY A METHOD FOR THE DETERMINATION OF PHOSPHORIC ACID

By H. HEIDENHAIN

Received December 12, 1917

Of the numerous quantitative precipitation methods comparatively few have had the benefit of a thorough critical investigation. With most of them their authors have been satisfied when "good results" had been obtained. Such, however, are by no means proof of the correctness of a method. A compensation of errors must always be considered a possibility. As long as there exists any doubt in this respect, the scientific analyst will not be satisfied. On the contrary, he will desire to learn how a method will work under various conditions, *i. e.*, what influence the quantity of substance employed, concentration of solution, temperature, presence of certain substances, etc., may have on the result.

The task of examining a method as to its reliability has been put up to me repeatedly. While at first such work was lined out by me just for the particular case on hand, I later found that certain methods employed in my researches were applicable in a great number of cases. I might say that in a measure I have found a scheme for this class of work.

It is the purpose of this article to develop this scheme. However, before taking up my subject proper, I think it advisable to show how in one case of my experience the scheme has been successfully applied, as by so doing it will be easier for me to make myself clear later on.

A PRACTICAL CASE

The method of determining phosphoric acid by precipitating the same by molybdic acid solution and transforming the molybdic precipitate into magnesium ammonium phosphate is generally known. This transformation was necessary as long as we did not understand how to produce the molybdic precipitate in constant form. This, however, has finally been accomplished. Several articles on this subject have been published, but it was the thorough researches by Hundeshagen, *Zeitschrift für analytische Chemie*, 1889, which chiefly aroused my interest. Hundeshagen proved in convincing manner that the precipitate contains, for every 3 equivalents of phosphoric acid, 24 equivalents of molybdic acid and 3 equivalents of ammonium, if produced under certain conditions, and that the precipitate could be determined by titration with standard alkali solution, using phenolphthalein as indicator. Testing Hundeshagen's method I could confirm his findings, but I noticed that the end reaction at titration was lacking in sharpness.

Hundeshagen used a solution of ammonium nitrate as wash liquor, an appreciable amount of which remains in the filter and precipitate. This, as well as the ammonium in chemical combination with the phosphoric and molybdic acids, evidently is to be blamed for the uncertainty at titration, as ammonium salts cannot be titrated with exactness with phenolphthalein as indicator. On the other hand, this indicator seems indispensable to bring phosphoric acid to a definite stage of neutralization. There was, however, a way out of this dilemma. After the precipitate had been washed with ammonium nitrate solution, this salt could be removed by washing with alcohol and the ammonium in the precipitate could be gotten rid of by supersaturation and evaporation with the standard alkali solution, and determination of the excess of alkali by boiling with an excess of standard acid solution and titrating back with standard alkali solution. Thus the end-reaction was made sufficiently sharp and the results obtained were very satisfactory, but the method had become rather cumbersome.

As stated, the trouble was caused by the presence of ammonium. If in its stead a fixed alkali could be used, all difficulties, it seemed, were overcome. The thought suggested itself, to precipitate the phosphoric acid in the form of potassium phosphomolybdate, which likewise is a compound of very little solubility. Hundeshagen mentions the potassium compound in his article and states that its composition is analogous to that of the ammonium compound, but that it is more soluble than the latter. My own experiments confirmed this. At the same time, the results I obtained were so good that I thought it worth while to follow the matter up, *i. e.*, to subject the contemplated method to my scheme of criticism.

One of the first observations made was that the washing of the precipitate could not be declared finished by any test employed, be it a test for acidity or for molybdic acid. The wash liquor used at first was a solution of 10 per cent potassium nitrate in water. The filtrate remained acid even after prolonged washing. When the washing finally was stopped after such large quantities of wash liquor had been used that undoubtedly all free acid had been removed, the results were too low. Obviously the solubility of the precipitate was the cause of this loss. Following famous precedents I might have declared the washing finished after a "certain" amount of wash liquor had been used. Such arbitrary methods, however, I never approved of. I tried washing until constant acidity of the filtrate was attained, assuming that the acidity of the filtrate must gradually diminish until all free acid had been removed, and that when the acidity of the filtrate was caused only by the solubility of the precipitate, constant acidity would prevail. This principle was a good one, only I found that when constant acidity was attained, already losses had been sustained which could not very well be disregarded. It then occurred to me to give the wash liquor from the beginning a certain acidity by addition of nitric acid, thus rendering the precipitate less soluble. This move was successful. I found that in a 10 per cent solution of potassium nitrate with so much free nitric acid as corresponds to a 1/100 normal acid, the solubility of the precipitate was but 1/20 of that in the neutral solution. The losses were now so small that the results were not affected any more to any serious extent. The small quantity of free acid remaining in the filter and precipitate could be determined with satisfactory accuracy and a corresponding correction applied. While in my first experiments the results were too low, I now obtained figures a trifle too high, presumably caused by some molybdic acid which had been carried down by the precipitate.

From these preliminary experiments I had learned to handle the method. However, in order to become clear concerning all phases of the method I had to proceed systematically. I made a series of experiments.

I—As to the solubility of the precipitate in a neutral solution of potassium nitrate.

II—As to the solubility of the precipitate in an acidified solution of potassium nitrate.

III—As to the completeness of the precipitation of phosphoric acid by the solution of potassium molybdate in nitric acid by standing without stirring.

IV—As to the effect of stirring on the completeness of precipitation.

V—As to the influence of nitrate of potash on the precipitation.

VI—As to the influence of nitric acid on the precipitation.

VII—As to the influence of different substances as chlorides, sulfates and tartrates on the precipitation.

The results of these investigations are given in the following tables. Table VIII shows a few determinations of phosphoric acid in a chemically pure monopotassium phosphate.

TABLE I—SOLUBILITY OF POTASSIUM PHOSPHOMOLYBDATE IN SOLUTIONS OF POTASSIUM NITRATE

		After Digestion with Potassium Phosphomolybdate	
Expt. No.	KNO_3 in 100 cc. Grams	10 cc. Solution Neutralized by $N/50$ KOH Cc.	Corresponding to P_2O_5 Mg.
1	10	2.1	0.130
2	15	2.1	0.130
3	20	2.1	0.130

TABLE II—SOLUBILITY OF POTASSIUM PHOSPHOMOLYBDATE IN SOLUTIONS OF POTASSIUM NITRATE ACIDIFIED BY NITRIC ACID

	Solution Contained			After Digestion with Potassium Phosphomolybdate	
Expt. No.	KNO_3 in 100 cc. Grams	HNO_3 Corresponding to a	10 cc. Neutralized by $N/50$ KOH Cc.	10 cc. Solution Neutralized by $N/50$ KOH Cc.	Corresponding to P_2O_5 Mg.
1	10	1/100 N soln.	5	5.1	0.006
2	10	1/125 N soln.	4	4.2	0.012
3	10	1/250 N soln.	2	2.3	0.018
4	10	1/500 N soln.	1	1.8	0.049

TABLE III—PRECIPITATION OF PHOSPHORIC ACID BY POTASSIUM MOLYBDATE SOLUTION AFTER 16 HRS. STANDING WITHOUT STIRRING

Volume = 100 cc.
P_2O_5 employed = 0.6174 mg.
KNO_3 = 15 g.
Potassium molybdate solution[1]—varying
} Constant

Expt. No.	Solution of Potassium Molybdate Cc.	Titration of Precipitate by $N/50$ KOH Cc.	P_2O_5 Lost Mg.
1	0.5	0.0	0.6174
2	1.0	0.0	0.6174
3	2.5	7.15	0.176
4	5.0	7.60	0.148
5	10.0	7.65	0.145
6	20.0	7.35	0.164

[1] This solution was prepared analogous to the usual ammonium molybdate solution. It contained 5 per cent MoO_3.

TABLE IV—PRECIPITATION OF PHOSPHORIC ACID BY POTASSIUM MOLYBDATE SOLUTION AFTER 5 MIN. STIRRING AND 45 MIN. STANDING

See Table III for description of solution

Expt. No.	Solution Potassium Molybdate Cc.	Titration of Precipitate by $N/50$ KOH Cc.	P_2O_5 Lost Mg
1	2.5	0.3	0.599
2	5.0	9.65	0.014
3	10.0	9.9	0.006
4	20.0	9.45	0.034
5	40.0	8.10	0.117

TABLE V—INFLUENCE OF POTASSIUM NITRATE ON THE PRECIPITATION OF PHOSPHORIC ACID AS POTASSIUM PHOSPHOMOLYBDATE

Volume = 100 cc.
P_2O_5 employed = 0.6174 mg.
Potassium molybdate soln. = 10 cc.
Potassium nitrate—varying
} Constant

Expt. No	KNO_3 Grams	Titration of Precipitate by $N/50$ KOH Cc	P_2O_5 Lost Mg
1	5	0.0	0.6174
2	10	4.2	0.358
3	15	7.55	0.151
4	20	9.3	0.043
5(a)	20	9.2	0.049

(a) This solution was stirred for 5 min. and allowed to stand 2½ hrs., the others were also stirred for 5 min. but allowed to stand only 1 hour.

TABLE VI—INFLUENCE OF FREE NITRIC ACID ON THE PRECIPITATION OF PHOSPHORIC ACID AS POTASSIUM PHOSPHOMOLYBDATE

Volume = 100 cc.
P_2O_5 employed = 0.6174 mg.
Potassium nitrate = 20 g.
Potassium molybdate soln. = 10 cc.
Nitric acid, sp. gr. = 1.2—varying
} Constant

Expt. No. (a)	HNO_3 Cc.	Titration of Precipitate by $N/50$ KOH Cc.	P_2O_5 Lost Mg.
1	0	9.3	0.043
2	10	8.4	0.099
3	20	0.0	0.6174

(a) These solutions were stirred for 5 min. and allowed to stand 1 hr.

TABLE VII—INFLUENCE OF DIFFERENT SUBSTANCES ON THE PRECIPITATION OF PHOSPHORIC ACID AS POTASSIUM PHOSPHOMOLYBDATE

Volume = 100 cc.
P_2O_5 employed = 0.6174 mg.
Potassium nitrate = 20 g.
Potassium molybdate soln. = 10 cc.
} Constant

Expt. No.	Additions 1 g. of Each	Titration of Precipitate by $N/50$ KOH Cc.	P_2O_5 Lost Mg.
1	KCl	8.95	0.065
2	K_2SO_4	8.60	0.086
3	$KHC_4H_4O_6$	0.0	0.6174
4	$CaCO_3$ dissolved in HNO_3	9.25	0.046

TABLE VIII—DETERMINATIONS OF PHOSPHORIC ACID AS POTASSIUM PHOSPHOMOLYBDATE IN MONOPOTASSIUM PHOSPHATE[1]

Expt. No.	KH_2PO_4 Employed Gram	P_2O_5 Found Per cent	P_2O_5 Calculated Per cent	Difference Per cent	Time of Standing Hours
1	0.1	52.14	52.20	—0.06	1/2
2	0.1	52.20	52.20	0.0	1/2
3	0.1	52.14	52.20	—0.06	1/2
4	0.1	52.23	52.20	+0.03	1/2
5	0.05	52.17	52.20	—0.03	2 1/2
6	0.05	52.35	52.20	+0.15	3 1/2
7	0.1	52.17	52.20	—0.03	1/2

[1] The sample of KH_2PO_4 and 7 g. KNO_3 was dissolved in 30 cc. water. Then 40 cc. potassium molybdate solution was added. The precipitate was washed with a 1/100 normal nitric acid solution containing 10 g. KNO_3 in 100 cc. until 10 cc. of the filtrate were neutralized by 5.1 cc. $N/50$ KOH solution. (Compare Table II, Expt. 1.)

Returning to my subject proper—it seems to me that the accuracy of a precipitation method depends upon two circumstances—first, upon the degree of solubility of the precipitate; second, upon its purity. If we fail to find satisfactory conditions in these two respects we consider the method as worthless or employ it only conditionally. However, we must always keep in mind that ideal conditions can never be fulfilled. All precipitation methods, therefore, are more or less defective.

If we wish to try a method as to its accuracy, it is not sufficient to submit a certain quantity of a substance to a prescribed process and accept the result as final criticism, because the two sources of error mentioned may influence the result in such a manner that one compensates the other. In order to avoid the danger of such deception, either source of error must be investigated separately and the amount of either error must be determined. Not until these are known will it be possible to pass judgment upon the worth of a method.

INVESTIGATIONS AS TO THE SOLUBILITY OF PRECIPITATES

As mentioned above, precipitates are afflicted with the evil of impurity. If, in order to determine the solubility of a precipitate, we would digest a *large* quantity of it with a liquid or a solution, it is not at all impossible that the parts of the main substance and the impurities going into solution stand to each other in a ratio different from that in which they were originally present. In such a case, no matter whether the part going into solution or that remaining undissolved be determined, the results are misleading. This error, however, may be neutralized if, instead of large quantities, small quantities are employed, for in small quantities the absolute amount of the impurities is very small and may, therefore, be disregarded.

In experiments to study the solubility of precipitates we must keep apart (*a*) the influence of the solution from which the precipitate is separated, (*b*) the influence of the wash liquor.

(*a*) For the determination of the former the method is the same as with an ordinary determination, only the quantity employed is to be taken so small that while a considerable portion remains in solution, still a decided precipitation is taking place so that the effect of supersaturation has not to be taken into account. According to circumstances, either the part remaining in solution or the precipitated part is determined. Sometimes both parts may successfully be determined which, of course, will give the most satisfaction. It is hardly necessary to mention that solutions employed for these tests ought to contain all substances in the same proportion as in a practical analysis.

For the purpose of determining the influence of the single substances of the solution, it is commendable to make series of tests in which, at a time, one substance is varied while the others remain constant and to present the results in the form of tables. The study of the influence of temperature and concentration does not need any explanation.

(*b*) The determination of the solubility of a precipitate in the wash liquor seldom presents any difficulty if we have plain water or another volatile liquid. All that need be done is to digest a small quantity of the washed precipitate for a sufficiently long time to ensure saturation and to determine the dissolved part by weighing after evaporation or by titration, etc. If solutions of salts are used as wash liquors the determination by evaporation and weighing the residue is out of the question. There remain, however, all other methods of determination.

It is hardly necessary to mention that the methods for the determination of such small quantities as we have to do with in this class of investigations must be adapted to the conditions. Filters, funnels, evaporating dishes, etc., must be taken proportionately small and standard solutions proportionately dilute, or the unavoidable errors from weighing and measuring may invalidate the results.

INVESTIGATIONS AS TO THE PURITY OF PRECIPITATES

The purity of a precipitate may be impaired by two different causes—first, by incorrect stoichiometric composition; second, by foreign substances.

In contradistinction to the experiments on solubility for which small quantities are employed, the examination as to purity requires large quantities, because impurities or deviations from the theoretical composition are perceptible only to a small extent in precipitates which are adapted for quantitative determinations.

A general scheme of procedure for these researches cannot very well be given, as the variety of cases is too great. All that may be said in a general way is

that the precipitates must be subjected to analysis just as if they were original substances for an analysis. If it is found that the composition of a precipitate comes up to expectation fairly well, it might be sufficient to establish a factor by which the results are to be multiplied. However, if this is not the case we must endeavor to improve the purity of the precipitate. In general, precipitates are the purer, the more dilute the solutions from which they have separated. Still, too great hopes in this respect should not be entertained, for the ratio of the precipitate to the substances in solution remains the same on dilution, and it is the influence of these substances which, in many cases, prevent the pure separation of the precipitates. The purpose is better accomplished if precipitation is repeated after the bulk of the first solution has been removed. Especially is this to be recommended if the precipitation had to take place in highly concentrated solution.

If removal of the impurities is impossible, nothing else remains to be done but to make determinations with varying quantities in order to arrive at an estimation of the amount of impurities, taking into account any losses caused by the solubility of the precipitate. If at the same time the possibility of incorrect stoichiometric composition prevails, such results, of course, allow more than one explanation.

From the aforesaid it is clear than two radically different methods of procedure are necessary to criticize precipitation methods. The completeness of precipitation and the losses on account of solubility must be studied on small quantities. As a matter of fact, a few milligrams of the substance are sufficient in most cases. Simultaneously we learn from this part of the critical work on a method the limit of its applicability for the determination of small quantities. In order to characterize these conditions I would like to introduce the term "micro-analytical." On the other hand, examinations as to purity and correct composition, likewise the final tests with the view to practical application, must be made with large quantities. For these reasons I would like to call this part of the criticism of the method "macro-analytical."

For another reason also it would be well to make such distinction. The micro-analytical errors are always *absolute* losses. Accordingly their corrections will consist in additions. But the macro-analytical errors have the form of *proportions* and must, therefore, find their corrections in multiplications or divisions. The general algebraic formula for the correction of a result will be thus:

$$Q \times M^1 \times M^2 + m^1 + m^2$$

in which Q represents the actual quantity of a precipitate, M^1 and M^2 the factors for the macro-analytical corrections and m^1 and m^2 the losses caused by solubility.

While methods requiring corrections have not been considered the best, there is no reason why one should hesitate to use a method after it has undergone a thorough critical treatment; in other words, after the errors have been scientifically determined. On the contrary, results corrected on a scientific basis deserve more confidence than such as are obtained by methods which are believed to be reliable, but which never have been criticized in a methodical manner.

25 Ogden Street
Hammond, Indiana

IMPROVED METHODS FOR THE ESTIMATION OF SODIUM AND POTASSIUM

By S. N. Rhue

Received September 19, 1917

A method for the estimation of sodium, involving considerable modification of the procedure of the Association of Official Agricultural Chemists, was published from this department by Forbes, Beegle and Mensching in *Bulletin* **255** of this Institution, under the date of January 1913. Since the time of this publication we have made extensive use of this improved method and have devised further improvements, which it is our purpose to record. The general principles of the method as now used are the same as stated in the earlier publication referred to above, but changes of detail have been devised which shorten the process and remove certain sources of possible error, at the same time calling for much less use of platinum. Incidentally, improvement has been effected in the method for the estimation of potassium.

For the quantitative test of the new procedures a salt solution was prepared in such manner as to contain the same kinds and proportionate amounts of the mineral elements as are present in wheat bran. Nitrogen, also, was added to this solution, in the form of ammonium sulfate. The elements and the compounds in which they were present were as follows:

Sodium	C_2H_5ONa
Potassium	C_2H_5OK
Calcium	$CaHPO_4.2H_2O$
Magnesium	$Mg_3(PO_4)_2.4H_2O$
Sulfur	H_2SO_4 and $(NH_4)_2SO_4$
Chlorine	HCl
Phosphorus	Salts of Ca and Mg
Nitrogen	$(NH_4)_2SO_4$

The sodium and potassium ethylates were prepared from the pure metals by dissolving in absolute alcohol and standardizing by titration against benzoic acid. Calculated from the weights of the metals (in air), 10 cc. of the solution should have contained 0.01045 g. Na and 0.03926 g. K. The titration against benzoic acid indicated the presence of 0.01037 g. Na and 0.03757 g. K (0.03202 g. sodium sulfate and 0.08373 g. potassium sulfate) in the same volume of solution. The latter weights were used as the basis for judgment as to the correctness of analytical methods.

MODIFICATION OF THE METHOD FOR SODIUM

In the use of the method for sodium, as published in Ohio Agricultural Experiment Station, *Bulletin* **255**, we have found much advantage in the principle of the second of the optional methods of ashing. The first method proposed for destroying the organic matter, by nitric-sulfuric acid digestion, necessitates the subsequent burning off of much sulfuric acid, in which process there is great likelihood of loss through spattering and overheating. In our later work,

therefore, the principle of the second optional method of ashing (in which the little sulfuric acid used is entirely driven off) has been followed, and the ashing is now conducted in porcelain, instead of platinum.

After the precipitation of the phosphorus, in the solution of the ash, as magnesium ammonium phosphate, the published method specified the evaporation of the filtrate and the burning off of ammonium salts in a platinum dish. In the later work, the ammonium salts are destroyed by digestion with nitric and hydrochloric acids, these acids being finally driven off, first by evaporation and then by baking on the hot plate.

The details of our later method for the estimation of sodium are as follows:

Weigh the sample into a porcelain dish, cover with 25 per cent sulfuric acid, reduce to dryness on the steam bath, and char completely on the hot plate.[1] After all foaming has ceased, ash over an open flame. If necessary, to complete the ashing, leach with hot water, and reburn the residue. Digest the ash and leachings in HCl and water on the steam bath for one hour, and filter into a 400 cc. beaker, washing the residue on the filter paper with hot water; or, in case the same solution is to be used for both sodium and potassium estimations, filter into a volumetric flask.

Add enough ammonia to the solution to render it almost neutral,[2] and enough magnesia mixture to precipitate the phosphorus as magnesium ammonium phosphate. After 15 minutes add 5 to 10 cc. of concentrated ammonia, and allow to stand over night. Filter, and wash out sodium and potassium sulfates with 2.5 per cent ammonia. Now add 20 cc. of concentrated HNO_3 and a little HCl, and evaporate to dryness on the hot plate. Continue heating for 1 or 2 hrs. to drive off all excess acid. Dissolve the residue of sulfates with hot water and transfer to a 250 cc. beaker. Boil, and add a saturated solution of freshly prepared $Ba(OH)_2$ to the complete precipitation of the magnesium. Filter, and wash with hot water, testing the filtrate for complete precipitation of magnesium. (If the filtrate is milky it is an indication of incomplete precipitation of magnesium.) After all the magnesium is filtered out make the solution ammoniacal, boil, and add enough ammonium carbonate and ammonium oxalate (saturated solutions) to completely precipitate the barium and calcium. Allow to stand at least 2 hrs.; filter, wash with hot water, add 5 cc. ammonium sulfate solution (75 g. $(NH_4)_2SO_4$ per liter) and evaporate to dryness. Dissolve the residue in hot water and transfer directly to unweighed platinum dishes. Evaporate to dryness on the steam bath and heat carefully over a free flame to dull redness. Dissolve residue in hot water and filter into weighed platinum dishes. Evaporate to dryness on the steam bath and heat to constant weight over the open flame. The residue weighed consists of the sodium and potassium sulfates. Calculate the amount of potassium found to the sulfate, and subtract from the weight of combined sulfates to obtain the amount of sodium sulfate.

MODIFICATION OF THE METHOD FOR POTASSIUM

Potassium was estimated by the official Lindo-Gladding procedure, modified as to the method of ashing, and also for preliminary precipitation of calcium and iron, where such treatment is necessary.

The details of the method as used are as follows:

Prepare and digest the ash in the same manner as specified for sodium above. Make the solution ammoniacal; boil and filter, washing well with hot water. Heat the ammoniacal filtrate to boiling and add sufficient ammonium oxalate (saturated solution) to completely precipitate the calcium. Allow to stand over night. Filter, and wash with 2.5 per cent ammonia. Add 20 cc. of concentrated HNO_3 and a little HCl; evaporate to dryness and bake on the hot plate for 1 or 2 hrs. to drive off excess nitric acid. Take up the residue with hot water and a few drops of HCl; filter into a 150 cc. beaker. Add enough H_2PtCl_6 solution for the complete precipitation of potassium.

Evaporate the solution on the steam bath almost to dryness, cool and add a few cc. of 80 per cent alcohol. Filter through a small sugar tube, and transfer the precipitate to the tube by means of a rubber-tipped rod and 80 per cent alcohol. Wash the precipitate and asbestos free from H_2PtCl_6 with 80 per cent alcohol. Wash the precipitate about five times with 5 to 10 cc. of NH_4Cl solution (100 g. NH_4Cl in 500 cc. H_2O saturated with K_2PtCl_6) or until all white or light orange material is dissolved. Then wash the precipitate and pad free from NH_4Cl with 80 per cent alcohol and drive off the alcohol in a hot-air oven. Wash the K_2PtCl_6, with hot water, from the sugar tube into a weighed platinum dish; evaporate to dryness on the steam bath, and heat to constant weight in a hot-air oven at 105° C., weighing as K_2PtCl_6.

ANALYTICAL RESULTS OBTAINED BY MODIFIED METHODS

Estimation of sodium in the test solution, by the improved method, gave results as stated below:

	Gram
Combined sulfates found in 10 cc. solution	0.1131
	0.1135
	0.1139
	0.1141
	0.1143
	0.1153
	0.1169
	0.1173
AVERAGE	0.1148
ACTUALLY PRESENT	0.11575

This method was found much superior to the usual procedure, both as to ease of operation and agreement of results. The amount of sodium found was 99 per cent of the amount present.

SODIUM ESTIMATIONS ON FOODSTUFFS - DRY BASIS

SAMPLE No	FOODSTUFF	Wt. of sample Grams	Combined sulfates Gram	Combined sulfates per gram sample Gram	Potassium sulfates per gram sample Gram	Sodium sulfates per gram sample Gram	Per cent sodium
1	Corn meal	10	0.0888				
2	Corn meal	10	0.0870				
3	Corn meal	10	0.0880				
	AVERAGE		0.0853	0.00853	0.00770	0.00083	0.2269
1	Corn silage	5	0.0824				
2	Corn silage	5	0.0820				
3	Corn silage	5	0.0808				
	AVERAGE		0.0817	0.01634	0.01463	0.00171	0.0554
1	Linseed oil meal	3	0.0852				
2	Linseed oil meal	3	0.0852				
3	Linseed oil meal	3	0.0848				
	AVERAGE		0.0824	0.02747	0.02617	0.00130	0.0421
1	Wheat bran	3	0.0860				
2	Wheat bran	3	0.0846				
3	Wheat bran	3	0.0808				
	AVERAGE		0.0838	0.02793	0.02791	0.00002	0.0007
1	Alfalfa	3	0.1834				
2	Alfalfa	3	0.1860				
3	Alfalfa	3	0.1860				
	AVERAGE		0.1851	0.06170	0.05549	0.00621	0.2011

The burning of the sample in a porcelain dish with H_2SO_4 does not introduce an error by removing potassium or sodium compounds from the dish. To determine this point 10 g. of chemically pure sugar and 25 cc. of 25 per cent H_2SO_4 were burned in new and in old porcelain dishes, and potassium and sodium were determined by these methods.

[1] Recent unpublished work in this laboratory by J. O. Halverson has shown that manganese and aluminum if present should be precipitated and removed at this point. —E. B. Forbes.

Estimation of potassium in the test solution, by the improved method, gave results as stated below:

	Gram
Potassium (as platinic chloride) found in 10 cc. solution..	0.2247
	0.2247
	0.2269
	0.2275
	0.2285
	0.2291
	0.2299
	0.2305
	0.2311
AVERAGE	0.2281
ACTUALLY PRESENT	0.2336

Results obtained by the usual method were high, and the agreement was not satisfactory, probably because of incomplete washing out of the calcium and magnesium sulfates with ammonium chloride solution. The improved method of ashing converts the calcium and magnesium into the chlorides which are easily washed out with ammonium chloride solution. The agreement of results by the improved method is satisfactory, and the amount of potassium found was 98 per cent of the amount present.

POTASSIUM ESTIMATIONS ON FOODSTUFFS—AIR-DRY BASIS

Sample No.	Foodstuff	Wt. of sample Grams	Potassium platinic chloride Gram	Potassium platinic chloride per gram sample Gram	Potassium sulfate per gram sample Gram	Per cent potassium
1	Corn meal	5	0.1083	...	...	..
2	Corn meal	5	0.1163	...	...	..
3	Corn meal	5	0.1065	...	...	..
	AVERAGE 1 and 3	...	0.1074	0.02148	0.00770	0.3455
1	Corn silage	2	0.0937	...	...	..
2	Corn silage	2	0.0913	...	...	..
3	Corn silage	2	0.0897	...	...	..
	AVERAGE	...	0.0916	0.04080	0.01463	0.6562
1	Linseed oil meal	1.5	0.1083	...	...	..
2	Linseed oil meal	1.5	0.1115	...	...	..
3	Linseed oil meal	1.5	0.1087	...	...	..
	AVERAGE	...	0.1095	0.07300	0.02617	1.1741
1	Wheat bran	1.5	0.1147	...	...	..
2	Wheat bran	1.5	Dish broke during ignition			
3	Wheat bran	1.5	0.1189	...	...	..
	AVERAGE 1 and 3	...	0.1168	0.07786	0.02791	1.2523
1	Alfalfa	1	0.1561	...	...	..
2	Alfalfa	1	0.1539	...	...	..
3	Alfalfa	1	0.1545	...	...	..
	AVERAGE	...	0.1548	0.15480	0.05549	2.4898

DEPARTMENT OF NUTRITION
OHIO AGRICULTURAL EXPERIMENT STATION
WOOSTER, OHIO

A COMPARATIVE STUDY OF THE THERMAL DECOMPOSITION OF COAL AND OF SOME OF THE PRODUCTS OF ITS CARBONIZATION[1]

By M. C. WHITAKER AND JOHN RICHARD SUYDAM, JR.

The work of Whitaker and Rittman,[2] Egloff,[3] Alexander,[4] Leslie,[5] Zanetti,[6] and others has shown that it is possible to control the thermal decomposition of hydrocarbons in such a way as to give the maximum yields of certain products of decomposition, such as constituents of gases, aromatic hydrocarbons, etc.

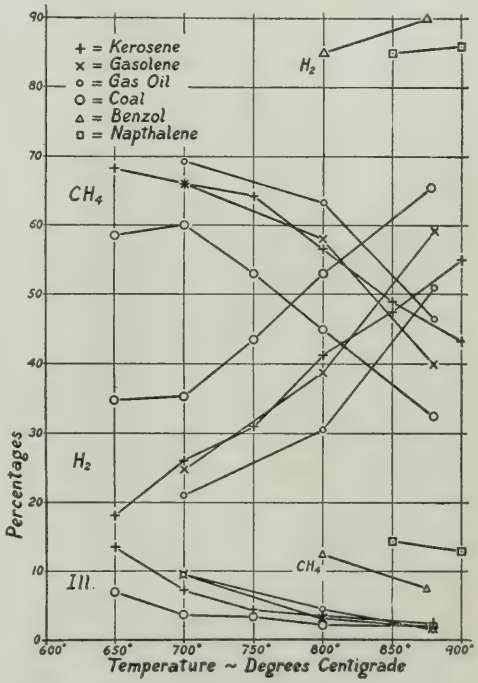
The purpose of this investigation was to determine if different hydrocarbons and other organic compounds did not give results that were peculiar to their ultimate composition and chemical structure. It was hoped in this way to throw further light on the chemical structure of the substances in coal, by comparing the results obtained from organic compounds with those obtained from coal when treated in the same way.

The experiments were carried out in a vertical, electrically heated, iron tube furnace, 4 in. in diameter and a little more than 6 ft. long.

The substances examined were powdered coal, gasoline, kerosene, gas oil, benzene and naphthalene. The coal used was a Pennsylvania gas coal of the following composition:

	Moisture	Volatile Matter	Fixed Carbon	Ash
Proximate, per cent	0.9	34.1	59.2	5.8
	Carbon	Hydrogen	Nitrogen	
Ultimate, per cent	80.2	5.7	1.6	

In the experiments in which powdered coal was used, it was fed in by a worm conveyor from a hopper at the top of the furnace. The powder dropped through the heated furnace, some of it sticking to the walls, and the coke was collected below. The gas formed was led off from the bottom of the furnace to a gasometer.



Experiments were carried out studying the effect of temperature, rate of feed, and size of coal particles on the production and composition of the gas. The results are summarized in the table on page 432.

The quantity of tar produced was too small for examination.

In the work on the thermal decomposition of the other substances examined, the liquid was fed into the

[1] Abstract of dissertation submitted in partial fulfillment of the requirements for the Ph.D. degree, Columbia University, New York City, 1917.
[2] THIS JOURNAL, **6** (1914), 383, 472.
[3] *Met. and Chem. Eng.*, **7** (1915), 16, 17; *J. Phys. Chem.*, **1916**; THIS JOURNAL, **7** (1915), 481, 578, 1019.
[4] THIS JOURNAL, **7** (1915), 484.
[5] *Ibid.*, **8** (1916), 593, 684.
[6] *Ibid.*, **8** (1916), 674, 777.

Run No.	Temp. °C.	Feed Lbs. per Hr.	Size of Coal Mesh	Cu. Ft. Gas Per Lb. Coal
2a	650	0.38	20–60	2.82
2b	650	0.38	20–60	2.79
4a	750	0.38	20–60	3.92
4b	750	0.38	20–60	3.96
12a	875	0.38	20–60	6.14
12b	875	0.38	20–60	6.26
11	650	0.78	20–60	
10	750	0.78	20–60	3.40
6a	800	0.38	40–50	4.60
8	800	0.38	30–40	4.60
7	800	0.38	20–30	4.50

Run No	Analysis of Gas						
	CO_2	CO	H_2	C_nH_{2n+2}	C_nH_{2n}	O_2	N_2
2a	2.2	15.2	6.7	30.2		0.7	
2b	2.2	12.1	5.6	28.6	47.2	0.4	3.5
4a	1.9	12.3	2.7	38.3	43.0	0.2	5.6
4b	1.7	12.0	2.8	34.8	41.0	0.4	7.3
12a	1.1	15.7	2.0	53.3	26.0	0.3	2.6
12b	0.9	16.5	1.3	53.6	27.1	0.2	0.6
11	1.8	12.0	4.8	31.1	45.6	0.5	4.6
10	1.6	12.4	2.5	36.8	41.0	0.5	5.3
6a	1.6	11.9	1.6	45.2	36.0	0.4	3.4
8	1.1	12.3	1.5	44.4	36.5	0.2	4.4
7	1.7	12.4	1.7	42.7	37.1	0.2	4.1

top of the furnace from a sight feed pressure oiler and vaporized from a length of chain hung in the upper part of the furnace. Curves showing the composition of the gas produced by the cracking of these liquids and by carbonizing coal by the above method at various temperatures and equal rates of feed of volatile matter are contained in Fig. I.

CONCLUSIONS

The paraffin hydrocarbons when cracked by the method herein described give gases which at the same temperature have practically the same composition.

The aromatic hydrocarbons without side chains gave a totally different form of gas curves. They do not begin to decompose at such low temperatures as the paraffins do and when they do break down they apparently yield only hydrogen and methane.

After eliminating the nitrogen- and the oxygen-containing constituents of the coal gas produced, this gas is similar to that produced from paraffin oils and not at all similar to the gas produced from the aromatic bodies examined.

The above results indicate that coal is made up in general of straight chain compounds. The best evidence of this that has been put forward to date is the fact that "low temperature" coal tar consists practically entirely of straight chain oils.

CHEMICAL ENGINEERING LABORATORY
COLUMBIA UNIVERSITY
NEW YORK CITY

THE INFLUENCE OF COLD SHOCK IN THE STERILIZATION OF CANNED FOODS

By L. D. BUSHNELL

Received March 29, 1918

INTRODUCTION

The influence of rapid cooling, after heating, is a matter of considerable importance in the canning industry. Its value in the blanching of foods was first mentioned by Benson[1] who reports in part as follows:

> When a food product has been blanched in boiling hot water or live steam, remove quickly from this and plunge immediately into cold water. The influence of this method upon bacteria, spores, and molds is very effectual; when this is followed by a single period of sterilization, we contend that the success of canning is just as sure as though three periods on three successive days were used.

Bitting and Bitting,[1] in discussing the influence of cooling, make the following statement:

> The primary effect is to make a better appearing product, but secondly it appears to be a factor in insuring the sterility of some products.

The only possible influence that this procedure could have, would be that of shock to the bacterial cell. This might possibly devitalize the cell in such a way that it would be more easily destroyed by a subsequent heating, or, perhaps, perish slowly, or not be able to grow under such rather unfavorable conditions as exist in sealed containers. Of course, this initial period of heating during blanching will destroy many organisms in the vegetative stage, but a glance at Table X will show that the organisms in the spore stage are the only ones which are of importance in canning.

If the shock of cold is of value in sterilization it should be more widely known than it is at present, as it could be used in many lines of investigation other than that of food canning.

The question of blanching and cold dipping is of particular importance in the canning of foods, as in this case the cooling can be made much more rapid than is possible after the material is packed in jars. For this reason we conducted quite extensive experiments upon this problem during our preliminary work upon canned vegetables in the summer of 1917. The process consists of a short period of heating in boiling water or steam, followed by rapid cooling. The product is later subjected to the sterilizing process. This procedure is of much practical importance in improving the physical condition of the product and in causing shrinkage before the material is added to the jars. The experiments were conducted to establish its value as an aid to sterilization.

In much of this preliminary work we used large test tubes and half-pint bottles with large mouths. Some of these were plugged with cotton, while others were sealed with rubber stoppers. This was not from an idea of economy in cost of material so much as an economy in laboratory space and time, as rubber stoppers usually cost more than jars. Several dozen test tubes, however, occupy no more space in the steamer than would be occupied by one dozen pint jars. Also, heat penetrates them much more rapidly and we were able in this way to save at least half an hour on each experiment. The results which we obtained were comparable in every way to results which we obtained by the use of jars.

The tubes are somewhat more difficult to seal, but if they are completely filled before heating begins and are sealed at once by a sterile solid glass rod as soon as the heating period is completed, practically no trouble is experienced by the stoppers being blown out on second heating. Better results are obtained by using stoppers with one hole and plugging this with

[1] "Home Canning Club Instruction to Save Fruit and Vegetable Waste," Office of Farmers' Cooperative Demonstrations, Northern and Western States, Washington, D. C., 1915, p. 4.

[1] "Bacteriological Examination of Canned Foods," Research Laboratory National Canners' Association, *Bull.* **14** (1917), 7.

a sterile glass rod, than by fitting the tubes with solid stoppers. The rods should fit very firmly, otherwise they may be drawn into the tube or leak air on cooling. The stoppers should be pushed well into the tube before the heating begins.

In all the vegetables the time allowed for heat to penetrate in test tubes was 5 min.; in bottles, 15 min.; in pint jars, 30 min. This time was always allowed to elapse before sterilization was supposed to have begun.

EXPERIMENTAL

EXPERIMENT 1—The method of heating for a short time followed by a plunge into cold water was tried on several kinds of culture media containing varying numbers of spores of both aerobic and anaerobic bacteria. The tubes were subjected to a short heating in the steamer, followed by plunging them into cold water, and by a second and longer heating. This method failed in every case to shorten the time necessary to sterilize, either in the streaming steam or in the autoclave.

EXPERIMENT 2—The same procedure was followed as in Experiment 1, except that the tests were made in duplicate; half of the tubes were cooled rapidly in ice water and half allowed to cool slowly to this temperature. The time required was from 15 to 30 min. In no case was the reduction in number more marked in the tubes cooled rapidly than in those cooled slowly.

EXPERIMENT 3—Several pure cultures obtained from spoiled canned goods were used in this experiment. The cultures were grown in broth for several days and equal amounts placed in test tubes as near the same thickness of wall and the same diameter as could be obtained. These were then placed in streaming steam for 10 min. Half of the tubes were plunged into ice water and the remaining half allowed to cool slowly to the same temperature. These tubes were then all placed in the steamer and steamed for 30 min. and plates made. Table I shows the results obtained.

TABLE I

No.	Original Per Cc.	Cooled Rapidly Per Cc.	Cooled Slowly Per Cc.
1	38,000,000	2,600,000	2,500,000
2	1,000,000	0	100
3	90,000,000	14,000,000	11,000,000
4	40,000,000	7,000,000	600,000
5	70,000,000	200,000	200,000
6	268,000,000	4,300,000	1,300,000
7	1,580,000,000	60	0
8	600,000,000	20	0

This table shows that the shock of cold did not influence the thermal death-point of pure cultures, as all the above data, except, perhaps, No. 4, are easily within the limits of experimental error.

EXPERIMENT 4—In this experiment we tried the influence of cold shock upon the time necessary to sterilize peas. The peas were treated in every way as in ordinary canning and blanched for different periods of time. In order to avoid contamination in handling and to insure rapid cooling in the ice water, the peas were placed in test tubes of medium size, covered with water, and the tubes plugged with cotton. The tubes were heated in streaming steam for different periods of time. No time was allowed for penetrating, which was found later to be about 5 min. The time of spoilage was noted by the appearance of clouding of the liquid surrounding the peas and by presence of growth on the surface. We have always noted these signs when spoilage appeared in containers sealed with cotton only.

TABLE II

Blanched Min.	Heated Min.	Cooled Rapidly Time of Spoilage Hrs.	Cooled Slowly Time of Spoilage Hrs.
5	30	48	48
10	30	48	48
20	30	48	48
5	60	72	120
10	60	72	120
20	60	72	120
5	90	72	120
10	90	72	120
20	90	72	120

In this case there is no evidence that the length of blanching time or the rapidity of cooling influenced in any way the ease with which the spores were subsequently killed by heat. In fact, those cooled more slowly seem to be least easily destroyed if the time of spoilage is an indication. We may account for this on the basis of germination of the spores during the slow process of cooling, as this usually requires several minutes (see Table IV).

EXPERIMENT 5—Table III shows the influence of cold shock followed by intermittent heating. In this case green beans were used and the conditions of the experiment were similar to those in Experiment 4, except that blanching was continued for 15 min. in the steamer.

TABLE III

Heated	Time between Last Heating and Spoilage Cooled Rapidly	Cooled Slowly
15 min. twice 1 day	Spoiled after 48 hrs.	Spoiled after 60 hrs.
30 min. twice 1 day	Spoiled after 60 hrs.	Spoiled after 60 hrs.
60 min. twice 1 day	Good after 10 days	Good after 10 days
90 min. twice 1 day	Good after 10 days	Good after 10 days

This experiment also shows that spores are not devitalized by cold shock and that blanching for rather long periods followed by cold dipping does not aid in sterilization.

EXPERIMENT 6—This experiment was devised to test the possibility of spore germination between the time of blanching and heating. Fresh peas were used. The conditions of the experiment are as in Experiment 5, except that the blanching was for 5 min.

TABLE IV

Blanched Min.	Heated Min.	Incubation at 35° C. 10 min.	20 min.	40 min.	80 min
5	60	Sp. 48 hrs.	Sp. 48 hrs.	Sp. 48 hrs.	Sp. 48 hrs.
5	60	Sp. 48 hrs.	Sp. 48 hrs.	Sp. 120 hrs	Sp. 48 hrs
5	180	Sp. 48 hrs.	Sp. 72 hrs.	Sp. 96 hrs	Good 7 days

Sp. = Spoilage.

Table IV shows that the incubation period has but little influence upon the ease of sterilization. In the column showing incubation for 80 min. and heating for 180 min., the product did not spoil. This might have been due to the fact that the spores had all changed to the vegetative stage, but this is not likely, because heating for 60 min. will easily kill all in the vegetative stage and this, together with that heated 120 min., spoiled. This would seem to indicate that the incubation period, due to slow cooling, will not explain why, in some cases, the organisms cooled slowly are more easily killed, or at least grow more slowly, than those cooled more rapidly. In several instances, however, we have observed spoilage to take place more

rapidly, and in some cases more spoilage follows blanching than when no blanching is practiced.

EXPERIMENT 7—This, together with some of the following experiments, was conducted to determine the necessity of complete sterilization to insure the keeping of canned foods. We believe that it is usually considered necessary to sterilize completely to avoid spoilage unless some substance is added to alter the physical or chemical nature of the product. We have repeatedly received inquiries concerning this point at the laboratory. Also, many conflicting reports have reached us as to the time necessary to process to insure keeping, certain people losing the entire pack, while others, under very similar conditions and methods of treatment, lose very little.

TABLE V

Heated	Cooled Rapidly		Cooled Slowly	
Min	Cotton Seal	Rubber Seal	Cotton Seal	Rubber Seal
60	Sp 48 hrs	Good 5 days [a]	Sp 48 hrs	Good 5 days
120	Sp. 96 hrs	Good 5 days	Good 5 days	Good 5 days
180	Sp. 72 hrs	Sp 72 hrs [b]	Sp 60 hrs	Good 5 days

[a] We have found that a product which will keep for 5 days at 35° C. will usually keep indefinitely. We have some of these rubber sealed bottles which are still good after 6 mos.

[b] Rubber stopper became loosened and leaked air

In some of our work we have been surprised to note the ease with which certain foods, supposed to be very difficult to sterilize, would keep indefinitely if properly sealed. Also to find that most organisms isolated from the product after prolonged heating were aerobic in nature.

To determine this point we devised the method of sealing one set of tubes with rubber and a duplicate set with cotton plugs.[1]

In this experiment small beets were used. They were first dipped in boiling water and the skins removed. They were then blanched for 10 min. in streaming steam. Upon removal from the steamer they were divided into two lots. One lot was dipped immediately into cold water and the second cooled very slowly to the same temperature. These were then packed in large, wide mouth bottles and processed as indicated below. No exceptional precautions were taken to prevent contamination. In this case 15 g. of salt were added to each 1000 cc. of liquid used.

Table V shows the results of this experiment. Spoilage was determined by the appearance of the material after standing at 35° C. for the time mentioned.

EXPERIMENT 8—This is an experiment similar to Experiment 7 except that vinegar was used in place of salt, 15 cc. of vinegar being added to each 1000 cc. of water used. (Five cc. of the vinegar required 4 cc. $N/20$ NaOH to neutralize to phenolphthalein.) Table VI shows the results obtained. The results are similar to those in Experiment 7.

EXPERIMENT 9—The following experiment was devised to see if blanching increased the ease of sterilization over a similar product packed without blanching.

In this experiment fresh green beans were used. These were snapped into small pieces and divided into two lots. One lot was placed directly into large, clean test tubes which had been autoclaved shortly before use. A second lot was blanched in a steamer

TABLE VI

Heated	Cooled Rapidly		Cooled Slowly	
Min	Cotton Seal	Rubber Seal	Cotton Seal	Rubber Seal
60	Sp 48 hrs	Good 5 days	Sp 48 hrs	Good 5 days
120	Sp 60 hrs	Good 5 days	Sp. 72 hrs	Good 5 days
180	Good 5 days	Good 5 days	Sp 96 hrs	Good 5 days

for 5 min., dipped into cold water, and placed in similar tubes. All were then covered with salt solution of various strengths, plugged with cotton, and processed as indicated in Table VII.

In filling the tube with blanched beans a sterile funnel and forceps were used so that they did not come into contact with the hands of the operator. They were, however, cooled in running water from the tap. Table VII shows results obtained.

These results show that blanching does not increase ease of sterilization and that salt, except in amounts too large to be permissible, has no influence upon the keeping quality.

EXPERIMENT 10—In this experiment an attempt was made to show the influence of blanching upon sweet corn. The corn was of excellent quality and freshly picked. Test tubes were used throughout the experiment. The corn, after blanching for 5 min. in steam, was cut from the cob with a sterile knife and poured into large, sterile glass bottles, at the end of the blanching period. The unblanched corn was treated in a similar manner except that no preliminary heating was applied. Tables VIII and IX show the

TABLE VII

Heated	Blanched 5 Minutes			Packed without Blanching		
	1.0 Per cent Salt	2.0 Per cent Salt	4.0 Per cent Salt	1.0 Per cent Salt	2.0 Per cent Salt	4.0 Per cent Salt
60 min 1 day	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs	Sp. 72 hrs	Sp. 72 hrs.	Sp 72 hrs
120 min 1 day	Sp 48 hrs	Sp. 48 hrs	Sp 48 hrs	Sp. 72 hrs	Sp 72 hrs	Good 10 days
180 min 1 day	Good 10 days	Sp 48 hrs	Good 10 days	Good 10 days	Good 10 days	Good 10 days
15 min 2 days	Sp 48 hrs	Sp. 48 hrs.	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs
30 min 2 days	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs	Sp. 48 hrs.	Sp 48 hrs
60 min 2 days	Sp 48 hrs	Sp. 60 hrs	Sp 60 hrs	Sp 48 hrs	Sp 48 hrs	Good 10 days
90 min 2 days	Sp 60 hrs	Good 10 days	Good 10 days	Sp 48 hrs	Good 10 days	Good 10 days
15 min 3 days	Sp 48 hrs	Sp 48 hrs	Sp 48 hrs	Sp 60 hrs	Sp. 4 days	Sp 48 hrs
30 min 3 days	Good 10 days	Sp 48 hrs	Good 10 days	Sp 48 hrs	Sp. 4 days	Good 10 days
60 min 3 days	Sp 60 hrs	Good 10 days	Good 10 days	Sp 48 hrs	Good 10 days	Good 10 days
90 min 3 days	Good 10 days	Good 10 days	Good 10 days	Good 10 days	Good 10 days	Good 10 days

This experiment shows that no improvement in keeping quality is to be expected from blanching and cold dipping. Exclusion of air, however, does have a very marked influence upon keeping quality. This point will be discussed more in detail later.

influence of heating upon the keeping quality of corn treated by various methods. The plus sign indicates spoilage. The minus sign indicates that the product was good after 10 days in the warm room.

These results show that there is no influence due to blanching, very little due to small amounts of salt, very little due to small amounts of acid, and a great deal due to larger amounts of acid and to sealing.

[1] There are two reasons for using cotton plugs in this work. The first is that spoilage takes place very rapidly, if it takes place at all, the second is that cotton acts as a bacterial filter and at the same time allows air to enter.

TABLE VIII—CORN BLANCHED 5 MINUTES

Heated	Sealed with Cotton Stopper: Water	1.0 Per cent Salt	3.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.3 Per cent Acid	Sealed with Rubber Stopper: Water	1.0 Per cent Salt	2.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Salt	0.3 Per cent Salt
60 min. 1 day.....	—	+	—	+	—	—	—	—	—	—	—	—
120 min. 1 day.....	—	+	—	+	—	—	—	—	—	—	—	—
180 min. 1 day.....	—	—	—	—	—	—	—	—	—	—	—	—
15 min. 2 days.....	+	+	+	+	+	—	+	—	—	+	—	—
30 min. 2 days.....	+	+	+	+	+	—	—	—	—	—	—	—
60 min. 2 days.....	—	—	—	+	+	—	—	—	—	—	—	—
90 min. 2 days.....	—	—	—	+	0	—	—	—	—	—	—	—
15 min. 3 days.....	+	—	—	—	—	—	—	—	—	—	—	—
30 min. 3 days.....	—	—	—	—	—	—	—	—	—	—	—	—
60 min. 3 days.....	—	—	—	—	—	—	—	—	—	—	—	—
90 min. 3 days.....	—	—	—	—	—	—	—	—	—	—	—	—
15 min. twice 1 day	+	—	+	+	—	—	+	+	—	+	—	—
30 min. twice 1 day	+	+	+	—	—	—	—	—	—	—	—	—
60 min. twice 1 day	+	—	—	+	—	—	—	—	—	—	—	—
90 min. twice 1 day	—	+	—	—	—	—	—	—	—	—	—	—
15 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
30 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
60 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
90 min. twice 2 days	—	—	—	—	—	—	—	—	—	0	—	—
15 min. twice 3 days	—	—	—	—	+	—	—	—	—	—	—	—
30 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—
60 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—
90 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—

It is interesting to note the influence of heating twice a day upon the keeping quality. We devised this method for the sterilization of culture media. Occasionally we resort to this method in the summer time when the temperature of the laboratory remains nearly that of the incubator for the entire 24 hrs. Several types of spore-forming aerobes not only change from the spore to the vegetative stage, but change again into the spore stage in 24 hrs. These types grow but very little at low temperature and do not show in the media for several days if the room is cold. Thus the incubation of the product with two applications of heat each 24 hrs. usually aids greatly in the sterilization. These types also grow but little in the absence of free oxygen and are the types which we have obtained most commonly from spoiled vegetables in cotton-sealed tubes. This method may be of considerable value in canning of vegetables but we have not done enough work to advocate its use.

EXPERIMENT 11—This experiment shows something of the influence of heating upon the reduction in numbers of bacteria in sweet corn. To determine these numbers the tubes were shaken for several minutes before the sample was taken. The kernels were usually reduced to a pulp by the shaking process so the results may be considered fairly representative

TABLE X

Number before heating Number after heating Min.	Per Cc. 4000	Per cent Destroyed
5	30	99.25
30	15	99.62
60	10	99.75
90	7	99.82
120	6	99.85
150	4	99.90
170	1	99.97
180	1	99.97

of the numbers present. Every test will give slightly different numbers. We have in some cases found more and in some less, but this is a fair illustration for a good quality of corn. In this case the material was in a jar sealed only with cotton. The temperature surrounding the jar was 98° C. (boiling point of water at this altitude).

TABLE IX—CORN NOT BLANCHED

Heated	Sealed with Cotton Stopper: Water	1.0 Per cent Salt	2.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.3 Per cent Acid	Sealed with Rubber Stopper: Water	1.0 Per cent Salt	5.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.3 Per cent Acid
60 min. 1 day . . .	+	+	+	—	—	—	+	—	—	—	—	—
120 min. 1 day.....	+	+	+	—	—	—	—	—	—	—	—	—
180 min. 1 day	—	—	—	—	—	—	—	—	—	—	—	—
15 min. 2 days.....	+	+	—	—	—	—	—	—	—	—	—	—
30 min. 2 days.....	—	—	—	+	+	—	—	—	—	—	—	—
60 min. 2 days.....	—	—	—	—	—	—	—	—	—	—	—	—
90 min. 2 days.....	—	—	—	—	—	—	—	—	—	—	—	—
15 min. 3 days.....	+	+	—	+	—	—	—	—	—	—	—	—
30 min. 3 days.....	—	+	—	—	—	—	—	—	—	—	—	—
60 min. 3 days.....	+	—	—	—	—	—	—	—	—	—	—	—
90 min. 3 days.....	—	—	—	—	—	—	—	—	—	—	—	—
15 min. twice 1 day	—	+	+	+	—	—	—	—	—	—	—	—
30 min. twice 1 day	—	—	—	—	—	—	—	—	—	—	—	—
60 min. twice 1 day	—	+	—	—	—	—	—	—	—	—	—	—
90 min. twice 1 day	—	—	—	—	—	—	—	—	—	—	—	—
15 min. twice 2 days	—	—	—	+	—	—	—	—	—	—	—	—
30 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
60 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
90 min. twice 2 days	—	—	—	—	—	—	—	—	—	—	—	—
15 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—
30 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—
60 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—
90 min. twice 3 days	—	—	—	—	—	—	—	—	—	—	—	—

Table X shows that over 99 per cent of the organisms are killed in 5 min. at this temperature, but that 0.03 per cent survived even after 3 hrs. This is probably enough to cause spoilage in a container sealed with cotton, but not in one sealed with rubber.

EXPERIMENT 12—This experiment shows the influence of heating upon the thermal death-point of organisms found on sweet corn treated in various ways.

Table XI tends to show that the total number of bacteria which may be cultivated from a product after a short heating is very small. The few remaining, however, may bring about spoilage if they develop. This apparently is not always the case, as too few are present to establish the initial growth which seems to be necessary. In comparing the relationship of

TABLE XI

Heated	Water	1.0 Per cent Salt	2.0 Per cent Salt	3.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.3 Per cent Acid
	Number of Bacteria per Cc.						
Before heating.....	20,000	20,000	20,000	20,000	20,000	20,000	20,000
60 min.....	34	38	27	24	32	24	18
120 min.....	8	8	4	3	6	3	1
180 min.....	4	2	1	0	3	1	0
15 min. twice 1 day	50	44	32	28	32	28	21
30 min. twice 1 day	20	19	10	12	14	10	8
60 min. twice 1 day	8	6	2	6	2	1	0

bacterial counts to the keeping quality of the product it is often found that certain containers may show a few organisms upon culture media and yet show no signs of spoilage, especially if acid is present or the tube has been properly sealed to exclude air. It is very difficult to make comparisons between two lots of this kind of material as the organisms are so unevenly distributed throughout the mass; for this reason averages of several trials should be used in compiling tables.

Many tests in this laboratory have led to the belief that keeping is not due, in a great many cases, to absolute sterilization. We have had jars of vegetables that are easily spoiled by bacteria, which have kept under conditions of incomplete sterilization. Others that had been heated for a long time and plugged carefully with cotton have spoiled in a few days. We have kept some of the sealed jars for 10 mo.

with no signs of deterioration, either in flavor, odor, or appearance, and have been able to cultivate both aerobes and anaerobes from them after that time.

Under-processing in favor of sealing as a preserving agent should not be advocated, but we feel sure that many products have been placed on the market which were under-processed and have not spoiled. We hope to determine this point later.

Table XII shows a comparison between numbers of bacteria destroyed by sterilization and the keeping quality. This table is a compilation from Tables IX and XI. The two tables were not made on the same date or from the same lots of corn. We have, however, made several tests of this sort with similar results. Unfortunately no counts were obtained from sealed tubes, but they probably would differ but very little from those sealed with cotton.

TABLE XII

		Number of Bacteria per Cc.				
Heated	Water	1.0 Per cent Salt	2.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.3 Per cent Acid
60 min. 1 day	34	38	27	32	24	18
120 min. 1 day	8	8	4	6	3	1
180 min. 1 day	4	3	1	3	1	0
15 min. twice 1 day...	50	44	32	32	28	21
30 min. twice 1 day...	20	19	10	14	10	8
60 min. twice 1 day...	8	6	2	2	1	0
90 min. twice 1 day...	4	2	1	0	0	0
Sealed with Cotton						
60 min. 1 day.....	+	+	+	+	—	—
120 min. 1 day.....	+	—	—	—	—	—
180 min. 1 day.....	—	—	—	—	—	—
15 min. twice 1 day...	—	+	+	+	—	—
30 min. twice 1 day...	—	—	—	—	—	—
60 min. twice 1 day...	—	+	—	—	—	—
90 min. twice 1 day...	—	—	—	—	—	—
Sealed with Rubber						
60 min. 1 day.....	+	—	—	—	—	—
120 min. 1 day.....	—	—	—	—	—	—
180 min. 1 day.....	—	—	—	—	—	—
15 min. twice 1 day...	—	—	—	—	—	—
30 min. twice 1 day...	—	—	—	—	—	—
60 min. twice 1 day...	—	—	—	—	—	—
90 min. twice 1 day...	—	—	—	—	—	—

These results show that in several cases spoilage did not occur even when there were, no doubt, a few organisms present. This is shown particularly in the case in which acid is used. The influence of sealing is also very marked. Even in cases in which considerable spoilage occurred in cotton-sealed tubes no spoilage appeared in tubes properly sealed with rubber.

EXPERIMENT 13—This experiment was devised to show influence of rubber alone upon the keeping quality.

TABLE XIII

Heated	Water	0.5 Per cent Salt	1.0 Per cent Salt	2.0 Per cent Salt	0.05 Per cent Acid	0.1 Per cent Acid	0.2 Per cent Acid
Plugged with one-hole rubber stoppers, the hole being plugged with cotton							
15 min. 1 day	+	+	+	+	+	—	—
30 min. 1 day	+	+	+	—	—	—	—
60 min. 1 day	—	—	—	—	—	—	—
Plugged with one-hole rubber stopper and glass rod							
15 min. 1 day	+	—	+	—	—	—	—
30 min. 1 day	—	—	—	—	—	—	—
60 min. 1 day	—	—	—	—	—	—	—
Plugged with cotton only							
15 min. 1 day	+	+	+	+	—	—	—
30 min. 1 day	+	+	—	—	—	—	—
60 min. 1 day	+	—	—	—	—	—	—

Since we had obtained such marked results by sealing tubes with rubber as compared to sealing with cotton it was considered possible that the rubber stoppers might contain some substance toxic to the bacterial cell and thus prevent growth. Beets were used in this case and were packed in large mouth bottles and treated as indicated in Table XIII. The plus sign means spoilage. The minus sign means good after 10 days.

We may conclude from Experiment 13 that it was not the influence of the rubber alone that could account for the preserving action in rubber-sealed containers. Table XIII serves again to emphasize the great value of sealing and the use of acid in the canning industry.

CONCLUSIONS

1—Blanching is of no value in reducing the time necessary to properly process canned foods.

2—Small amounts of salt are of little value in preventing the growth of bacteria in canned foods.

3—Small amounts of organic acid (acetic acid) have a distinctly retarding action upon the growth of bacteria in canned vegetables. The use of small amounts should be advocated in all cases in which it will not injure the texture, flavor, or appearance of the product.

4—In many cases an unsterile product will keep indefinitely if properly sealed. This, however, is not true in all cases and sealing should not be expected to take the place of proper processing because of the danger of loss due to spore-forming anaerobes.

DEPARTMENT OF BACTERIOLOGY
KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

DETECTION OF ADDED COLOR IN BUTTER OR OLEOMARGARINE

By HERBERT A. LUBS

Received December 12, 1917

I—OBSERVATIONS ON SOME QUALITATIVE TESTS FOR THE DETECTION OF ADDED COLORS IN FATS

A study of the various methods described for the detection of added colors in butter and butter substitutes reveals a number of misleading statements which might lead a more or less inexperienced analyst to false conclusions. For example, certain tests described in the literature lead to the false conclusion that some aniline colors are vegetable colors, and vice-versa. Furthermore, certain azo colors cannot be detected by methods which are supposed to reveal their presence. Some of the tests described in the literature for the detection of added color are perfectly satisfactory when certain compounds are present, but fail to reveal the presence of added color when other dyes are used, and for this reason some changes must be made in the procedure. These modifications will be discussed under the tests in question. The analyst should make a combination of tests with the modifications subsequently recommended to obtain reliable results.

LOW'S TEST—According to Low,[1] if a fat containing an azo color is shaken with a mixture of four parts of glacial acetic acid and one part of concentrated sulfuric acid the acid layer will settle out with a wine-red color. It is quite true that in some cases a wine-red color is obtained, but in other cases a yellow, brown, or even a blue color is imparted to the acid layer in the presence of various azo colors. For

[1] J. Am. Chem. Soc., 20 (1898), 882

instance, Yellow O B, Yellow A B,[1] Sudan I, Sudan II, Butter Yellow, Aniline Yellow, and some other dyes will give reddish colorations to the acid layer, while with Sudan G and Aniline-azo-phenol a yellowish brown color is obtained. Sudan III imparts a bluish tinge to the acid layer. Although turmeric is not often used for the coloration of butter, its presence has been occasionally detected, and in this test will impart a brilliant violet-red coloration to the acid layer. However, if turmeric is present it will be detected upon extracting the fat with aqueous alkali and identifying by the usual methods.[2]

When the test is made as originally described by Low, the separation of the two layers is very slow and indistinct and, particularly in the case of oleomargarine, the color due to the reaction of the fat practically obscures the color due to the presence of an azo dye. A decided improvement on the method of Low consists in first diluting the fat, about 20 g., with an equal volume of petroleum ether, and shaking in a separatory funnel with 10 cc. of the acid mixture, consisting of one volume of concentrated sulfuric acid and 10 volumes of glacial acetic acid (99.5 per cent). In this way a more rapid and clean-cut separation of the two layers is effected and there is less decomposition of the constituents of the fat. Pure butter fat will impart no color to the acid layer, except upon very long standing. Some specimens of oleomargarine after standing for a short time will impart a brownish coloration to the acid layer, the intensity of which increases upon standing. If an azo color be present the coloration of the acid layer is very distinct and appears immediately.

DOOLITTLE'S TEST[3]—A small portion of the fat is dissolved in ether, the solution divided into two equal parts and one portion is shaken with dilute alkali and the other with dilute hydrochloric acid. If the aqueous alkaline layer is colored yellow, it is stated that a vegetable color is present; and if the acid layer is colored pink, the presence of a coal-tar color is assumed.

Since this test was developed the list of coal-tar, oil-soluble colors has been considerably augmented and some of these colors will give reactions by the above method which might lead to false conclusions. For instance, Aniline-azo-phenol and Sudan G will impart a yellow color to the alkaline layer and furthermore, many oil-soluble azo colors do not give a pink coloration with dilute hydrochloric acid. In order to determine the limitations of this method solutions of ten different oil-soluble azo colors in butter were prepared. Two imparted a pink color to the acid layer when dilute acid was used; with the remainder the acid layer was colorless. When concentrated hydrochloric acid was used, eight imparted color to the acid layer. Six of the eight gave a red coloration, and two, a yellow coloration. In making Doolittle's test it is advisable to use 10 to 20 g. of fat and in the acid extraction to substitute concentrated for dilute hydrochloric acid.

[1] These are the trade names for *o*-toluene-azo-*β*-naphthylamine and benzene azo-*β*-naphthylamine. For butter coloring a mixture of the two is usually used.

[2] Allen's "Commercial Organic Analysis," **5** (1911), 415.

[3] U. S. Dept. of Agr., Bureau of Chemistry, *Bull.* **65** (1902), 152.

GEISSLER'S TEST[1]—Geissler states that if a few drops of clarified fat are mixed with a small amount of fuller's earth, a pink to red coloration will be produced in the presence of various azo dyes. Several azo colors will give this test quite satisfactorily, but the majority will not and hence this test cannot be relied upon as a general method for the detection of azo colors.

PROCEDURE RECOMMENDED FOR PRELIMINARY EXAMINATION OF FAT FOR THE DETECTION OF ADDED COLOR

Dissolve about 20 g. of the fat in 50 cc. of petroleum ether, and 20 g. in 50 cc. of ethyl ether. Shake out the ethyl ether solution in a small separatory funnel with dilute sodium hydroxide solution. If the aqueous solution is colored yellow a vegetable color is indicated and the alkaline extract must be tested for such colors. Add 10 cc. of a mixture of one volume of sulfuric acid and 10 volumes of glacial acetic acid to the petroleum ether solution and shake vigorously. The acid layer will settle out in a few minutes with a decided coloration if an azo dye is present. In this test annatto, if present in sufficient concentration, will impart a momentary green color which changes over to brown. Turmeric imparts a fairly permanent violet-red coloration similar to that given by certain azo dyes, but its presence will be detected in the alkaline extract. The azo colors impart a yellow, brown, red or blue color to the acid layer.

AN IMPROVED METHOD FOR THE DETECTION OF ANNATTO

Perhaps the most extensively used vegetable color for butter at the present time is annatto. Its presence can be readily determined by a slight modification of described tests. If the aqueous alkaline extract from about 20 g. of fat dissolved in 50 cc. of ether is passed through a filter paper several times, the excess of alkali washed off, the red coloration produced by a solution of stannous chloride is very readily obtained. It is advisable to add a small amount of hydrochloric acid to the stannous chloride solution.

In applying the Massachusetts State Board of Health method[2] to fats which contain very small amounts of annatto, about 30 g. of fat should be warmed with 60 cc. of 2 per cent sodium hydroxide and filtered through a funnel surrounded by warm water. The aqueous filtrate is returned through the filter paper repeatedly for 3 or 4 hours. After washing the fat and alkali from the paper the test for annatto is made in the usual way. The paper need not be dried.

II—THE SEPARATION OF THE AZO COLORS FROM FATS AND THE IDENTIFICATION OF YELLOW O B AND YELLOW A B

In a bulletin[3] recently issued from this Bureau, Mathewson has summarized the various methods previously used for the separation of azo dyes from oil solutions and described several new methods which he developed. For the Sudan dyes particularly, he suggests extraction with a mixture of phosphoric and sulfuric acids and states that this method is not

[1] *J. Am. Chem. Soc.*, **20** (1898), 110.

[2] Bureau of Chemistry, *Bull.* **107** (1913), rev. 126.

[3] *Ibid.*, **448** (1917).

applicable to such colors as *o*-toluene-azo-*β*-naphthylamine, since they are destroyed by treatment with strong acids. This statement is not quite correct, as will be shown below.

A solution of Yellow O B, one part in 12,500, was made as follows: 2 cc. of 0.4 per cent alcohol solution of O B were diluted to 100 cc. with a mixture of 90 cc. glacial acetic acid, 10 cc. concentrated sulfuric acid and 10 cc. of water. The spectrophotometric curve of this solution was read immediately in a Hüfner type spectrophotometer.[1] Since the extinction coefficients are proportional to the weight of light-absorbing material per unit of volume, by determining these extinction coefficients after certain definite times had elapsed, it was possible to calculate the percentage decomposition of the dye. The loss expressed as per cent is plotted against time and it will be seen from the curve that even after 5 hrs. have elapsed, a time surely sufficient for any analyst to have completed this step of the procedure, there is still 85 per cent of the original dye undecomposed, while after half an hour, the time usually required, the loss is only 2 per cent. The points on the curve are each the average of seven observations at different wave lengths on the absorption spectrum of the dye solutions.

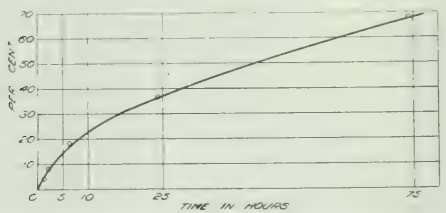


FIG. 1—CURVE SHOWING THE PERCENTAGE DECOMPOSITION OF YELLOW O B IN ACID SOLUTION WITH TIME

A concentration of one part in 50,000 of Sudan I, under the same conditions, showed *absolutely no* decomposition during the same time interval, namely 75 hrs. The specific action on Yellow O B is possibly a direct result of the presence of the free amino group in the dye molecule.

In the same bulletin[2] it is stated that *o*-toluene-azo-*β*-naphthylamine (Yellow O B) and its benzene analog can be slowly extracted from the gasoline solution of the fat by 4- to 6-normal hydrochloric acid. This is true if the dye is present in relatively large amount, but if the quantity of dye in the fat is about one part or less in 50,000, practically no extraction of Yellow O B can be effected. Very rarely would an amount of dye greater than this be used.

The phenol method of extraction[3] is, as stated, "somewhat inconvenient" and particularly so if one attempts to work with a pound or so of the fat.

Though the method suggested in this paper is of general application in the separation of azo dyes from fats in a fairly pure state, yet very often it is more convenient to use a different method. For example, if a dye is easily removed by dilute acid or alkali from the fat such a procedure would be more convenient. The proper procedure to be used should be decided by the judgment of the analyst from a few preliminary tests on small amounts of the fat. It might be suggested at this point that if it is found preferable to extract with dilute acid or alkali, dilution of the fat with ethyl ether is more preferable than dilution with gasoline having a low boiling point, since a more satisfactory extraction can be secured when the former solvent is used.

TABLE I—COLORS OF THE ACID AND ALKALINE EXTRACTS FROM BUTTER SOLUTIONS OF VARIOUS OIL-SOLUBLE DYES

Butter solutions containing 1 part of dye in 50,000 of fat were prepared. Before extraction with hydrochloric acid or alkali these solutions were diluted with an equal volume of ethyl ether, before extraction with the sulfuric-acetic acid mixture the solutions were diluted with petroleum ether. The colors of the acid or alkaline extract are listed in the following table. In the case of butter the shades are permanent for a fairly long period but with oleomargarine the change of shade is comparatively more rapid.

Dye	1 Vol. Conc HCl 4 Vols. H_2O	Conc HCl	1 Per cent NaOH	1 Vol. H_2SO_4 10 Vols. Acetic Acid
Aniline-azo-phenol	No color	Yellow	Yellow	Yellow-brown
Sudan G	No color	Yellow-brown	Yellow-brown	Yellow-brown
Aniline Yellow	Red color	.....	.....	Brownish red
o-Toluene-azo-*β*-naphthylamine (Yellow O B)	No color	Red	..	Red
Benzene-azo-*β*-naphthylamine (Yellow A B)	No color	Red	.....	Red
Sudan I	No color	Very faint red	..	Cherry-red
Sudan II	No color	Very faint red	..	Violet-red
Sudan III	No color	No color	No color	Blue
Butter Yellow	Red	.....	.....	Red
Amino-azo-*α*-naphthalene	No color	Violet	.....	Violet

It is not the purpose of this paper to present a systematic scheme for the separation and identification of all of the possible oil-soluble colors, but to present a method for the separation from fats of some oil-soluble azo colors not easily removed by dilute acids or alkalies, and principally to enable the analyst to determine whether the dye present is Yellow A B or Yellow O B, either singly or in combination, or some other azo dye.

TABLE II—A LIST OF SOME OIL-SOLUBLE COLORS (*a*)

COMMON NAME	COMPONENTS	Schultz No. (*b*)
Yellow A B	Aniline + *β*-naphthylamine	..
Yellow O B	*o*-Toluidine + *β*-naphthylamine	..
Aniline Yellow	Aniline + aniline	31
Butter Yellow	Aniline + dimethylaniline	32
Spirit Yellow R	*o*-Toluidine + *o*-toluidine	68
Benzene-azo-phenol	Aniline + phenol	..
Sudan I	Aniline + *β*-naphthol	36
Sudan II	Xylidine + *β*-naphthol	76
Sudan III	Amido-azo-benzene + *β*-naphthol	23
Sudan G	Aniline + resorcin	35
Benzene-azo-*α*-naphthylamine	Aniline + *α*-naphthylamine	..
Amino-azo-*α*-naphthalene	*α*-Naphthylamine + *α*-naphthylamine	..
β-Naphthalene-azo-*α*-naphthol	*β*-Naphthylamine + *α*-naphthol	..
Benzene-azo-*α*-naphthol	Aniline + *α*-naphthol	..
Sudan Brown	*α* Naphthylamine + *α*-naphthol	105
Carminaph Garnet	*α* Naphthylamine + *β*-naphthol	106

(*a*) Probably the most used are Butter Yellow, Aniline Yellow, Yellow A B and O B and the Sudans.
(*b*) *Farbenstofftabellen*, Schultz, 1914.

The writer has effected quite satisfactory separations and identifications of Yellow A B and Yellow O B from butter and oleomargarine containing the dye in the proportion of one part in 100,000 by means of the procedure described.

PROCEDURE FOR THE SEPARATION FROM FATS AND THE IDENTIFICATION OF YELLOW A B AND YELLOW O B

If the preliminary tests have shown the presence of azo colors the analyst must first examine the fat for the presence or absence of certain azo colors. For this purpose about 40 g. of the melted fat are dissolved in

[1] The spectrophotometric determinations were made by A. B. Clark of this laboratory, to whom the writer wishes to acknowledge his indebtedness.

[2] Bureau of Chemistry, *Bull.* **448** (1917), 7.

[3] *Ibid.*, **107** (1917).

about 100 cc. of ethyl ether and the solution divided into two portions. One portion is extracted with 12 per cent hydrochloric acid and the other with 5 per cent sodium hydroxide. If the acid extract is colored, the presence of any of the following dyes is indicated: Aniline Yellow, Amino-azo-α-naphthalene, Benzene-azo-α-naphthylamine, and Butter Yellow.

The coloration of the alkaline extract would indicate Sudan G, Aniline-azo-phenol or β-Naphthalene-azo-α-naphthol.[1] If the absence of dyes which can be extracted by dilute acid or alkali has been shown, proceed in the following manner:

Melt one or two pounds of fat[2] (it is usually desirable to use an amount of fat containing about 10 mg. of dye) on a water bath; allow the water and solids to settle; pour off the liquid fat and dilute with an equal volume of petroleum ether. Filter through a Büchner funnel or large folded filters. Place the filtrate in a separatory funnel and extract with a mixture composed of 10 cc. of concentrated sulfuric acid, 90 cc. of glacial acetic acid (99.5 per cent) and 10 cc. of water. Use about 100 cc. of the acid mixture for 200 cc. of petroleum ether solution of the fat. If Yellow A B or Yellow O B are present the acid layer will separate with a wine-red coloration.[3] Separate the acid layer, and for each 100 cc. of acid mixture originally used add 10 cc. of water and 10 cc. of concentrated hydrochloric acid; add about 100 cc. of ether and shake; if the ether layer does not separate out add more ether and shake again; separate the aqueous layer and repeat extraction with one-half the amount of ether originally used. Beside the fatty material, Sudan I, II and III and Carminaph Garnet are removed by the ether. Yellow O B and Yellow A B remain in the acid solution. The acid layer is then diluted with water, about two volumes, and carefully neutralized with strong alkali, cooling during the process. The solution is then extracted with ethyl ether, the ether solution washed first with water and then with an excess of dilute alkali, drawn off, and evaporated to dryness. Care must be taken that all of the acid is removed from the ether solution before evaporation to dryness. The residue consists of Yellow O B or Yellow A B, or a mixture of both. Further confirmation of the identity of these two dyes can be obtained in several ways.

CONFIRMATORY TESTS FOR THE IDENTIFICATION OF YELLOW O B AND YELLOW A B

The residue obtained from the sulfuric-acetic acid extraction is then dissolved in several cc. of alcohol, transferred to a test tube and reduced with hydrochloric acid and zinc dust. It is to be emphasized that the volume of alcohol and hydrochloric acid used should be as small as possible. This reduction mixture is then diluted with a few cc. of water, made alkaline with sodium hydroxide solution, cooled and quickly extracted with ether. The ether solution after filtration through a small, dry filter paper into a small separatory funnel is then treated with a few drops of a 0.5 per cent ferric chloride solution and shaken vigorously. If Yellow A B or Yellow O B is present a brilliant green coloration of the ether will be evident. Upon adding several cc. of water and again shaking, the green layer settles out beneath the ether. This color reaction depends upon the effect of ferric chloride upon 1-2-diaminonaphthalene, but is not specific for this compound, since it will be given by a number of diaminobenzenes and diaminonaphthalenes. Though the ethereal solution of the reduction products of Sudan III will give a reaction with ferric chloride identical with that obtained from Yellow A B or Yellow O B, as previously pointed out, the presence of Sudan III is indicated by the very characteristic blue color of the acetic-sulfuric acid extract, and furthermore this dye would have been previously eliminated. It is because of the lack of specificity of the ferric chloride reaction that a preliminary exclusion of a large number of dyes must be effected as described.

In order to obtain a further check on the identity of the isolated dye a portion should be used in making a dyeing test. The colors of many oil-soluble dyes on silk and the reactions of the dyed fiber are tabulated by Mathewson.[1] Yellow O B and Yellow A B dye silk a yellowish brown. The dried dyed fiber gives a violet coloration with concentrated sulfuric acid and a red coloration with concentrated hydrochloric acid.

COLOR INVESTIGATION LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

[1] For a systematic scheme for separating and identifying many of the oil-soluble colors see Mathewson, Bureau of Chemistry, *Bull.* **137** (1910), 54, or Allen's "Commercial Organic Analysis," **5** (1911), 666; see also Bureau of Chemistry, *Bull.* **448** (1917).

[2] One experienced in the method can satisfactorily separate and identify 2 mg. of dye in 200 g. of fat. As a rule it is more satisfactory to use larger amounts of fat. Of course, the amount of dye used is variable. Only occasionally will 2 lbs. of butter contain more than 10 mg. of dye.

[3] By noting the color of the acid layer, often a very good idea of the nature of the dye present can be obtained. See Table I

AN ACCURATE LOSS-ON-IGNITION METHOD FOR THE DETERMINATION OF ORGANIC MATTER IN SOILS[2]

By J. B. Rather

Received December 10, 1917

The loss-on-ignition method for the determination of organic matter in soils gives highly erroneous results which are due, as is well known, to hydrated mineral constituents of the soil, carbonates and unoxidized minerals. The organic carbon method for the determination of organic matter requires the determination of total and inorganic carbon and an arbitrary factor for the calculation of the carbon to organic matter. Since the carbon content of that portion of the organic matter which has been separated from the soil may vary from 44 to 64 per cent[3] many workers content themselves with reporting organic carbon.

It is evident that if the hydrated, unoxidized, and carbonaceous minerals were removed from the field of action the loss-on-ignition method would be superior

[1] Bureau of Chemistry, *Bull.* **448** (1917), 45.

[2] Abstracted by the author from *Bull* **140**, Arkansas Experiment Station, to which publication the reader is referred for additional details and further data. The material under the heading "Application of the Method to Abnormal Soils" does not appear in the publication referred to. This article was read in part before the *Association of Official Agricultural Chemists*, Washington, D. C., November, 1917.

[3] See Fraps and Hamner, Texas Experiment Station, *Bull.* **129**.

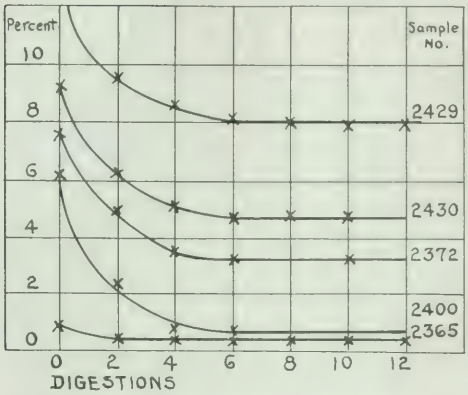


FIG. 1—EFFECT OF ACID REAGENT ON LOSS OF IGNITION

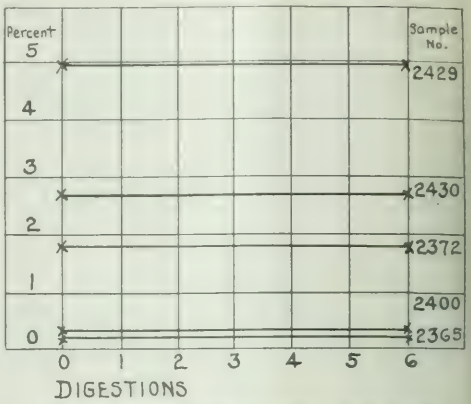


FIG. 2—EFFECT OF TREATMENT ON ORGANIC CARBON IN SOILS

to the organic carbon method. The attempt is made to do this in the method to be described.

AN ACCURATE LOSS-ON-IGNITION METHOD FOR THE DETERMINATION OF THE ORGANIC MATTER IN SOILS

The proposed method depends on the fact that the minerals in the soil which interfere with the accuracy of the loss-on-ignition method can be removed by digesting in the warm with a weak mixture of hydrofluoric and hydrochloric acids without decomposing or dissolving more than a very small amount of organic matter.

After a large number of preliminary experiments to determine the optimum conditions of concentration, temperature, length of digestion, ratio of soil to reagent, fineness of division of sample, etc., the following method was adopted:

REAGENTS—Acid-washed and ignited asbestos; 2.5 per cent hydrochloric acid; 2.5 per cent hydrofluoric acid in ceresine- or paraffin-lined bottle.

PROCEDURE—Weigh out 1 g. sample, prepared as in the Official Method of the A. O. A. C., into a platinum dish and add 50 cc. water. Digest for 5 min. on a boiling water bath or at 85° C. Allow to settle 2 or 3 min. if necessary and decant through a Gooch made with a thin felt of asbestos, using suction. To the residue in the dish add a second 50 cc. of water and digest and decant as before. Transfer[1] extract to beakers and boil down to a small volume. Measure into a glass cylinder 10 cc. of 2.5 per cent HCl, 10 cc. of 2.5 per cent HF, and 30 cc. of water. Mix and add to soil the residue in dish. Digest and decant as with the water extract. Repeat, and then transfer contents of crucible, including the asbestos, to the platinum dish, using 30 cc. water. Add 10 cc. each of the acids and digest and decant as before, making a new felt in the Gooch. Then digest and decant three times more with the acid mixture mentioned above, making a total of 6 digestions with the acid reagent. Transfer residue in dish to crucible with water and wash with water. Now transfer contents of crucible to a smaller dish, add the concentrated water extract obtained above, evaporate to dryness on the water bath, dry to constant weight, ignite and weigh. The loss in weight represents organic matter.

The acid reagent does not have any appreciable effect on the glass and porcelain vessels necessary in the above operation, nor is the use of a hood necessary. It is possible that fused silica dishes can be used in the digestion. In order to avoid slow filtration it is necessary that the decantation be made carefully after settling for 2 or 3 min., if necessary. In the table which follows, the above procedure is designated Method A.

The proof of the accuracy of the method rests on the fact that after a certain number of digestions with the acid reagent the loss on ignition does not decrease further (Fig. 1), while at the same time the loss of organic carbon is not appreciable (Fig. 2). The fact that the loss on ignition reaches a minimum is evidence that there is no progressive decomposition of the organic matter, and the fact that the organic carbon decreases only slightly when considered in connection with the above facts is evidence that the loss on ignition ob-

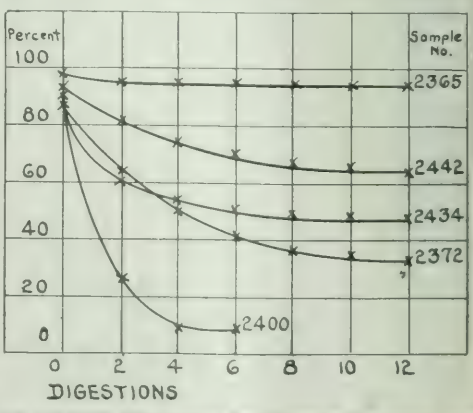


FIG. 3—RESIDUE AFTER IGNITION WITH DIFFERENT TREATMENTS WITH REAGENT

[1] With soils containing over 3 per cent $CaCO_3$ make two digestions with 20 cc. 2.5 per cent HCl and 30 cc. water, after extracting water under conditions described for water extraction

tained is due to organic matter. The fact that the mineral residue continues to decrease (Fig. 3) after the loss on ignition reaches a minimum is evidence that the mineral matter remaining in the soil is not hydrated. The number of digestions actually necessary varies from 2 with sands to 6 with heavy clays.

Since the amount of water-soluble organic matter was small the following method was also used:

PROCEDURE—Treat 1 g. of the soil as described in Method A above, but omit the water extraction. Dry, weigh, ignite and weigh in the Gooch crucible (Method B). Coors crucibles have been found satisfactory for this purpose.

Method B adds about one hour to the time required for the ordinary loss-on-ignition determination when the soils are run in sets of six. Method A adds about 3 hrs.

Detailed studies of the action of the acid reagent on some soil minerals, on the mineral matter of the soil, and its effect on the loss on ignition and the organic carbon of the soil were made, on which studies the proof of the accuracy of the method rests, will be published in *Bulletin* **140**, Arkansas Experiment Station.

RESULTS OBTAINED WITH THE METHOD ON SOILS OF DIFFERENT TYPES

In Table I are given the results of determinations by the method proposed, together with those by other methods. These results are selected from a larger number given in the publication referred to. The discussion relates to the whole of the data.

TABLE I—PERCENTAGE OF ORGANIC MATTER IN SOILS BY DIFFERENT METHODS

NUMBER	SOIL TYPE	ORGANIC MATTER CALC. FROM ORGANIC CARBON: Organic Carbon	Basis 44%	Basis 64%	Basis 58% (C)	Loss on Ignition	Method B	Method A	Modified Method A	Diff. bet. Results by Method A and (C)
2365	Norfolk sand	0.16	0.36	0.25	0.28	0.78	0.34	0.34	.	0.04
2446	Orangeburg fine sandy loam	0.37	0.84	0.56	0.64	2.57	0.66	0.62	.	0.02
2447	Orangeburg fine sandy loam, ss	0.20	0.45	0.31	0.34	1.13	0.37	0.35	..	0.01
2449	Berryville stony loam	0.94	2.14	1.47	1.62	2.62	1.41	1.54	.	0.08
2450	Berryville stony loam, ss	0.44	1.00	0.69	0.76	2.22	0.73	0.84	.	0.08
2373	Brewer silt loam	1.24	2.82	1.94	2.16	3.77	2.21	2.13	..	0.03
2400	Brackett silt loam, ss(*a*)	0.23	0.52	0.36	0.40	6.17	..	0.60	..	0.20
2429	Huntington silt loam	4.91	11.16	7.67	8.47	12.77	8.12	8.10	.	0.37
2435	Huntington silt loam, ss	2.64	6.00	4.12	4.55	8.59	4.54	4.53	..	0.02
2372	Brewer clay	1.80	4.09	2.81	3.10	7.61	3.13	3.14	.	0.04
2430	Sharkey clay	2.62	5.95	4.09	4.52	9.25	4.46	4.52	.	0.00
2434	Houston black clay	1.30	2.95	2.03	2.24	5.78	2.19	2.37	..	0.13
2409	Alfalfa hay	..	..	..	..	81.73	..	..	77.20	..
2431	Calcareous peat, Minnesota	30.07	..	..	..	53.70	.	..	51.60	..
2461	Acid peat, Minnesota	..	..	..	..	85.40	.	..	83.37	.
2507	Caribou loam, Maine(*b*)	3.88	8.82	6.06	6.69	9.35	.	.	6.45	0.24
2510	Apple stems (sawdust)	..	..	..	..	92.23	..	..	88.77	.

(*a*) About 86 per cent calcium carbonate.
(*b*) About 25 per cent organic matter soluble in warm, dilute acid.

In every case the amount of organic matter found by the proposed method falls within the limits shown possible by the organic carbon method. Method A gives results averaging somewhat higher than and in many cases very close to those obtained by calculations based on the conventional assumption that the carbon content of the organic matter is 58 per cent. Variations are from +0.37 to −0.37 and average +0.02 per cent. These variations are to be expected in view of the well-known variation in the carbon content of soil organic matter.

Results by Method B, in which the soluble organic matter is disregarded, are quite close to those by Method A. The maximum deviation is 0.18 per cent in favor of Method A, the minimum deviation is zero, and the two methods give results which average practically the same. With the soils under discussion Method B gives on the whole equally as satisfactory results and is much shorter than Method A.

There are some soils, however, to which these methods are not applicable without modification; such soils, which contain abnormally large amounts of acid-soluble organic matter, will be discussed below.

The loss-on-ignition method gives results which bear no relation whatever to the organic carbon content of the soil. In comparing this method with the proposed method it can be seen that the former method gives much higher results in every case. The difference is 1000 per cent in the case of No. 2400, even after correction for carbonates in the loss-on-ignition determination. The average difference between the loss-on-ignition method and the proposed method is 2.95 in per cent of soil and 153 in per cent of organic matter.

APPLICATION OF THE METHOD TO ABNORMAL SOILS

With soils containing a large amount of acid-soluble organic matter the above method will give low results, and it becomes necessary to modify it so as to recover the acid-soluble material without including hydrated or easily decomposed inorganic compounds.

The modification, designated in Table I as Modified Method A, is as follows:

Proceed as in Method A, using 2 per cent ammonium carbonate solution instead of water in the preliminary extraction. Moderate the heat if effervescence becomes vigorous before the end of the five-minute digestion. Two digestions with this reagent will be sufficient with mineral soils. Proceed from this point as directed in Method A, but evaporate the ammonium carbonate extract completely to dryness before combining with the residue from the acid digestion.

The ammonium carbonate volatilizes on evaporating the solution. There is a small retention of ammonia in chemical combination with the organic matter but this amount is quite small and may be disregarded. Results with this method are given at the bottom of Table I.

Alfalfa hay and sawdust from apple stems are taken as examples of undecomposed plant residues which may occur in the soil. With the former, assuming that all the volatile matter is organic, the recovery was 94.46 per cent, and with the latter 96.25 per cent. An acid and a calcareous peat are taken as examples of partially

decomposed organic matter. With the former the recovery was 97.62 per cent and with the latter, after allowing for the 1.80 per cent of inorganic carbon dioxide in the sample, the recovery was 99.44 per cent. The sample of Caribou loam is an example of a soil with an abnormally large amount of acid-soluble organic matter. The ammonium carbonate modification gave 33 per cent higher results on this soil than Method A, recovering 1.60 per cent of the acid-soluble organic matter, which is 25 per cent of the organic matter of the soil.

It is believed by the writer that the method and its modifications here proposed will indicate the organic matter content of the soil to within 3 per cent in per cent of organic matter and within the limit of experimental error with the average mineral soil.

The question of the carbon content of soil organic matter will be studied further.

The writer is indebted to Dr. G. S. Fraps, Dr. E. C. Shorey, and Mr. De F. Hungerford for some samples of soils, and to Mr. R. H. Ridgell for assistance in the analytical work.

SUMMARY

The minerals in the soil which interfere with the accuracy of the loss-on-ignition method for the determination of organic matter can be removed by digesting in the warm with a weak acid solution containing hydrofluoric and hydrochloric acids without dissolving more than a small amount of organic matter.

This fact has been made the basis of a method for the determination of organic matter in soils which is much superior to the loss-on-ignition method and is believed to be superior to the organic carbon method.

ARKANSAS AGRICULTURAL EXPERIMENT STATION
FAYETTEVILLE, ARKANSAS

THE AGRICULTURAL AVAILABILITY OF RAW GROUND PHOSPHATE ROCK[1]

By WILLIAM H. WAGGAMAN AND C. R. WAGNER

Received April 16, 1918

INTRODUCTION

The present shortage and high price of soluble phosphate is one of the most serious problems which confronts the agricultural interests of this country. The fact that the munitions industry calls for immense tonnages of sulfuric acid which are normally used in the manufacture of superphosphates makes it appear unlikely that the price of this latter material will decrease or its tonnage be much increased in the near future. While at least 200 patents[2] have been issued dealing with methods of producing soluble and available phosphates, without the use of sulfuric acid, either these have been proved commercially impracticable or their adoption would involve too much time to prove of immediate value. There is, therefore, a very urgent demand for a phosphatic fertilizer which will meet in part, at least, the present emergency, and raw ground rock phosphate is the only material which can be produced in sufficient quantities to make up this serious shortage.

The value of raw ground rock phosphate as a fertilizer has been a much-discussed question for over fifty years. Some agronomists and agricultural chemists have reported satisfactory results from its use both in pot and field experiments. Others have decided that while the material is beneficial to a number of crops when applied under certain conditions, it is so inferior to acid phosphate that it is unwise under normal conditions to depend upon it as a source of phosphoric acid, when one can obtain more soluble superphosphates. Still others have concluded that raw ground phosphate is entirely unprofitable on most of the soil in their particular States under their present crop systems.

In spite of the many adverse opinions regarding its value, however, the use of finely ground, raw rock phosphate has continued to increase until now the annual consumption is over 65,000 tons involving an expenditure of over $500,000.

THE NATURE OF MINERAL PHOSPHATES

It is not within the scope of this paper to discuss in detail the nature and origin of phosphate deposits, but the main constituent of most of the amorphous phosphate rock is tricalcium phosphate, a compound which is relatively insoluble in water and quite resistant to weathering influences. In fact the formation of phosphate deposits may be said to be largely due to the slight solubility of this latter compound.[1]

A quick response from applications of such material, therefore, is hardly to be expected unless it is subjected to some treatment by which its solubility is considerably increased, or is applied to the soil under such conditions that it will yield its phosphoric acid to the soil waters approximately as fast as it is taken up by growing crops.

In order to render the phosphoric acid in phosphate rock soluble and facilitate its distribution in the soil, it was proposed to treat the material with sulfuric acid. This method was first practiced on bones and bone products about 100 years ago and since then the use of acidulated phosphates has grown rapidly until now the vast bulk of the phosphate rock entering into the fertilizer industry is treated with sulfuric acid and manufactured into superphosphate.

It must be admitted, however, that most of the phosphoric acid contained in practically all productive soils is in the form of relatively insoluble phosphates of lime, iron and alumina, yet many of these soils continue to yield large crops without the addition of any soluble phosphates and frequently give no response to such applications.[2]

The question is, therefore, will raw rock phosphate increase the yield of crops when applied under proper conditions and if so, is the increase obtained commensurate with the cost of the material?

[1] This article is a summary of an exhaustive investigation of the subject made by the Bureau of Soils. The details of this investigation will appear in a later publication

[2] U. S. Department of Agriculture, *Bull.* 312 (1915)

[1] Eliot Blackwelder, "The Geologic Role of Phosphorus," *Scientific American* Supplement No. 2197, Feb. 9, 1918.

[2] The fact is particularly well exemplified in the "Blue Grass" regions of Kentucky and in the "Central Basin" Tennessee, where the soils are very high in phosphoric acid.

EFFECT OF FINE GRINDING AND ORGANIC FERMENTATION ON THE SOLUBILITY AND AVAILABILITY OF PHOSPHATE ROCK

No one questions the fact that fineness of division facilitates the solubility of mineral matter. Relatively insoluble substances, such as tricalcium phosphate, when in the precipitated conditions dissolve quite appreciably in water as well as in certain conventional solvents, such as ammonium citrate and 2 per cent citric acid.

It has also been repeatedly demonstrated both in laboratory and greenhouse experiments that the solubility of raw rock phosphate is considerably increased by fine grinding.[1] Not only is the distribution of the rock in the field much facilitated in this way, but an enormous surface of the mineral is thus exposed to the solvent action of the soil waters.

In the early experiments conducted with this material strict attention was probably not given to this important factor and it is very likely that a great deal of work with raw rock phosphate resulted adversely on this account. Several companies offer raw phosphate rock for sale guaranteeing 90 per cent to pass a sieve of 200 meshes to the linear inch. While tests performed in this laboratory seem to show that it is hardly feasible to put rock of this degree of fineness on the market at a low price, it is entirely possible to grind the material so that 90 per cent would pass a 100-mesh sieve, and material of this degree of fineness should prove quite effective. Because raw ground rock phosphate has in many cases proved more effective on soils rich in organic matter or when applied in connection with stable manure, it has been suggested that certain organic acids in the soil exert a solvent influence on the rock similar to the effect produced by sulfuric acid. The existence of organic acids in the soil in quantities sufficient to appreciably effect the solubility of phosphate rock is doubtful, but soils of high organic content are always rich in carbon dioxide and bacteria, both of which have an important influence on the solubility and alteration of soil minerals,[2] and hence it is reasonable to expect an increase in the solubility of the phosphate contained therein over that of soils of low organic content.

Other things being favorable, therefore, it appears that soils low in phosphoric acid and rich in organic matter should respond readily to additions of raw rock phosphate provided that the material is very finely ground, applied liberally, and is well distributed by thorough cultivation.

WORK OF THE EXPERIMENT STATIONS

The experiment station literature contains the results of 232 field experiments and 23 pot experiments conducted with raw rock phosphate, yet unless the relative merits of these experiments are very carefully weighed they cause the reader much confusion and lead to the conclusion that raw rock phosphate is of very questionable agricultural value.

It is now a generally accepted fact, however, that field experiments must be conducted for a period of several years before the results can be seriously considered, so after a careful study of the work recorded by the stations, the writers decided to give detailed consideration only to those field experiments which were conducted for 5 years or longer. This method of treatment has eliminated 195 field experiments, of which number, 144 were conducted for 1 year only, 21 for 2 years, 19 for 3 years and 11 for 4 years. The remaining 37 experiments (conducted for 5 years or longer) were then given detailed study, careful attention being paid (as far as possible) to the following important factors which influence the results of field work: (1) Uniformity of experiment field. (2) Topography and drainage conditions. (3) Chemical and physical composition of the soil. (4) Previous treatment of the field. (5) Climatic conditions. (6) Injuries from disease, insects, and animals. (7) Kinds of crops grown and selection of seed. (8) Rate of application and uniform distribution of phosphates. (9) Methods of comparing raw rock with other phosphates. (10) Effect of other fertilizers. (11) Number and distribution of plots. (12) Duration of experiment.

In most cases many of these factors were not recorded in the descriptions of the experiments, and since the work was conducted under such a variety of conditions and with so many objects in view it could not be reduced to a common basis for the sake of comparison.

The details of these experiments will be discussed in a subsequent publication, but a summary of the results obtained is given below in Table I. It must be borne in mind, however, that the classifications made are necessarily somewhat arbitrary since it is impossible to summarize the results of field work in such a way as to give each experiment its proper weight.

Out of the 37 tests given in Table I, 22 were carried on with a view to comparing the relative merits of raw rock and acid phosphate. The conditions under which such a comparison was attempted varied greatly, but it may be said that in a general way, 13 of these experiments or 59.1 per cent gave crop yields as favorable to raw rock as to the more soluble form of phosphoric acid. Of the 9 experiments in which raw rock did not compare favorably with acid phosphate, 2 were conducted on fields unresponsive to phosphate treatments and 2 gave results which could be classed as either favorable or unfavorable, depending on the method of interpretation employed.

Of the 15 experiments in which no comparison between raw ground rock and acid phosphate was attempted, 11, or 73.3 per cent, gave results strongly indicating beneficial effects from the applications of the former material, and 2 of the remaining 4 experiments were conducted on fields showing little or no response to phosphate treatment.

[1] J. A. Voelcker, *J. Roy. Agr. Soc.*, **4** (1868), 176–196; W. H. Jordon, N. Y. Exp. Sta. (Geneva), *Bull.* **358** (1913); W. L. Burlison, *J. Agr. Res.*, **6** (1916), 507–8.

[2] C. P. Williams, *Chem. News*, **24** (1871), 306; T. Schloesing, *Compt. rend.*, **131** (1900), 149; P. Kossowitch, *Biedermann's Zentr.*, **32** (1902), 44–49; E. Truog, Wis. Exp. Sta., *Research Bull.* **20** (1912); Sackett, Patten and Brown, Mich. Exp. Sta., *Bull.* (Special) **43** (1908); Tottingham and Hoffman, Wis. Exp. Sta., *Research Bull.* **29** (1913), 213–312; C. A. Mooers, THIS JOURNAL, **6** (1914), 487–8; Fred and Start, Wis. Exp. Sta., *Bull.* **35** (1915), 35–66; Hopkins and Whiting, Ill. Exp. Sta., *Bull.* **190** (1916), 395–406.

TABLE I—SUMMARY OF RESULTS OF FIELD EXPERIMENTS WITH RAW ROCK CONDUCTED BY THE STATE STATIONS AND BUREAU OF SOILS FOR PERIODS OF FROM 5 TO 20 YEARS

STATE	Total No. of experiments	Experiments comparing raw rock with acid phosphate: Total	No. favorable	No. unfavorable	Experiments making no comparison of raw rock with acid phosphate: Total	No. favorable	No. unfavorable	Experiments where raw rock applications were relatively light: Total	No. favorable	No. unfavorable	Experiments where raw rock applications were liberal: Total	No. favorable	No. unfavorable	Experiments where raw rock was used in connection with organic matter: Total	No. favorable	No. unfavorable	Apparent cumulative effect: Evident No.	None No.	Unknown No.
Ala.																			
Conn.																			
Del.																			
Fla.																			
Ga.																			
Ill.	12	8	2	1(a)	9	7	2(a)	4	4		8	6	2(a)	11	9	2(a)	8	3(a)	1
Ind.	2	2	1	1(a)							2	1	1(a)				1(a)		2
Ky.	1	1		1							1	1		1	1		1		
La.	3	3	1	2				2		2	1		1				1	1	1
Me.	2	2	1	1				2	2								1		1
Md.	2	2	2								2	2		1	1			1	1
Mass.	2	2	1	1(b)				1	1		1	1							2
Miss.	2	2	1	1				2	2										2
Mo.	4				4	2	2	4	2	2				4	2	2	4		
N. J.	0																		
N. Y.	0																		
N. C.	0																		
Ohio	4	2	1	1(b)	2	2		3	2	1(b)	1	1		3	3		1		3
Pa.	1	1	1					1	1									1	
R. I.	1	1	1					1	1								1		
S. C.	0																		
Tenn.	0																		
Va.	1(a)	1(a)	1(a)					1(a)		1(a)								1(a)	
Wash.																			
W. Va.																			
Wis.																			
TOTAL	37	22	13	9	15	11	4	21	15	6	16	13	3	23	18	5	17	7	13

(a) Soil not responsive to phosphate treatment.
(b) Figures for this experiment are favorable according to one method of computation and unfavorable according to another.

In 21 experiments the applications of raw rock were relatively light (250 lbs. or less per acre), yet 15 of these experiments, or 71.4 per cent, showed distinctly favorable increases in yields on the fields treated with this material.

In 16 experiments where the raw rock applications were more liberal, 13, or 81.3 per cent, resulted favorably to raw rock phosphate, and the remaining 3 experiments were conducted on soils showing little or no response to phosphate treatment.

Raw rock phosphate was applied in connection with organic matter in 23 experiments. Out of this number, 18, or 78.3 per cent, gave distinctly favorable results, and of the 5 remaining experiments 3 were conducted on fields unresponsive to other forms of phosphoric acid.

In regard to the cumulative effect of raw ground phosphate rock it may be said that in 17 instances (46 per cent of the entire number of experiments) there was evidence of greater availability after raw rock had been applied for a number of years. In 13 out of the remaining 20 experiments the data are not sufficient to give evidence on this point, and in 4 out of the 7 cases where no cumulative effect was shown the soils were not responsive to phosphate treatments.

CONCLUSIONS

After carefully weighing the results of all laboratory, field and greenhouse experiments with raw rock phosphate the writers feel that the following general conclusions are justified:

1—Field experiments conducted for only one or two years, where the various fertilizer treatments are not replicated or where no index is given to the relative natural fertility of the various plots employed, have little or no meaning.

2—Liberal and even medium quantities of raw rock phosphate to most soils produce an increase in the yields of many crops the first year of its application.

3—The effectiveness of raw rock phosphate depends largely on its thorough distribution in the soil, this distribution being brought about by liberal applications of very finely divided material and thorough cultivation.

4—The presence of decaying organic matter in the soil increases the effectiveness of raw ground rock phosphate, due probably both to greater bacterial activity and the higher content of carbon dioxide in such soils.

5—As a corollary of 3 and 4, the effectiveness of raw rock phosphate is usually increased after remaining in the soil for a year or more.

6—Most crops respond more quickly to applications of acid phosphate than to bone, basic slag, or raw rock phosphate. Therefore, where the early stimulation and quick maturity of the crop are the main consideration, acid phosphate is probably the best form of phosphoric acid to apply.

7—Field experiments in which raw rock and acid phosphate are compared on the basis of equal applications of the two materials or on equal applications of phosphoric acid in the two forms result often in favor of acid phosphate (particularly when such experiments are conducted for a short period), since in order to get the maximum benefit from the natural phosphates they must be applied at a rate far exceeding that at which acid phosphate proves effective.

8—The question whether increases in yield can ordinarily be produced more economically by applications of the soluble or relatively insoluble phosphates must be considered in a measure a separate problem for each farmer, since it depends on a number of factors of which the most important are the nature of the soil, the crop system employed, the price of the various phosphates in each particular locality, and the length of the growing season.

BUREAU OF SOILS
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

UPON THE ACTION OF TETRAZODI-*o*-TOLYLMETHANE CHLORIDE UPON NAPHTHOL AND NAPHTHYLAMINE SULFO ACIDS

[FIRST PAPER]

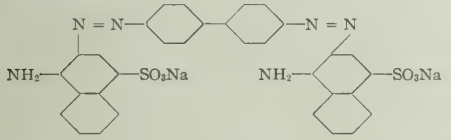
By James H. Stebbins, Jr.

Received December 17, 1917

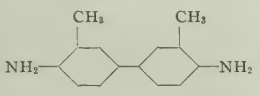
Prior to 1885, cotton fiber had to be put through a preparatory treatment before it could be dyed with artificial coloring matters. In 1884, P. Böttiger[1] discovered and patented a new dyestuff, which a year later was introduced into commerce by the "Actiengesellschaft für Anilinfabrikation" under the name of Congo. This new product was the first of a series which had the property of dyeing the cotton fiber direct, without prior mordanting.

Congo is produced by the action of 1 molecule of tetrazobenzidine chloride (tetrazodiphenyl chloride) upon 2 molecules of sodium naphthionate.[1]

G. Schultz[2] has shown that benzidine is a diparaaminodiphenyl, NH_2—⟨⟩—⟨⟩—NH_2, hence the constitution of Congo is:



When *o*-nitrotoluene is subjected to alkaline reduction it forms hydrazotoluene, which, on treatment with acids, is transformed into di-*p*-aminoditolyl, or tolidine having the constitution:[3]



This product like benzidine is capable of forming a tetrazo compound on treatment with nitrous acid, which in turn may be coupled with two molecules of sodium naphthionate to form the red substantive dye known as Benzopurpurin 4B. The property of Congo of fixing itself directly to the cotton fiber is evidently due to the presence of the diphenyl residue in its molecule, since other coloring matters derived from benzidine and its homologues possess the same characteristics.

The homologous bases of the aniline series may be divided into two classes, according to their behavior with formaldehyde:[4]

1—Those in which an unsubstituted carbon atom (*i. e.*, hydrogen-bearing carbon atom) stands in the para position to the amino group. Among the technically most important bases of this class are aniline, H—⟨⟩—NH_2; *o*-toluidine, H—⟨⟩(—CH_3)—NH_2; and *p*-xylidine, ⟨⟩(CH_3, H, CH_3)—NH_2.

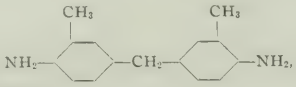
2—Those which contain a substituted carbon atom in the para position to the amino group.

The technically most important bases of this class are *p*-toluidine, CH_3—⟨⟩—NH_2, and asymmetrical *m*-xylidine, ⟨⟩(CH_3, CH_3, NH_2).

The bases of this second class unite with formaldehyde with much greater difficulty, under the same conditions, than those of Class 1. Furthermore, bases of Class 2 in admixture with bases of Class 1 will not unite at all with formaldehyde as long as bases of Class 1 are present. This peculiarity permits a complete quantitative separation of such bases.

Availing myself of this reaction, 200 g. technical *o*-toluidine (about 2 moles) were dissolved in the calculated amount of HCl of sp. gr. 1.19 or 71.9 cc., diluted with 400 cc. H_2O, and 75 g. of 40 per cent formaldehyde added. The mixture was now heated on the water bath to 70–76° C. for 4 hrs. and then made alkaline with NaOH solution. A copious, whitish, crystalline precipitate is thus thrown down and the latter steam-distilled until no more toluidine passed over. The crystalline mass thus obtained was collected upon a filter, dried and then recrystallized from alcohol, from which, on rapid cooling, it is obtained in the shape of small octahedra, among which are many twin crystals. On slow cooling, it crystallizes in rhombic prisms, also showing much twinning. Melting point, 149° C.

The product is, therefore, diparaaminodi-*o*-tolylmethane,



obtained by the condensation of 2 molecules of *o*-toluidine with 1 molecule of formaldehyde.

As this product partakes somewhat of the structure of benzidine and toluidine, but differing from the latter compounds in having the two benzene rings coupled to a methane rest, it was of interest to ascertain whether diaminodi-*o*-tolylmethane, like benzidine and tolidine, may be tetrazotized and coupled with phenols, amines and their sulfo acids to form substantive dyes, or whether its difference in structure would materially affect the nature of the dyestuffs derived therefrom. To answer these questions, the following experiments were made.

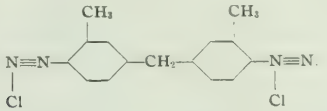
[1] D. R. P. No. 28,753, Feb. 27, 1884.
[2] *Ann.*, **174** (1874), 227.
[3] *Ber.*, **17** (1884), 467.
[4] D. R. P. No. 87,615, Sept. 1895; Friedländer, **4**, 65.

EXPERIMENTAL

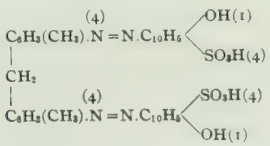
TETRAZODI-*o*-TOLYLMETHANE CHLORIDE—A few qualitative tests showed that nitrous acid combines with diaminodi-*o*-tolylmethane in HCl solution to form a diazo compound, but the question which naturally arose was whether only one, or both of the amino groups in the above-named product were diazotized. This question was easily settled by titrating a known quantity of the diamino base with sodium nitrite solution, using iodide of starch paper as an indicator.

Base taken	1.00 g.
Dissolved in 3 cc. HCl (sp. gr. 1.2) diluted with 200 cc. H_2O. Cooled with ice and titrated with $NaNO_2$ solution.	
1 cc. $NaNO_2$ soln. =	0.0047 HNO_2
Required for titration	85.4 cc. $NaNO_2$ soln.
HNO_2 used	0.4003 g.
Calculated	0.4159 g.

It will be seen that the above figures agree very closely with the theory for di-para-aminodi-*o*-tolylmethane and consequently the product formed on treating the above compound in hydrochloric acid solution with nitrous acid must be a tetrazo-di-*o*-tolylmethane chloride,

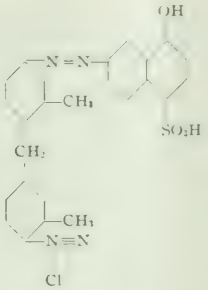


DI-*o*-TOLYLMETHANE - 4 - HYDROXYAZO-1-NAPHTHOL-4-SULFO ACID—According to the usual manner of coupling tetrazo compounds with amines, phenols and their sulfo acids,[1] it was expected that 1 molecule of tetrazo-di-*o*-tolylmethane chloride and 2 molecules of 1,4-naphtholsulfo acid would interact to form



However, subsequent examination of the product obtained showed this not to be the case.

0.01 mole diaminodi-*o*-tolylmethane, or 2.26 g., were dissolved in 0.04 mole HCl, or 3.11 cc. HCl of sp. gr. 1.2, diluted with 200 cc. water. This solution was now cooled with ice and tetrazotized by slowly stirring in 0.02 mole $NaNO_2$, or 1.38 g. dissolved in 50 cc. H_2O. The above solution was now allowed to stand until the complete absorption of the HNO_2 had taken place as shown by iodide of starch paper, and then slowly stirred into a solution of 0.01 mole of 1,4-naphtholsulfo acid, or 2.24 g., made alkaline with 0.02 mole Na_2CO_3, or 2.12 g. My motive in using only one-half the theoretical quantity of 1,4-naphtholsulfo acid was to note whether as in the case of tetrazodiphenylchloride[2] an intermediary compound of the following formula would be formed:



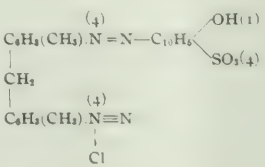
On mixing the tetrazo solution with the 1,4-naphtholsodiumsulfonate solution a copious blood-red precipitate is formed. The latter was allowed to stand over night and the next morning was collected upon a filter and washed. The filtrate, on being tested with an alkaline solution of β-naphthol, was found to be free from tetrazo compound. The red precipitate formed is insoluble in water and when boiled with the latter gives off nitrogen, which would suggest the presence of an intermediary compound of the foregoing composition. It was then rinsed into a beaker and treated with an additional 0.01 mole 1,4-naphtholsulfo acid, or 2.24 g., and made alkaline with 0.01 mole of Na_2CO_3, or 1.06 g., and the mixture allowed to stand, with occasional stirring, for 24 hrs.

No apparent change having taken place, the red precipitate was collected upon a filter, thoroughly washed and dried.

The product thus obtained is but little soluble in hot or cold water, but is soluble in dilute caustic soda solution. The filtrate from the above red precipitate on being tested with diazosulfanilic acid showed the presence of considerable uncombined 1,4-naphtholmonosulfo acid, showing that the second molecule of sulfo acid had not combined with the red product.

Thinking that possibly better results might be obtained by treating the tetrazo compound at once with the two moles of 1,4-naphtholsulfo acid, the experiment was twice more repeated, using 4.48 g. sulfo acid instead of 2.24. The final result, however, was the same.

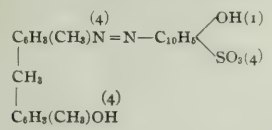
Believing prolonged digestion of the red product (which was considered to be an intermediary product) with an extra molecule of naphtholsulfo acid might bring about a union of the two, a mixture of the two was digested at 37.5° for 24 hrs. A more soluble product was obtained, but the additional molecule of sulfo acid remained uncombined. Therefore, we must infer that an intermediate compound of the formula



[1] Böttiger, D. R. P. No. 28,753; Witt, *Ber.*, **19**, 1719; G. Schultz, 2d Edition, p. 302; *Ibid.*, 257.

[2] Bucherer, p. 362.

has been formed, which on standing or upon heating loses nitrogen and is gradually transformed into a product of the following composition:

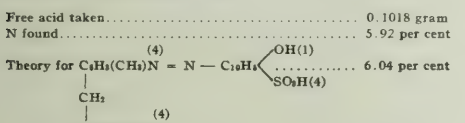


This reasoning has been fully borne out in the course of our experiments. In further evidence of the foregoing, a nitrogen estimation of the free dyestuff acid, prepared as follows, was made:

The acid soda salt of di-*o*-tolylmethane-4-hydroxy-azo-1-naphthol-4-sulfo acid, obtained by boiling the insoluble red precipitate with the calculated amount of sodium hydroxide, was filtered and the filtrate treated with an excess of concentrated HCl. The red precipitate of the free acid thrown down was collected upon a filter, washed with cold water till free from HCl and NaCl, air-dried upon a porous plate and then finally dried at 130–135° C.

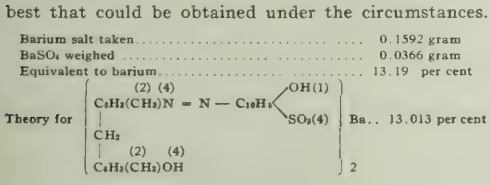
All attempts to obtain the free acid in a crystalline form failed and, therefore, the product obtained as just described had to be used for analysis.

The nitrogen was estimated by the Kjeldahl method and gave the following result:

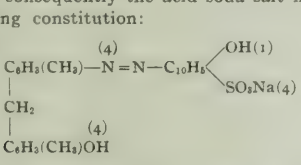


Barium in the barium salt was estimated as follows:

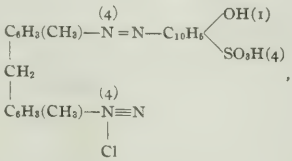
The salt was prepared by dissolving the acid soda salt in boiling water and treating with an excess of barium chloride. This threw down the barium salt as a red precipitate. The latter was collected upon a filter, washed with boiling water till free from $BaCl_2$, air-dried, and then finally dried at 100° C. The product thus obtained is by no means pure, but is the best that could be obtained under the circumstances.



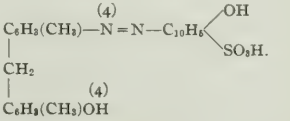
Hence the free acid must be constituted as previously stated and consequently the acid soda salt must have the following constitution:



It is further shown that in following the technique previously described, one molecule of tetrazodi-*o*-tolylmethane chloride unites with only one molecule of 1,4-naphtholsulfo acid to form the intermediate product,



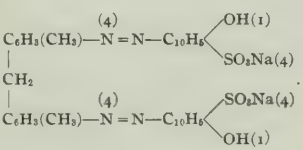
which latter compound is gradually transformed by substitution of OH for N into



Up to very recently it was found to be impossible to combine 1 molecule of tetrazodi-*o*-tolylmethane chloride with more than 1 molecule of 1,4-naphtholsulfo acid, but lately upon taking the subject up again and slightly modifying the technique, I have been able to combine 1 molecule of the tetrazo compound with two molecules of 1,4-naphtholsulfo acid with the greatest ease. Briefly described, the new technique is as follows:

2.26 g. diaminodi-*o*-tolylmethane are dissolved in 4.5 cc. HCl of 1.19 sp. gr. diluted with 100 cc. H_2O. The solution is then cooled with ice and tetrazotized by gradually stirring in 1.38 g. $NaNO_2$ dissolved in 25 cc. H_2O.

The tetrazo solution is then gradually stirred into a solution of 4.48 g. 1,4-naphtholsulfo acid (0.02 mole) dissolved in 50 cc. water and 50 cc. alcohol (denatured will do). A heavy carmine precipitate with bluish tinge is at once formed. This is allowed to stand over night and the next morning is filtered under suction and dried. The product thus obtained is the acid soda salt of[1]



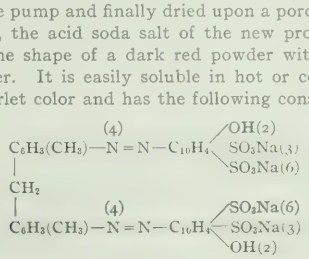
It appears as a dark red powder, is easily soluble in water, and dyes wool, in a bath containing sulfuric acid and sodium sulfate, a fine, scarlet color, which is fairly fast to light (4 weeks' exposure) and to washing and fulling. Contrary to expectations, however, it has but little affinity for cotton. Why the mere addition of a little alcohol to the reaction mixture should bring about a union of 1 molecule of tetrazo compound with 2 molecules of sulfo acid is hard to explain.

DI-*o*-TOLYLMETHANEAZO-2-NAPHTHOL-3,6-DISULFO ACID, AZO-2-NAPHTHOL-3,6-DISULFO ACID—On mixing an

[1] That the 2 molecules of 1,4-naphtholsulfo acid had combined with the 1 molecule of tetrazo compound was easily proved by treating a drop of the reaction mixture upon filter paper with a drop of diazosulfanilic acid. As no coloration was observed, it is evident that all the sulfo acid had combined with the tetrazo solution.

aqueous solution of 1 mole tetrazodi-*o*-tolylmethane chloride with an aqueous Na_2CO_3 solution of 2 moles 2,3,6-naphtholdisulfo acid, an intense scarlet-red precipitate is obtained, and on testing the outer watery edge of a drop of this solution upon filter paper with a drop of diazosulfanilic acid, no red coloration is obtained. From this it is evident that the 2 moles of 2,3,6-naphtholdisulfo acid have combined with the 1 mole of tetrazo compound.

On heating the solution to boiling, all the red precipitate dissolves, and separates again, on cooling, in a semi-crystalline form. It was collected upon a filter at the pump and finally dried upon a porous plate. When dry, the acid soda salt of the new product appears in the shape of a dark red powder with beetle-green luster. It is easily soluble in hot or cold water with a scarlet color and has the following constitution:



It likewise is a strong wool dye and dyes the latter, in a bath acidulated with sulfuric acid, a bright scarlet shade, somewhat resembling that obtained with the previous product.

It will, therefore, be seen that we here have a certain deviation from the results obtained with 1,4-naphtholmonosulfo acid, for, whereas only 1 molecule of the latter will unite with 1 molecule of tetrazodi-*o*-tolylmethane chloride when operating under normal conditions, *i. e.*, in aqueous solution, in the present case the tetrazo compound unites easily in an all-aqueous solution with 2 molecules of the disulfo acid.

Why these two naphtholsulfo acids should act so differently I am hardly prepared to say, but if I may venture an opinion, I would attribute it to the different positions of the sulfo groups in the naphthalene rings.

In coupling diazo salts with phenols or amines of the naphthalene series, if a hydroxyl group or amino group is in the alpha-position, combination takes place in the 4-position. If this is occupied, or if the positions 3 or 5 are occupied by sulfonic groups, union takes place in the 2-position.

Now in the case of the product from 1 molecule of tetrazo compound and 1 molecule of 1,4-naphtholsulfo acid the 4-position of the naphtholsulfo acid is occupied by a sulfo group, thereby forcing the tetrazo compound to couple in the 2-position and it has been shown that it took quite a little coaxing to cause the tetrazo compound to unite with an extra molecule of 1,4-naphtholsulfo acid under these conditions. On the other hand, in the case of the last-named dye from 1 molecule of tetrazodi-*o*-tolylmethane chloride and 2 molecules of 2,3,6-naphtholdisulfo acid, the 4-position, of the disulfo acid being unoccupied, the tetrazo compound was enabled to couple directly in the 4-position, and as we may infer that the 4-position is the one of least resistance, this may possibly account for the greater ease of union between the 1 molecule of tetrazodi-*o*-tolylmethane chloride and 2 molecules of 2,3,6-naphtholdisulfo acid.

If, as is supposed, the presence of the diphenyl residue in the molecule is necessary for the production of substantive cotton dyes, then it is possible that the presence of the methane rest uniting the two benzene rings in tetrazodi-*o*-tolylmethane may be the reason why the dyes obtained from this product are wool dyes and have practically no affinity for cotton.

This is only a surmise on my part which at present I am unable to back up by further proof.

27 East 22nd Street
New York City

METHOD OF CALCULATING COMPARATIVE STRENGTH AND EFFICIENCY OF HIGH EXPLOSIVES FROM THEIR COMPOSITION AND APPARENT DENSITIES

By Charles E. Waller
Received April 2, 1918

INTRODUCTION

A number of laboratory tests have been devised for obtaining comparative or definite values as to "strength" of explosives, of which may be mentioned the Trauzl test, ballistic pendulum, mortar tests, pressure gauges, etc., in each of which it is the practice to note the effect of a certain *unit weight* of an explosive and compare some with results of an equal of another explosive.

These results, however, do not always conform with those obtained in the field, for the reason that "strength" of explosives is there often judged by the effect of a certain *bulk* of explosive, *i. e.*, the volume of the charge chamber, in which explosives are compared in the field, is practically a constant, whether it is a bore hole or a war head. The importance of loading density of explosives for military purpose has been considered by the U. S. Ordnance Department, which even includes the same in their specifications.

It would therefore seem more rational to compare explosives in the laboratory by *volume;* for instance, instead of using the customary charge of 10 g. in the Trauzl test, a charge equivalent to the weight of 10 cc. at its apparent (or loading) density should be used.

All ballistic tests in the laboratory require careful and elaborate execution, and the method of calculating "strength" and efficiency as outlined in this paper is suggested as a means of obtaining values which have been proved to conform with carefully made laboratory tests.

The word efficiency, as applied to explosives, is generally used to express the amount of useful work that is done with a certain weight or "bulk" of an explosive; in coal-mining, for instance, it means the amount of lump coal that is obtained from a certain amount of explosive, while in tunnel work it means the progress that can be made, etc. In this article, however, the word efficiency denotes *the maximum available energy stored up in a unit "bulk" of an explosive*, and which, according to definition below, is proportional to the volume which the gaseous products of explosion of a unit "bulk"—say 1 cc.—would occupy at $t°$ and atmospheric pressure.

The method used in calculating $t°$ is practically the same as outlined in the literature on this subject,[1] but in constructing the chemical equations representing the explosion, special rules have been outlined and followed, and the object of calculating $t°$ is here only to obtain a value, theoretically correct, from which the gas volume at $t°$ may be found.

In the method used for calculating the gas volume at $t°$ of explosives containing nitrostarch with a specified nitrogen content, it will be noted that the chemical formula given to such nitrostarch contains fractional numbers of atoms, which, although irregular from a chemical standpoint, is mathematically correct and facilitates the calculations.

DEFINITIONS

The STRENGTH of high explosives may be considered as a function of the maximum pressure of the gaseous products, obtained by detonating unit weights (1 gram) of the explosives under exactly equal conditions.

The EFFICIENCY of high explosives may be considered as a function of the maximum pressure of the gaseous products, obtained by detonating unit volumes (1 cc.) of the explosives at the apparent densities at which they are intended to be used under exactly equal conditions.

According to a well-known physical law the pressure of gases confined in a closed vessel is proportional to their temperature ($t°$), and also to the volume that the same gases would occupy at $t°$ under atmospheric pressure. The above definitions may therefore be substituted by the following:

The STRENGTH of high explosives is proportional to the volume which the gaseous products of explosion of a unit weight (1 gram) of the explosives to be compared would occupy at $t°$ and atmospheric pressure.

The EFFICIENCY of high explosives is proportional to the volume which the gaseous products of explosion of a unit volume (1 cc.) of the explosives to be compared would occupy at $t°$ under atmospheric pressure.

TEMPERATURE OF EXPLOSION ($t°$)

No means have been found to directly measure the temperature of explosion, but by knowing the products of explosion as they exist at $t°$, their heat of formation as well as their mean specific heat between 0° and $t°$ and, furthermore, the heat of formation of the ingredients of the explosive, a correct value for $t°$ may be calculated by the well-known formula:

$$t° = \frac{Q}{a + bt} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

in which Q = calorific power of the explosive (in gram-calories), obtained by subtracting the sum of molecular heats of formation of the ingredients of the explosive from the heats of formation of the products of explosion; a = specific heat at 0° C. of the products of explosion; and b = increment of specific heat for 1° C. of these products.

By solving $t°$ in above equation we obtain:

$$t° = \frac{-a + \sqrt{4bQ + a^2}}{2b} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

[1] Bureau of Mines, *Bull.* 15.

GAS VOLUME AT 0° C.

Assuming that 1 gram-molecule of a gas occupies 22.4 liters at 0° C. and 760 mm. pressure, the gas volume at 0° C. per gram of explosive is found from the following formula:

$$V_0 = \frac{M \times 22.4}{g} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

in which M = number of gram-molecules formed from g grams of explosive.

GAS VOLUME AT $t°$ PER GRAM OF EXPLOSIVE

The gas volume at $t°$ and 760 mm. is found from equation:

$$V_t = V_0 (1 + 0.003665\, t) \quad \ldots\ldots\ldots\ldots\ldots (4)$$

GAS VOLUME AT $t°$ PER CC. OF EXPLOSIVE

The gas volume at $t°$ per cc., which has been defined as a function of comparative efficiency, is obtained by multiplying the gas volume at $t°$ per gram by the apparent density of the explosive, or

$$V_{td} = d \times V_t \quad \ldots\ldots\ldots\ldots\ldots (5)$$

HEAT OF FORMATION

Berthelot and Thomsen have made extensive research on determining the heat of formation of a number of substances which may enter as ingredients in explosives or may be formed on explosion, and although their results vary somewhat, the difference is so small that practically the same results as to gas volume at $t°$ are obtained whether following a table by one or by the other of above authorities. The following table gives the heat of formation of substances which have entered into calculations in this paper:

SUBSTANCE	Formula	Molecular Weight	Mol. Heat of Formation Calories
Ammonium nitrate	NH_4NO_3	80	88.0
Barium nitrate	$Ba(NO_3)_2$	261	228.4
Barium carbonate	$BaCO_3$	197	285.6
Sodium nitrate	$NaNO_3$	85	111.25
Sodium carbonate	Na_2CO_3	106	272.6
Sodium sulfate	Na_2SO_4	142	328.6
Nitroglycerine	$C_3H_5(NO_3)_3$	227	98.9
Nitrostarch	$C_6H_{10-x}(NO_3)_xO_{5-x}$	$162 + 45x$	$225.9 - 15x$
Trinitrotoluene	$C_6H_2(NO_2)_3CH_3$	227	29.0
Picric acid	$C_6H_2(NO_2)_3OH$	229	50.9
Vaseline	$C_{24}H_{58}$	338	270.2
Wood pulp	$C_{18}H_{32}O_{16}$	382	463.4
Water vapor	H_2O	18	58.1
Carbon dioxide	CO_2	44	94.3
Carbon monoxide	CO	28	26.1

The following table gives the molecular specific heat at $t°$ of the following substances, which have entered into calculations below:

SUBSTANCE	Mol. Sp. Heat at $t°$
1 mol. CO_2	$6.26 + 0.0037\, t$
1 mol. H_2O	$5.61 + 0.0033\, t$
1 mol. N_2	$4.80 + 0.0006\, t$
1 mol. O_2	$4.80 + 0.0006\, t$
1 mol. CO	$4.80 + 0.0006\, t$
Carbon (C)	$6.40 + 0.00128\, t$
Na_2CO_3	$26.00 + 0.0052\, t$
Na_2SO_4	$33.00 + 0.0066\, t$
$BaCO_3$	$21.00 + 0.0042\, t$
$BaSO_4$	$28.00 + 0.0056\, t$
$CaCO_3$	$20.00 + 0.0040\, t$

CHEMICAL REACTIONS OF EXPLOSION AND PRODUCTS EXISTING AT $t°$

In collecting and analyzing the products of explosion (as, for instance, in a Bichel pressure gauge) a number of products are often found, which our knowledge of chemistry tells us could not exist at $t°$, but which must be the results of secondary reactions taking place

on cooling. Of such products may be mentioned carbonates and bi-carbonates of alkaline metals, methane, etc.

In order to obtain a theoretically correct value for $t°$ it is clear that only such products as exist at $t°$ should be considered, and only such reactions as have taken place before and up to the moment that $t°$ has been reached should enter into the calculations of strength and efficiency of explosives.

Assuming, for instance, that $NaNO_3$ enters as an ingredient in an explosive containing a sufficient amount of C and H (in some combination or other) to form with the oxygen CO_2 and H_2O, this salt may be decomposed according to one or the other of the following reactions:

$$(a)\ 2NaNO_3 + H_2 + 2C = Na_2O + 2CO_2 + H_2O + N_2 \quad (6)$$

$$(b)\ 2NaNO_3 + H_2 + 2C = Na_2CO_3 + CO_2 + H_2O + N_2 \quad (7)$$

$$(c)\ 2NaNO_3 + H_2 + 2C = 2NaHCO_3 + N_2 \quad (8)$$

Assuming that the explosion takes place according to one or the other of these equations and calculating $t°$ for each, we obtain

$$(a)\ t = 1772° \text{ C.}$$
$$(b)\ t = 2660° \text{ C.}$$
$$(c)\ t = 3161° \text{ C.}$$

Reaction (*c*) not only seems improbable, but the results of various ballistic tests of explosives containing a high percentage of $NaNO_3$ indicate that the explosion does not take place according to this reaction. In our calculations as to strength and efficiency of high explosives we have, therefore, to choose between reactions (*a*) and (*b*), and to find what influence one or the other of these reactions has on the gas volume at $t°$.

Let us assume an explosive consisting of

Nitrostarch (with 12.75 per cent N)	58.4 per cent
$NaNO_3$ (pure)	41.6 per cent
	100.0

According to (*a*) the explosion may be represented by the following equation:

$$C_{12}H_{15}(NO_3)_5O_5 + 4.6NaNO_3 = 2.3Na_2O + 12CO_2 + 7.5H_2O + 4.8N_2$$

and according to (*b*):

$$C_{12}H_{15}(NO_3)_5O_5 + 4.6NaNO_3 = 2.3Na_2CO_3 + 0.7CO_2 + 7.5H_2O + 4.8N_2$$

Calculating $t°$ and gas volume at $t°$ according to these two reactions, the following values are obtained:

	According to (*a*)	According to (*b*)
Gas volume at 0° C. and 760 mm.	0.59 l.	0.524 l.
Calorific power (cal. per g)	1000 cal.	1192 cal.
$t°$	2490° C.	2836° C.
Gas volume at $t°$ per g	5.987 l.	5.97591.

A number of calculations of $t°$ and gas volume at $t°$ have been made for explosives containing $NaNO_3$, according to one or the other of the above reactions, and it has been found that although different values are obtained for gas volume at 0°, calorific power, and $t°$, the *gas volume at $t°$ per gram of explosive is practically the same, whether following reaction (a) or reaction (b)*. The same holds true with explosives containing sulfur as an ingredient.

When an explosive or explosive mixture contains a deficiency of oxygen for oxidizing the C and H to CO_2 and H_2O, free hydrogen is often found in the products, resulting from the well-known reaction $CO + H_2O = CO_2 + H_2$. Should there still remain some CO in the gases, this may under certain conditions react with the H_2 according to the equation $CO + 3H_2 = CH_4 + H_2O$, but as this reaction can take place only at a comparatively low temperature, it must be considered as a secondary reaction and not be taken into account in calculating the strength and efficiency of explosives.

DETAILS OF CALCULATIONS

Calculations as to strength and efficiency of high explosives involve the following steps:

1—Construction of the equation representing the explosion.

2—Finding the gas volume at 0° C. and 760 mm. per gram of explosive.

3—Calculating the calorific power (Q).

4—Calculating $t°$.

5—Calculating the gas volume at $t°$ and 760 mm. *per gram* of explosive.

6—Calculating the gas volume at $t°$ and 760 mm. *per cc.* of explosive.

1. CONSTRUCTING THE EQUATION REPRESENTING THE EXPLOSION—When a number of calculations have to be made on explosives containing one and the same explosive base, the following method has been found to greatly facilitate the work:

The equation is commenced by one molecule of the explosive base, and from its molecular weight the total number of gram-molecules which should enter into the equation is found by dividing the percentage of explosive base into 100 times the molecular weight of same. The number of gram-molecules of each ingredient which should enter into the equation is then found by proportion, and the number of molecules of the ingredient in question is again found by dividing the number of gram-molecules by the molecular weight of same.

Example:

Assuming an explosive having following composition:

	Per cent
Nitroglycerine	40
Sodium nitrate	43
Wood pulp	15
$CaCO_3$	1
Moisture	1
	100

Nitroglycerine ($C_3H_5(NO_3)_3$) has a molecular weight of 227 and the total number of gram-molecules which should enter into the equation is therefore $\frac{227 \times 100}{40}$, or 567.5 gram-molecules.

Sodium nitrate ($NaNO_3$) has a molecular weight of 85, and according to our formula the number of gram-molecules of $NaNO_3$ should be $0.43 \times 567.5 = 244.03$, and the number of $NaNO_3$ molecules $\frac{244.03}{85}$, or 2.87 $NaNO_3$.

Wood pulp, $C_{15}H_{22}O_{10}$, has a molecular weight of 362 and the number of molecules of this substance which

should enter the equation is therefore $\frac{0.15 \times 567.5}{362}$, or 0.235 $C_{15}H_{22}O_{10}$.

$CaCO_3$ (100), of which 1 per cent enters into the composition of the explosive, should enter into the equation as

$$\frac{0.01 \times 567.5}{100}, \text{ or } 0.05675 \text{ mol. } CaCO_3.$$

In similar manner the moisture (H_2O = 18) should enter as

$$\frac{0.01 \times 567.5}{18}, \text{ or } 0.315 \text{ mol. } H_2O.$$

After thus having constructed one side of the equation, the order of proceeding is as follows:

(1) The Na in $NaNO_3$ combines to form Na_2CO_3 so that $\frac{2.87}{2}$ = 1.435 mol. Na_2CO_3 are obtained. It may be mentioned that in presence of sulfur the Na first combines to form Na_2SO_4 while any remaining Na combines to Na_2CO_3, providing there is sufficient oxygen present.

(2) All H atoms combine with O to form H_2O; the total number of H atoms in above terms being 10.8, we obtain 5.4 mols. H_2O.

(3) The remaining carbon combines with oxygen to form CO_2, providing there is a sufficient amount of oxygen (as in this case), while any remaining oxygen remains free.

By analyzing our results up to this point we find:

in 1 mol. $C_3H_5(NO_3)_3$	3 C atoms
in 0.235 mol. $C_{15}H_{22}O_{10}$	3.525 C atoms
Total C atoms	6.525

But we have used

in 1.435 mol. Na_2CO_3	1.435 C atoms
Remaining C atoms	5.090
In the above terms there is a total of	20.275 O atoms
But we have used	9.705 O atoms
Remaining O atoms	10.570

or sufficient to form, with the remaining C atoms, 5.09 mol. CO_2, which leaves 0.39 O atom, equivalent to 0.195 O_2.

The probable dissociation of the small amount of $CaCO_3$ entering into the reaction is not considered to influence the results to any appreciable extent, and this ingredient is therefore assumed to remain unaltered as 0.0567 mol. $CaCO_3$.

By adding up the N atoms we find 5.87, which is equivalent to 2.935 N_2.

The complete equation representing the explosion of the above high explosive is therefore as follows:

$$\underset{227}{C_3H_5(NO_3)_3} + \underset{243.95}{2.87NaNO_3} + \underset{85.07}{0.235C_{15}H_{22}O_{10}} +$$

$$0.0567CaCO_3 + \underset{5.67}{0.3155H_2O} = 1.435Na_2CO_3 + \underset{5.67}{5.4H_2O}$$

$$+ 5.09CO_2 + 2.935N_2 + 0.195O_2 + 0.0567CaCO_3.$$

2. FINDING THE GAS VOLUME AT 0° C. AND 760 MM. PER GRAM—By comparing the specific gravity of gases with their molecular weights it has been definitely established that the volume of any gas molecule is a constant at 0° C. and 760 mm. barometric pressure and in the following calculations 1 gas volume is assumed to occupy 22.4 liters at 0° C. and 760 mm. As our object in finding the gas volume at 0° is only to obtain a theoretical value from which we may calculate the gas volume at $t°$, *i. e.*, when H_2O is gaseous, we must assume H_2O as a gas—even at 0° C. and 760 mm.—and include same in our calculations.

By summing up the gas molecules formed in the above reaction we find: 5.4 mol. H_2O + 5.09 mol. CO_2 + 2.935 mol. N_2 + 0.195 mol. O_2, or a total of 13.620 gas molecules from a total of 567.5 g., or 0.53773 liters per gram.

3. CALCULATING THE CALORIFIC POWER—The calorific power (Q) is found in the usual way by subtracting the sum of the heats of formation of the different ingredients of the explosive which undergo a change in the explosion, from the total heat disengaged on formation of the various products of explosion. By applying to our equation the values found in the above table of heats of formation, we obtain:

Heat disengaged on formation of

1.435 mol. Na_2CO_3	= 1.435	× 272.6	= 391.18 cal.		
5.4 mol. H_2O	= 5.4	× 58.1	= 313.74 cal.		
5.09 mol. CO_2	= 5.09	94.3	= 479.99 cal.		
13.62 gas mol.	= 13.62	× 0.545	= 7.42 cal.	Total =	1192330 cal.

Heat of formation of

1 mol. $C_3H_5(NO_3)_3$	= 1	× 98.9	= 98.90 cal.		
2.87 mol. $NaNO_3$	= 2.87	× 111.25	= 319.29 cal.		
0.235 mol. $C_{15}H_{22}O_{10}$	= 0.235	× 463.4	= 108.91 cal.		
0.315 mol. H_2O	= 0.315	× 69.0	= 21.74 cal.	Total =	548840 cal.
				Calorific power (Q) =	643490 cal.

$$\frac{643490}{567.5} = 1134 \text{ calories per gram of explosive.}$$

4. CALCULATION OF $t°$—According to the formula given above, the temperature of explosion, $t° = \frac{Q}{a + bt}$, in which we have found Q = 643490 cal.

A value for $a + bt$ is obtained from the table given for specific heats as follows:

1.435	mol. Na_2CO_3	= 1.435 (26	+ 0.0052 t)	= 37.310 + 0.007462 t
5.4	mol. H_2O	= 5.4 (5.61	+ 0.0033 t)	= 30.294 + 0.017820 t
5.09	mol. CO_2	= 5.09 (6.26	+ 0.0037 t)	= 31.863 + 0.018833 t
3.13	mol. (N_2 + O_2)	= 3.13 (4.8	+ 0.0006 t)	= 15.024 + 0.001878 t
0.0567	mol. $CaCO_3$	= 0.0567 (20	+ 0.0040 t)	= 1.134 + 0.000227 t
			$a + bt$	= 115.625 + 0.046220

$$t_o = \frac{-115.625 + \sqrt{4 \times .04622 \times 643490 + 115.62^2}}{2 \times 0.04622}$$

$$t° = 2670.7° \text{ C.}$$

5. CALCULATING THE GAS VOLUME AT $t°$ PER GRAM OF EXPLOSIVE—The gas volume at $t°$ per gram of explosive is found from Equation 4 to be

$V_t = 0.53773 (1 + 0.003665 \times 2670.7)$ = 5.8007 liters per gram.

6. GAS VOLUME AT $t°$ PER CC.: $V_{dt} = d \times V_t$—As the density of this explosive has been found to be approximately 1.22, the gas volume per cc. at $t°$ and 760 mm. is

$$1.22 \times 5.8007 = 7.0768 \text{ liters.}$$

Example of calculating the strength and efficiency of an explosive containing nitrostarch as base:

Nitrostarch is a name applied to nitration products of starch, consisting of a mixture of starch-nitrates. The formation of a starch-nitrate from starch and HNO_3 takes place according to the following equation:

$$(C_6H_{10}O_5)_n + XHNO_3 = (C_6H_{10-X}(NO_3)_XO_{5-X})_n + (XH_2O)_n$$

It will be seen that for each NO_3 group there is one HO group eliminated and therefore there is a certain relationship between the per cent of nitrogen and the number of NO_3 groups (X), which is readily found to be

$$N = \frac{162X}{1400 - 45X} \quad (9)$$

and

$$X = \frac{1400N}{162 + 45X} \quad (10)$$

Assuming an explosive of the following composition:

	Per cent
Nitrostarch with 13.05 per cent N	25
Ammonium nitrate	35
Sodium nitrate	33
Sulfur	3
Charcoal	2
$CaCO_3$	1
Vaseline	1
	100

According to Equation 9 the number of NO_3 groups (X) in nitrostarch, containing 13.05 per cent nitrogen is

$$\frac{162 \times 13.05}{1400 - 45 \times 13.05}, \text{ or } 2.6 \text{ } NO_3 \text{ groups.}$$

The chemical formula for above nitrostarch may therefore be assumed to be $C_6H_{7.4}(NO_3)_{2.6}O_{2.4} = 279$ gram-molecules, which according to our formula should be 25 per cent of the total gram-molecules entering into the equation, *i. e.*, $\frac{279}{0.25} = 1108$.

By following the method described above, we obtain the following terms to represent our formula:

$$C_6H_{7.4}(NO_3)_{2.6}O_{2.4} + 4.85NH_4NO_3 + 4.3NaNO_3 + 1.04S + 1.85C + 0.033C_{24}H_{50} + 0.11CaCO_3$$

As sulfur enters into this composition, this is first set down as Na_2SO_4, *i. e.*, 1.04 Na_2SO_4, while the remaining Na is next combined to form Na_2CO_3, *i. e.*, $\frac{4.3 - 2 \times 1.04}{2} = 1.11$ Na_2CO_3. By following the methods used in the former example, the complete equation is as follows:

$$C_6H_{7.4}(NO_3)_{2.6}O_{2.4} + 4.85NH_4NO_3 + 4.3NaNO_3 + 1.04S + 1.85C + 0.033C_{24}H_{50} + 0.11CaCO_3 = 1.04\ Na_2SO_4 + 1.11Na_2CO_3 + 14.225H_2O + 7.532CO_2 + 0.3855O_2 + 8.3N_2 + 0.11CaCO_3.$$

There are 30.44 gas molecules from 1110 grams of explosive, or $\frac{30.44 \times 22.4}{1110} = 0.6143$ liter at 0° C. and 760 mm. per gram.

In order to calculate the calorific power of this explosive, the heat of formation of a starch-nitrate, corresponding to above formula must be known. Berthelot gives the heat of formation of a starch-nitrate as follows:

$225.9 - 15a$, in which 225.0 is the heat of formation of starch ($C_6H_{10}O_5$) and a represents the number of NO_3 groups which have taken the place of HO groups. The heat of formation of the above starch-nitrate is therefore

$225.9 - 15 \times 2.6 = 186.0$ cal. for 270 grams.

By carrying out the calculations as in the former example we obtain the following values:

Calorific power = 1288016 cal. or 1170 cal. per gram.

$t° = 2667°$ C.

Gas volume at $t°$ per gram = 6.634 liters.

This explosive may readily be packed to a density of 1.2, so that the gas volume at $t°$ per cc. is $1.2 \times 6.634 = 7.9608$ liters, and its efficiency should therefore be higher than that of the explosive cited above.

Both of the above explosives have contained a sufficient amount of oxygen to oxidize all the carbon to CO_2. In calculating $t°$, etc., of explosives containing a deficiency of oxygen, a slightly modified method must be used in completing the equation representing the explosion, and the following example is given to illustrate same.

Assuming the explosive to have the following composition:

	Per cent
Nitrostarch with 13.05 per cent N	50
Barium nitrate	47.5
Vaseline	2.5
	100.0

This explosive may be expressed in the following chemical terms:

$$\underset{274.5}{C_6H_{7.4}(NO_3)_{2.6}O_{2.4}} + \underset{261}{Ba(NO_3)_2} + \underset{13.5}{0.04C_{24}H_{50}}$$

Summing up we find these terms contain

9.5 H atoms, 6.96 C atoms, 1.0 Ba atoms, 16.0 O atoms, 4.5 N atoms

$Ba(NO_3)_2$ may be assumed to split up in BaO + N_2 + $2.5O_2$, of which the BaO immediately combines with CO_2 to form $BaCO_3$.

9.5 H with 4.75 O forms 4.75 mol. H_2O.

4.5 N atoms are equivalent to 2.25 mol. N_2.

There remain now 16 — 7.75 = 8.25 O atoms and (6.96 — 1) = 5.96 C.

As the remaining C and O atoms are assumed to combine to form CO_2 and CO, the number of CO_2 molecules are found by subtracting 5.95 from 8.25, or 2.30 CO_2; and the number of CO molecules is again obtained by subtracting 2.30 from 5.96, *i. e.*, 3.66 CO molecules. The complete equation representing the explosion of above explosive is therefore:

$$C_6H_{7.5}(NO_3)_{2.5}O_{2.5} + Ba(NO_3)_2 + 0.04C_{24}H_{50} = BaCO_3 + 4.75H_2O + 2.25N_2 + 2.30CO_2 + 3.66CO$$

By now following the described methods for calculating calorific power, $t°$, etc., the following values are obtained:

Gas volume at 0° C. and 760 mm. = 0.5288 liter per gram.

Calorific power = 816 calories per gram.

$t° = 2582°$ C.

Gas volume at $t°$ and 760 mm. = 5.5259 liters per gram.

Assuming that the CO formed reacts with H_2O to form CO_2 + H_2, what results would this have on the gas volume at $t°$?

The equation would thus be:

$$C_6H_{7.5}(NO_3)_{2.5}O_{2.5} + Ba(NO_3)_2 + 0.04C_{24}H_{50} = BaCO_3 + 1.58H_2O + 2.25N_2 + 5.96CO_2 + 3.66H_2$$

The following results are then obtained:

Gas volume at 0° and 760 mm. = 0.5288 liter per gram.

Calorific power = 855 cal. per gram.
$t° = 2592°$ C.
Gas volume at $t°$ = 5.552 liters per gram, or practically the same as in the reaction above.

When sulfur is present in explosives containing a deficiency of oxygen, a part of it combines to form a sulfide (H_2S, Na_2S, etc.) while the remaining sulfur is oxidized and combines with the metal to form Na_2SO_4, etc. No definite rule can be made as to what part combines one way or the other, the proportions probably having some relation to the oxygen deficiency.

The following table gives the calculated $t°$ and gas volume at $t°$ per gram of some of the most common explosives:

Explosive	$t°$	Gas volume at $t°$ per gram
Nitroglycerine	3158° C.	8.8328 liters
Trinitrotoluene (TNT)	2217° C.	6.764 liters
Picric acid	2599° C.	8.7270 liters
Tetranitromethyl-aniline ("Tetryl")	3126° C.	9.81 liters
Tetranitro-aniline (TNA)	3238° C.	10.55 liters
Nitrostarch with 12.75 per cent nitrogen	2205.7° C.	8.168 liters
Nitrostarch with 13 per cent nitrogen	2277° C.	8.28 liters
Nitrostarch with 13.47 per cent nitrogen	2415.4° C.	8.4937 liters
Mixture of 21.27 per cent TNT 78.73 per cent Ammonium nitrate	2310° C.	8.2622 liters
34 per cent TNT 66 per cent Ammonium nitrate	2195° C.	8.3493 liters
44.77 per cent TNT 55.23 per cent Ammonium nitrate	2122° C.	8.3315 liters
58.6 per cent TNT 41.4 per cent Ammonium nitrate	2146° C.	7.974 liters
92 per cent Nitroglycerine 8 per cent Nitrocellulose (12 per cent N)	3208° C.	9.0424 liters

That certain relations exist between "strength" of explosives and their calculated gas volume at $t°$ per gram as calculated by this method, has been proved, for instance, by results of Trauzl tests. Although the latter are subject to some errors, due partly to impurities in the lead and partly to execution of the test, an approximate idea as to the number of cc. expansion that will be effected by 10 g. of a brisant explosive is obtained by multiplying the calculated gas volume at $t°$ per gram by 37.58.

Applying this factor to some of the explosives listed above we obtain:

Explosive	Calculated Cc.	Found Cc.
Nitroglycerine	332	...
TNT	253	235
Picric acid	328	330
"Tetryl"	368	375
TNA	395	415
Nitrostarch (12.75 per cent N)	306	305

This method of calculating "strength" and efficiency of high explosives is often useful to the explosives chemist in making up a formula for an explosive to be used for a certain class of work or to take the place of another explosive. A study must at the same time be made of the apparent densities of various ingredients as well as of the effect of the latter on the apparent density of the explosive.

Allentown, Pennsylvania

PARA CYMENE. I—NITRATION. MONONITROCYMENE, 1-CH_3, 2-NO_2, 4-$CH(CH_3)_2$[1]

By C. E. Andrews

Received May 9, 1918

Although many methods for the preparation of mononitrocymene from *p*-cymene have appeared in the literature, it is evident from the reports themselves and also from the present work that the yields were very low in every case. A method giving good yields has been developed on a laboratory scale. A description of this procedure together with a certain amount of closely related considerations forms the subject matter of this paper.

[1] Published by permission of the Secretary of Agriculture.

Review of Previous Nitration Methods

In 1856, J. Barlow[1] attempted to nitrate cymene by dropping the cold hydrocarbon into strong nitric acid cooled with ice and salt. He obtained by steam distillation of the product a large quantity of an oil lighter than water. By reduction he obtained only a small quantity of material soluble in hydrochloric acid. The greater portion consisted of a light oil which boiled at 175° and was undoubtedly unchanged cymene.

Landolph[2] about twenty years later stated that nitric acid (density 1.5) cooled with ice and salt did not react at all with cymene. He used nitric acid (density 1.4) at 15° to 20° and finished the reaction at 40° to 50°.

Fittica[3] in the same year nitrated cymenes from various sources according to the method of Landolph and obtained products which were volatile with steam and which he called nitrocymene. A year later he[4] gave the following directions for nitration: 20 g. cymene were dropped into 150 to 200 g. of nitric acid (density 1.4) heated to 40°. After the addition of a few drops of cymene, the mixture was cooled until the vigorous reaction had ceased. He steam-distilled the nitration product and then redistilled this *in vacuo*. He stated that his analysis showed contamination with cymene.

Widman and Bladin[5] repeated the work of Landolph and Fittica and found that the nitrocymene which they had obtained contained only very little nitrocymene. It consisted principally of a mixture of cymene and *p*-tolylmethylketone. They attempted to nitrate by dropping cymene into a mixture of sulfuric acid and the calculated amount of nitric acid cooled by a freezing mixture. By steam distillation they found that a large part of the cymene had been unattacked and that another part had been nitrated to derivatives higher than the mono. Söderbaum and Widman[6] admitted that Widman's earlier attempt was a failure. They then reported a method which had been found satisfactory for the nitration of certain compounds which were easily oxidized. The calculated amount of nitric acid mixed with one and one half times its weight of sulfuric acid was slowly added to the cymene cooled with water. The temperature was held between 20° and 25° at first but was finally allowed to rise to 40°. In addition to the nitrocymene, they obtained by steam distillation large amounts of unattacked cymene and *p*-tolylmethylketone. By fractional steam distillation they obtained a sample which gave a fairly good analysis for nitrocymene.

[1] *Ann.*, **98** (1856), 245.
[2] *Ber.*, **6** (1873), 937.
[3] *Ibid.*, **6** (1873), 938.
[4] *Ann.*, **172** (1874), 303
[5] *Ber.*, **19** (1886), 583.
[6] *Ibid.*, **21** (1888), 2126

G. Sumnov[1] discarded Fittica's method of nitration as unsatisfactory. He mixed glacial acetic acid solutions of cymene and nitric acid and kept the temperature down by continuous cooling with ice.

METHOD OF PREPARATION

NITRATION—One-half mole of *p*-cymene was added to an equal weight of sulfuric acid (density 1.84) with stirring and the temperature kept at 0° or below by means of a bath of ice and salt. This required about 15 min. A well-cooled mixture of 50 g. of nitric acid, density 1.42 (110 per cent of theoretical amount required), and 105 g. of sulfuric acid (density 1.84) was then added drop by drop to the sulfuric acid solution of the hydrocarbon, keeping the temperature at 0° or below and stirring the mixture efficiently. It required about 5 hrs. for this operation on account of the large amount of heat produced. The reaction proceeded very smoothly without the evolution of oxides of nitrogen and at the end the mixture became reddish brown in color and about as viscous as thick molasses. After all of the mixed acids had been added, the reaction was allowed to proceed for from 15 to 30 min.

PURIFICATION OF THE NITRATION PRODUCTS—The mixture was then poured into an equal volume of cold water and the oily nitration product allowed to collect on top of the dilute acids. The two layers were separated and the oily one washed with cold water in which it sank. It was washed further with dilute sodium hydroxide solution to remove the last trace of acids, and finally with more cold water. In this manner a dark reddish brown product was obtained which weighed about 85 g. after drying with calcium chloride.

DISTILLATION—This oily product was then either distilled with steam or in reduced pressure. When distilled with steam, about 8 g. of an oil came over at first which was lighter than water. After this the greater portion, about 65 g., came over as a light yellow oil heavier than water and having a strongly aromatic odor. There remained in the distilling flask a brown viscous mass (about 10 to 12 g.) which became quite hard on cooling.

When distilled in an atmosphere of 3 to 5 mm. pressure the first product came over at about 95° and continued distilling until the temperature reached about 120°. The greater portion boiled at 115 to 116°. When the temperature reached 120°, the rise was very rapid and therefore the distillation was stopped. A residue remained in the flask similar to the one above. The product obtained by distillation *in vacuo* was not so pure as by the steam distillation since the former product contained the low-boiling fraction which was difficult to remove by fractionation.

LIGHT OIL FROM STEAM DISTILLATION—O. Widman and J. O. Bladin[2] in investigating methods of nitrating cymene proposed by Fittica[2] and Landolph[2] found that their product contained only very little mononitrocymene, but consisted almost entirely of unchanged cymene and *p*-tolylmethylketone. It was therefore thought that this light oil might contain some of this ketone together with cymene and nitrocymene. In order to free the oil from nitrocymene, it was reduced with tin and hydrochloric acid and steam-distilled from acid solution. Four grams of a colorless oil were obtained, all of which distilled near 175°, showing it to be essentially cymene. The reduction mixture was then made alkaline with sodium hydroxide and again steam-distilled, which gave 3 g. of an oil which formed a crystalline solid in concentrated hydrochloric acid with the liberation of heat, and entirely dissolved on dilution. This was undoubtedly an amine corresponding to the nitrocymene present. Therefore, the original 8 g. of light oil consisted of 4 g. of cymene and 4 g. of nitrocymene (equivalent to 3 g. of aminocymene). Working with this small amount of material it was impossible to recognize any *p*-tolylmethylketone.

TARRY RESIDUE—Landolph,[1] Fittica,[1] and Gerichten[2] have reported a solid mononitrocymene which they obtained from the tarry distillation residue by recrystallizing it from alcohol. In a later paper Gerichten[3] shows that the so-called solid nitrocymene was soluble in potassium hydroxide and from this solution *p*-toluic acid precipitated on acidification. A. F. Holleman[4] stated that this product had the formula $C_9H_8NO_2$ and therefore was not nitrocymene, and that it was changed by sodium hydroxide and sulfuric acid to *p*-toluic acid. The tar obtained in these experiments showed the following characteristics: It gave a very strong test for nitrogen but the substance obtained from this tar by two recrystallizations from alcohol solution was nitrogen-free. This recrystallized substance, as well as the original tar, was insoluble in boiling alkali of any concentration. The class of compounds indicated by these peculiar properties is not plain, and since it is evidently not a higher nitration product of cymene, it was thought not to be important enough to demand further investigation at this time.

HEAVY OIL FROM DISTILLATION—It was evident that this oil might contain the same compounds as the light oil mentioned above. It might also contain a mixture of the two isomeric mononitrocymenes. This decreased the possibility of purification by distillation. Fractionation at ordinary pressures was prohibited on account of the decomposition which took place. Under a pressure of 3 to 5 mm. practically all of it distilled at 100 to 120°, which gave a very narrow limit for fractionation. A fraction was obtained, however, boiling at 115 to 116° and 6 to 7 mm. pressure, which was taken for analysis.

Found, 7.75 and 7.9 per cent nitrogen
Calc. for $C_{10}H_{13}NO_2$, 7.82 per cent nitrogen

From these results it was evident that this oil was very nearly pure mononitrocymene. This fraction constituted practically the total yield. In this condition it appeared as a light yellow oil heavier than water with a strong, not unpleasant, aromatic odor.

[1] *Chem. Zentr.*, **1887**, 753; *Zurn. russk. fiz. chim.*, **19**, 1, 118–22
[2] *Loc. cit.*

[1] *Loc. cit.*
[2] *Ber.*, **10** (1877), 1251.
[3] *Ibid.*, **11** (1878), 1092.
[4] *Chem. Zentr.*, **1886**, 722; *Rec. trav. chim.*, **5**, 184–86.

Previous investigators have described their nitrocymene as possessing these same physical characteristics although no analyses have been reported which agree so well with the theoretical. Söderbaum and Widman[1] gave 7.49 per cent as the result of the nitrogen analysis. Fittica[1] reported 68.38 per cent carbon and 7.94 per cent hydrogen as the result of the analysis of the product he obtained. The theoretical hydrogen is 7.26 per cent and the carbon 67.03 per cent. The question of the presence of the two isomers will be taken up later.

INVESTIGATION OF THE POSSIBLE PRESENCE OF THE TWO ISOMERIC MONONITROCYMENES

REDUCTION—As far as could be determined there were no reports in the literature concerning the existence of two isomers of mononitrocymene except the liquid and the solid isomers reported by Landolph[1] and Fittica.[1] It has been proven, however, that the solid variety was not nitrocymene.[1] The liquid compound has been proven to have the constitution $CH_3(1)C_6H_3NO_2(2)CH(CH_3)_2(4)$ by oxidation to *o*-nitro-*p*-oxyisopropyl benzoic acid.[2] Although it has been reduced to the corresponding amine, no derivatives have been reported which would characterize it as a particular one of the isomers.[3] Lloyd[4] has reported the physical characteristics of several derivatives of the amines prepared from carvacrol and thymol. Walloch[5] prepared the derivatives of an amine obtained from carvoxime. Goldschmidt[6] reported the characteristics of an amine obtained from isocarvoxime. Widman[7] reported on an amine from cuminol. As the constitution of all these was definitely established it was decided to convert the nitro compound into an amine and compare its derivatives with those reported above. Accordingly, the whole portion (65 g.) of the heavy oil obtained from the steam distillation was reduced with tin and hydrochloric acid. After the reduction was complete, there was no oil visible which was insoluble in hydrochloric acid. Upon distillation, however, about 3 g. of a light oil came over. By making the solution alkaline with sodium hydroxide and steam-distilling again, about 54 g. of a colorless oil came over which floated on top of the water. The reduction was also carried out with iron and hydrochloric acid in the same way that nitrobenzene is reduced to aniline commercially. The results were the same in both cases except that the separation of the products is not affected by distillation from acid and alkaline solution, as is the case when an excess of acid is used in the reduction with tin. This was carried out separately with the same results as above.

LIGHT OIL FROM DISTILLATION OF ACID SOLUTION—By collecting the light oil from several distillations, enough material was obtained to carry out a fractionation. About two-thirds of the whole boiled near 175° (cymene) and the remainder boiled between 210° and 222°. This latter fraction had a pleasant odor, and from its boiling point was thought to be *p*-tolylmethylketone. By further fractionation the greater portion of it boiled from 218 to 221°. The boiling point of *p*-tolylmethylketone has been reported over quite a large range. Michaelis[1] gave 217°, Claus[2] 220°, and Widman and Bladin[3] 222.5 to 224°. The dibrom derivative was made according to Michaelis, and was found to melt at 99.5°, while Michaelis reported 100° and Widman and Bladin gave 99° as its melting point. The oxime was prepared according to R. Meyer[4] and melted exactly at 88° as reported by Meyer and also by Widman and Bladin. Analysis of the oxime showed the following percentages of nitrogen:

Found, 9.13 and 9.17 per cent nitrogen
Calc. for $C_9H_{11}ON$, 9.40 per cent nitrogen

From these results it seemed very probable that the fraction of light oil boiling between 210° and 222° was principally *p*-tolylmethylketone. The actual amount of ketone produced during any one nitration was about 1 g., which corresponded to a yield of 1.5 per cent. In many of the earlier reported nitrations of cymene large amounts of ketone had been produced.[5] This ketone together with the small amount of cymene constituted the impurity in the nitrocymene as obtained after distillation.

OIL FROM DISTILLATION OF ALKALINE SOLUTION—Lloyd[3] gave 241 to 242° as the boiling point of the amine (1-methyl, 2-amino, 4-isopropyl) obtained from carvacrol, and 230° for the one from thymol (1-methyl, 3-amino, 4-isopropyl). Walloch[3] gave 240 to 241° for the 1,2,4-amine. Semmler[6] gave 118 to 121° at 13 mm. pressure for the same one. Barlow[3] gave 250°, but did not attempt to say which amine it was. When the oil from the alkaline distillation was fractionated, it began to boil at 230° and then the temperature rose rapidly to 238°. Between 235° and 238° almost all of it distilled. Nitrogen analyses were made on this fraction which constituted almost all of the yield.

Found, 9.44 and 9.47 per cent nitrogen
Calc. for $C_{10}H_{13}NH_2$, 9.39 per cent nitrogen

These results showed that the total 54 g. of oil was very pure aminocymene and therefore represented a yield of 80 per cent, calculated on the cymene used. As high as 85 per cent was obtained but the lower yield was the most common. The yield of the nitro compound was therefore at least equal to this. Experiments showed the reduction to be practically quantitative. Both the hydrochloride and the sulfate were prepared and appeared as bright, lustrous plates. The hydrochloride melted at 207° as given by Walloch[3] and Goldschmidt[3] for the 1,2,4-amine. The acetyl derivative was prepared by boiling one mole of the amine with two moles of glacial acetic acid under a reflux condenser for 8 to 10 hrs. On cooling, the mixture solidified to a white mass which was re-

[1] *Loc. cit.*
[2] Söderbaum and Widman, *Loc. cit.*
[3] Barlow, *Loc. cit.*; Söderbaum and Widman, *Loc. cit.*
[4] *Ber.*, **30** (1887), 1262.
[5] *Ann.*, **279** (1894), 368.
[6] *Ber.*, **26** (1893), 2086.
[7] *Ibid.*, **15** (1882), 166.

[1] *Ber.*, **15** (1882), 185.
[2] *Ibid.*, **19** (1886), 234.
[3] *Loc. cit.*
[4] *Ann.*, **219** (1883), 234.
[5] Widman and Bladin, *Loc. cit.*
[6] *Ber.*, **25** (1892), 3352.

crystallized several times from dilute alcohol. Pure white crystals were obtained which melted at 71°. Goldschmidt reported 71° as the melting point of the acetyl compound of the 1,2,4-amine and Walloch gave 72° for the same compound. Goldschmidt pointed out that the melting point of 115° reported by Lloyd[1] was an error. Lloyd gave the melting point of the corresponding 1,3,4-compound as 112.5°. In order to determine whether or not the boiling range 230 to 238°, which was between that of the two amines, as reported, indicated the presence of both isomers, the acetyl compound of the lowest fraction and of the highest fraction were prepared separately. Both compounds melted sharply at 71°, which would not have been the case if both isomers had been present. The benzoyl compound was also prepared by the Schotten-Baumann reaction and found to melt at 96.5°, while it was reported at 102° by Lloyd.[1] Analysis showed that the compound was very pure and since Lloyd gave no analysis, it was assumed that his melting point was incorrect.

Found, 5.36 and 5.43 per cent nitrogen
Calc. for $C_{18}H_{19}ON$, 5.53 per cent nitrogen

The melting point of the corresponding isomeric compound could not be found in the literature. Since all of the derivatives melted very sharply and from the fact that the acetyl compounds from the two fractions farthest apart melted at the same temperature, there seemed very little chance for the presence of two isomers. The melting points also agreed very well with those reported for the 1,2,4-isomer which pointed to the fact that this was the isomer formed.

IDENTIFICATION OF THE MATERIAL SOLUBLE IN SODIUM HYDROXIDE—The sodium hydroxide solution obtained as described in the purification of the nitration product was investigated in order to determine the amount and character of the acids formed by any oxidation of the side chains of the *p*-cymene. It was boiled with decolorizing charcoal and filtered, the filtrate concentrated to a small volume and then made acid with hydrochloric acid. By this method no precipitation took place nor could any acid be extracted with ether when the alkaline solution from a single nitration was used. By employing the combined solutions from several nitrations a small amount of an acid was obtained which gave, after two crystallizations from boiling water, very light yellow crystals melting at 179° and giving a very slight test for nitrogen. By again decolorizing and recrystallizing, these crystals became colorless, soluble in alkali, and gave no test for nitrogen. Melting point, 180°. The compound is *p*-toluic acid. No statement has been found in the literature indicating that the products of nitration have been investigated in this way. The small amount of acid formed showed that the oxidation in this direction was almost negligible.

DISCUSSION OF METHODS

Although no yields were given in any of the methods of nitration reported in the literature, it was evident that very little nitrocymene was obtained. In repeating the work of Söderbaum and Widman,[1] it was found that very low yields were given when the reaction was carried out from 20 to 25°, but when it was kept down to zero, there was a marked increase. When nitric acid (density 1.42 to 1.5) was used alone at the temperature recommended by Landolph[1] and Fittica[1] (20 to 50°) low yields were also obtained and there was almost no reaction at 0°. Hence the presence of sulfuric acid and a low reaction temperature became important conditions. The solution of the hydrocarbon in a suitable solvent previous to nitration proved to be a very important factor. Petroleum ether, glacial acetic acid, and concentrated sulfuric acid gave increasingly good results as solvents in the order named. No mention of such a procedure could be found in the literature. Although Sumnov[1] nitrated in a solution of acetic acid, his yields were low, as shown by a series of experiments in which glacial acetic acid was substituted for concentrated sulfuric acid. Acetic anhydride in varying amounts was also added to the acetic acid to take the place of the sulfuric acid, but in every case there was practically no nitration. Some of the earlier investigators[2] let the cymene drop into the nitrating acid but it was found that by reversing this order, that is, by letting the acid drop into the cymene, much better results were obtained. A slight excess (110 per cent of the theory) of nitric acid (density 1.42) mixed with about twice its weight of sulfuric acid (density 1.84) formed the best nitrating mixture. Practically no time was required to complete the reaction after the acids had all been added. All of the previous investigators neglected to observe at least one of these important factors and consequently did not obtain good yields of mononitrocymene. In most cases several factors were not taken into consideration, which accounted for the very poor yields in those particular cases.

It is to be noted that one of the possible substitution products is produced and the other is not formed in any appreciable amount. The directing groups involving this phenomenon are the methyl and the isopropyl. The same nitro compound was produced under all of the widely varying conditions used in the course of the investigation, so it appeared that the other isomer could not be prepared by direct nitration.

SUMMARY

1—A method for the nitration of *p*-cymene is described which has given yields of mononitrocymene (1-CH_3, 2-NO_2, 4-$CH(CH_3)_2$) as high as 85 per cent.

2—Very small amounts of *p*-toluic acid and *p*-tolylmethylketone have been shown to be produced during nitration.

3—The nitrocymene has been reduced to the corresponding amine. This reaction has been made to give theoretical yields.

4—The amine, and hence the nitro compound, has been shown to consist of only the 1,2,4-isomer.

COLOR INVESTIGATION LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

[1] *Loc. cit.*
[2] Landolph, *Loc. cit.* Fittica *Ibid.* Widman and Bladin, *Ibid.*

EFFECT OF ACETYLENE ON OXIDATION OF AMMONIA TO NITRIC ACID[1]

By Guy B. Taylor and Julian H. Capps

Received May 13, 1918

In experiments on the oxidation of ammonia to nitric acid carried out in the laboratories of the Bureau of Mines, some attention has been given to the question of the effect of such impurities as normally occur in ammonia gas derived from commercial sources. It has been found that high-grade ammonia liquor derived from carbonization of coal contains no deleterious impurity whatever and that conversion efficiencies of 95 per cent are easily obtained with platinum as catalyzer.

An important source of ammonia is calcium cyanamide. Since this material is manufactured from carbide, small amounts of which remain in the finished product, the ammonia gas derived from it almost always contains acetylene. The object of the experiments described in this paper has been to determine the effect of acetylene in the ammonia gas upon catalytic oxidation with platinum.

EXPERIMENTAL

The oxidizer or converter consisted of two rectangular aluminum boxes, 6 by 3 by 12 in., bolted together

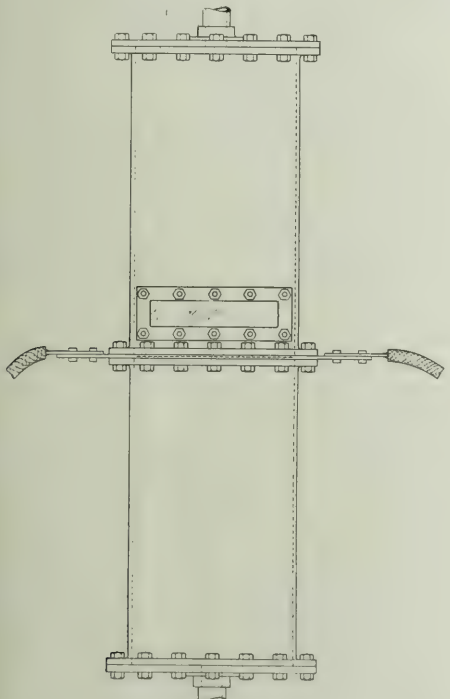


Fig. I

with a platinum gauze between (Fig. I). The gauze was crimped into two pieces of aluminum sheet at either end and held between "Janos" gaskets. Heavy cables connected the aluminum electrodes to a low-voltage transformer which furnished the current for heating the gauze. Ammonia mixed with air was admitted at the top and the reaction products issued at the bottom. A perforated aluminum plate was fixed 5 in. above the gauze to serve as a baffle for securing uniform distribution of the gas flow through the gauze. The mica window shown in the figure afforded an unobstructed view of the entire gauze surface.

The ammonia-air mixture was obtained by bubbling air through two metal drums in series containing pure ammonia liquor of such strength as to secure a suitable concentration of ammonia in the mixture. The feed mixture then passed into an empty 50-gal. drum to prevent pressure fluctuations and then through 10 ft. of rubber hose to the top of the converter. The arrangement of the rest of the apparatus has been previously described.[1]

Acetylene, with its accompanying impurities, was generated in a Kipp apparatus from high-grade calcium carbide and water, washed through water, and carefully measured. It was passed into the ammonia-air mixture in the rubber hose line connecting the ammonia saturator to the converter, about 8 ft. from the latter. The acetylene-bearing gas came into contact with iron only through a T-connection and short nipple.

The composition of the gas entering the oxidizers was calculated from the rates of flow of the acetylene and of the air through the ammonia vaporizer, together with analysis of the ammonia-air mixture for ammonia. The acetylene present in the gas could thus be determined more accurately than by analysis at the small concentrations employed.

The gauze used in these experiments was made of pure platinum wire 0.003 in. diameter, 80 wires to the linear inch. Platinum is never fully active when first placed in the converter but is "activated" by the reaction itself so that the conversion efficiency[2] rises with use, increasing from day to day until the maximum efficiency is reached. Gauzes vary widely in the time required to reach their full activity. The particular gauze used in these experiments reached its full activity unusually quickly. In Table I are presented results showing the performance of this gauze with pure ammonia. The converter was operated several hours continuously each day over the 5-day period.

Table I—Tests of Pure Platinum Gauze from Baker & Co., 80 Mesh, 0.003 In. Wire, Using Pure Ammonia

Date	Test No.	Cu. ft. of air per hr.	Amperes	NH_3 in air mixture Per cent	Yield Per cent
Feb. 6	341	175	160	9.10	92.4
Feb. 6	342	180	135	9.58	93.2
Feb. 7	343	170	160	8.40	93.5
Feb. 8	344	170	150	8.78	94.6
Feb. 8	345	170	150	8.73	96.0
Feb. 8	346	170	130	9.80	94.6
Feb. 8	347	170	130	9.80	94.4
Feb. 9	348	180	160	7.48	95.0
Feb. 9	349	180	160	7.49	94.0
Feb. 11	350	175	150	8.50	94.8
Feb. 11	351	175	150	8.55	94.3

Average yield 94.6 per cent, excluding Nos. 341 and 342.
Ammonia escaping oxidation, 0.5 per cent.

The result of the addition of acetylene is shown in detail in Table II. The poisoning effect at concentra-

[1] Published by permission of Director of U. S. Bureau of Mines.

[1] Taylor, Capps and Coolidge, This Journal, **10** (1918), 270.

[2] The vacuum bottle method was used in determining efficiencies, see Taylor and Davis, This Journal, **9** (1917), 1106.

TABLE II—EFFECTS OF ACETYLENE ON YIELD, 170 CU FT AIR PER HOUR

DATE	TIME	TEST NO.	AMPERES	INTAKE GAS NH_3 PER CENT	INTAKE GAS C_2H_2 PER CENT	YIELD PER CENT	MAP OF GAUZE
March 2		368	165	7.50	0.0	96.0	..
March 2	....	369	165	7.50	0.0	96.5	..
March 4	10 : 20	...	150	8.0	0.0	...	Clear
March 4	10 : 30	...	150	8.0	1.12	...	..
March 4	10 : 32	..	150	8.0	1.33	...	See Map A, Fig. II
March 4	10 : 38	...	150	8.0	1.54	..	See Map B, Fig. II
March 4	10 : 53	..	150	8.0	0.53	...	..
March 4	11 : 20	...	150	7.5	0.21	...	See Map C, Fig. II
March 4	11 : 45	...	150	7.8	0.13	...	..
March 4	12 : 10	...	150	7.7	0.13	...	Clear
March 4	12 : 22	370	155	7.7	0.13	71 8	Clear
March 4	12 : 27	371	155	7.7	0.13	75 0	Clear
March 4	1 00	...	155	7.7	0.04	...	Clear
March 4	2 00	..	155	7.6	0.04	..	Clear
March 4	2 20	..	155	7.5	0.0	...	Clear
March 4	2 : 23	...	155	7.5	0.21	...	See Map D, Fig. II
March 4	2 : 45	...	155	7.5	0.13	...	Clear
March 4	2 : 50	372	150	7.5	0.0	90 4	Clear
March 4	2 : 55	373	150	7.5	0.0	92.5	Clear

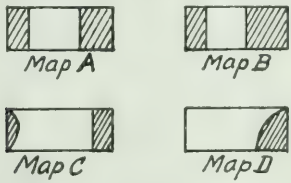


Fig. II

DATE	TIME	TEST NO.	AMPERES	INTAKE GAS NH_3 PER CENT	INTAKE GAS C_2H_2 PER CENT	YIELD PER CENT	AMMONIA ESCAPING OXIDATION PER CENT	REMARKS
March 5	10 : 30	...	...	...	0	...	..	Start
March 5	1 : 00	374	140	9.35	0	92.6	0.7	
March 5	1 : 05	375	140	9.35	0	92.5	0.7	
March 5	3 : 35	376	150	8.92	0	92.2	0.6	
March 5	3 : 38	377	150	8.92	0	92.5	0.6	Shut down 3 : 45
March 6	9 : 10	...	...	...	0	...	..	Start
March 6	10 . 40	378	150	8.80	0	94.2	0.6	
March 6	10 : 43	379	150	8.80	0	95.0	0.6	
March 6	2 : 53	380	150	9.06	0	93.5	0.6	
March 6	2 : 56	381	150	9.07	0	94.0	0.6	Shut down 3 P.M.
March 7	9 : 10	...	...	...	0	...	..	Start
March 7	11 : 05	382	165	7.40	0	95.9	..	
March 7	11 : 08	383	165	7.43	0	95.0	..	
March 7	1 : 40	...	...	7.0	0.12	...	..	
March 7	2 : 30	385	160	6.70	0.09	69.0	2.5	
March 7	3 : 19	386	165	6.40	0.16	46.5	5.4(a)	Shut down 3 : 25
March 8	10 : 40	...	...	...	0	...	..	Start
March 8	11 : 25	387	160	7.79	0	91.4	..	
March 8	11 : 45	...	...	...	0.04	...	..	
March 8	12 : 15	388	150	8.05	0.05	92.8	0.5	
March 8	1 : 10	389	150	8.05	0.04	85.6	1.5	
March 8	3 : 08	390	150	7.52	0.05	87.3	1.1	
March 8	3 : 12	...	...	...	0	...	..	
March 8	3 : 19	391	150	7.54	0	91.1	0.7	
March 9	9 : 05	...	...	...	0	...	..	Start
March 9	9 : 57	392	150	8.18	0	91 0	0.7	
March 9	10 : 00	393	150	8.21	0	92.0	0.7	
March 9	1 : 55	394	125	9.42	0	89.7	0.8	Shut down 4 : 15 P.M.
March 9	1 : 58	395	125	9.38	0	89.4	0.8	
March 11	9 : 30	...	...	...	0	...	..	Start
March 11	11 : 00	396	160	7.15	0	92.3	0.6	
March 11	2 : 50	397	140	9.32	0	93.6	0.5	
March 11	2 53	398	140	9 32	0	93.4	0.5	Shut down 4 15 P.M
March 12	11 . 00	...	...	...	0	...	..	Start
March 12	11 : 43	399	110	10.75	0	90.0	0.7	
March 12	11 : 46	400	110	10.75	0	89.6	0.7	
March 12	2 : 45	401	120	9.50	0	91.7	0.5	
March 12	2 : 55	402	120	8.70	0	93.8	0.5	
March 12	4 15	403	130	10.35	0	92.4	0.6	
March 12	4 20	404	130	10.50	0	92.6	0.6	Shut down 4 22 P.M
March 13	9 : 10	...	...	...	0	...	.	Start
March 13	10 : 22	...	...	...	0.03	...	..	
March 13	10 . 30	405	125	10.35	0 03	93 0	0.6	
March 13	11 00	406	125	9 90	0 03	90.0	0.6	
March 13	11 52	407	133	9.40	0.03	89.4	0.9	
March 13	2 25	408	150	8 37	0 03	88.4	1.2	
March 13	2 45	409	140	8.37	0.03	86.6	1.2	
March 13	3 37	410	146	8.40	0.025	87.3	..	
March 13	9 : 10	...	...	...	0	...	..	Start
March 14	9 : 15	...	...	...	0.08	...	..	
March 14	10 . 08	411	140	8.72	0.10	68.3	2.2	
March 14	10 15	412	140	8.73	0.10	68.7	2.4	
March 14	11 23	413	140	8.14	0.09	77.5	..	
March 14	1 08	414	150	7.92	0.10	63.0	2.9	
March 14	1 16	...	...	...	0.02	...	..	
March 14	1 33	415	150	8.07	0.02	88.4	1.0	
March 14	2 43	416	145	8.70	0.02	87.0	1.0	
March 14	2 45	417	145	8.75	0.02	88.7	0.8	

(a) Speed was 305 cu ft air. An increase of velocity of this order causes a decrease when running on pure ammonia of less than 2 per cent.

tions above 0.2 per cent in the mixture is immediately optically apparent on the gauze. Black inactive areas appeared which are shown by maps of the gauze. If the electric current is shut off, when running on pure ammonia, the gauze remains dull red from the heat of reaction. Under the same conditions with 0.1 per cent acetylene black areas immediately appeared tending to spread over the entire gauze. These areas are difficult to clear up and it is our opinion that oxidizing ammonia from sources which may even occasionally contain acetylene, would give unlimited trouble from development of black spots, which could not be cleared up readily without electric heating.

No black area appeared after March 4. The tests showed that the yield was a function of the concentration of acetylene and that when the acetylene was shut off the yield immediately rose to within 3 or 4 per cent of its original value, but required many hours running on pure ammonia to restore it completely.

A gauze that has been rendered active by oxidizing pure ammonia has a distinctive gray appearance to the naked eye. Under the microscope the wires appear to be covered with platinum sponge. Examination of the gauze at the conclusion of the tests on March 4 showed an entirely different appearance. It had a speckled crystalline appearance to the naked eye and the wires appeared rough but shiny under the microscope. Re-activation with pure ammonia returned the gauze to its original gray. At the conclusion of the experiments on March 14, the gauze was less different from the gray than the previous examination had showed.

REMOVAL OF ACETYLENE FROM AMMONIA

These results show so conclusively the poisoning action of acetylene or its accompanying impurities that some method for its removal seems imperative if cyanamide ammonia is to be successfully oxidized with high efficiency.

Several methods for accomplishing this result suggest themselves. Removal by scrubbing the gas with ammoniacal cuprous solutions might be managed. Cuprous acetylide was found to be readily precipitated from ammonia gas by bubbling it through ammoniacal copper nitrate solution containing metallic copper. Such a process involves complicated procedure for recovery of copper. Scrubbing with organic solvents appears to be impracticable on account of their volatility.

A thoroughly practical method is to convert the ammonia into liquor by dissolving it in water. Water dissolves its own volume of acetylene. Its solubility in strong ammonia liquor as shown by our experiments is of the same order. On this basis one liter of liquor containing 300 g. NH_3 would hold in solution 440 liters of ammonia gas and only 10 cc. acetylene if saturated with ammonia gas containing 1 per cent acetylene.

Such a liquor when vaporized with air to form a 10 per cent ammonia mixture should yield a gas for the oxidizer containing about 0.0002 per cent acetylene

or 1 part by volume in 500,000. Acetylene at this concentration would probably not poison platinum.

The calculation made above is based on Henry's law. Since the acetylene is only 1 per cent of the ammonia, its partial pressure is 0.01 atmosphere and it follows therefore that 1 liter of liquor will dissolve at equilibrium one liter of acetylene at 0.01 atmosphere, or 10 cc. at normal pressure. In dissolving ammonia-acetylene in water, the former is absorbed quite rapidly, thereby increasing the partial pressure of the acetylene so that the concentration of acetylene in solution is at first quite high. The gas must be passed in some time after all absorption of ammonia has ceased in order that equilibrium may be established and the acetylene concentration in the liquor reach its minimum value.

Laboratory experiments show conclusively that the deductions arrived at by application of Henry's law are correct. Ammonia gas containing 1 to 2 per cent acetylene was passed into water until the ammonia reached a concentration of 28 per cent. The acetylene in solution was then determined by precipitation as Ag_2C_2 with standard silver nitrate, and found to be 130 cc. C_2H_2 per liter. The ammonia-acetylene mixture was then continued through the solution until it passed freely and no more ammonia was being absorbed. The liquor now contained 10 cc. C_2H_2 per liter.

The application of this scheme industrially should offer no difficulties. Ammonia absorption apparatus is simple. Two or more absorbers would have to be employed since equilibrium conditions must be established by blowing the gas freely through the first absorber after the liquor is saturated. The temperature of the absorber could be adjusted so that the strength of the liquor would not be too high after cooling, to avoid loss of NH_3. This temperature in winter would probably be in the neighborhood of 35° C. and warmer in summer. The heat of solution makes such an adjustment easy.

Should it be desirable to make a liquor absolutely free from acetylene, pure ammonia gas could be blown through the absorber at the end of the operation. About 5 per cent of this very pure liquor could be reserved as a source of pure gas to treat the next batch. An ammonia liquor free from all non-reacting foreign gases may be prepared in this way.

SUMMARY

I—As little as 0.02 per cent acetylene in the ammonia-air mixture has a distinctly deleterious effect. The yield drops from about 95 per cent to 89 per cent or less.

II—The effect of 0.1 per cent acetylene, or its accompanying impurities, is disastrous. The yield may drop as low as 65 per cent.

III—A small quantity of acetylene will render the platinum so inactive that the yield on pure ammonia will be reduced 2 to 4 per cent for several hours. This means that the ammonia used for manufacture of nitric acid should be free from acetylene at all times.

IV—Operation of oxidizers working on the principle of a self-sustaining reaction without electric heating or preheating, and utilizing sources of ammonia that contain acetylene, is probably impracticable.

V—Ammonia gas may be freed from acetylene and other non-reacting gases by dissolving it in water to make a strong ammonia liquor. Such procedure involves no difficulty industrially, nor any considerable expense in operating a commercial oxidizing plant.

ACKNOWLEDGMENT

The experiments described herein are a part of an extensive investigation on commercial ammonia oxidation and the production of nitric acid thereby, conducted by the Bureau of Mines and the Semet-Solvay Company in coöperation with the General Chemical Company and the Ordnance Department, under the direction of the Chief Chemist, Dr. Charles L. Parsons.

Bureau of Mines
Washington, D. C.

LABORATORY AND PLANT

A ROCKING ELECTRIC BRASS FURNACE[1]

By H. W. Gillett and A. E. Rhoads

Received May 15, 1918

It seems inevitable that the next few years will see electric furnaces largely replacing crucible furnaces in the brass industry, a development comparable to that which the last few years have seen in the steel industry.

With Klingenberg clay not available and Ceylon graphite requiring shipping needed for other purposes, crucibles, despite the good work done on the problem by crucible manufacturers, the Bureau of Standards, and others, are still, speaking generally, of much poorer quality and many times more costly than they were under pre-war conditions. The time is ripe for the practical elimination of the crucible from the brass industry.

With the huge tonnage of brass required for war purposes, the use of the small units—averaging 200 lbs. per charge—in which crucible melting is done by the brass rolling mills, seems, and is, an anachronism. Besides the avoidance of crucibles and the ability to melt larger charges, electric melting (in a suitable type of furnace) decreases the loss of metal by oxidation and by volatilization, prevents the taking up of sulfur from the fuel, gives better and more healthful working conditions, and has many minor advantages such as freedom from handling and storing fuel and ash. Electric furnaces give crucible quality of metal without using crucibles.

However, not every type of electric furnace can be used for brass melting. If brass did not differ materially from steel in its behavior during melting, electric furnaces would long ago have superseded crucible

[1] Published by permission of the Director of the Bureau of Mines.

furnaces. But brass is made up of copper and zinc, and zinc is volatile at brass melting temperatures. For this reason, fuel-fired furnaces of the reverberatory type can be applied to brass only at the expense of a zinc loss so high as to prohibit the procedure. Similarly, the direct-arc type of electric furnace used for steel melting, such as the Héroult, can be used only on bronzes practically free from zinc, because of the high local temperature of the melt under the arc.

Indirect-arc furnaces, such as the Rennerfelt, can be used on brasses carrying up to about 20 per cent zinc, but are not suitable for ordinary yellow brass, on account of the formation of a superheated layer on the surface of the melt directly under the arc, and the resulting volatilization of zinc.

Induction furnaces of the ordinary horizontal ring type, like the Rochling-Rodenhauser, cannot be used on brass or bronze because the high electrical conductivity of these alloys requires a secondary current so high that the "pinch effect" causes rupture of the secondary ring.

Hence it has been necessary to develop types of furnaces radically different from those in use for steel in order to meet the requirements of brass.

ELECTRIC BRASS FURNACES IN COMMERCIAL USE

There are, however, two types of steel furnace which have been applied to brass (using the term brass loosely to include bronze, red brass, etc.): the Snyder, a single-phase, direct-arc furnace; and the Rennerfelt, a two-phase, indirect-arc furnace. At the Chicago Bearing Metal Company; Chicago, Ill., two one-ton Snyders and two one-ton Rennerfelts are melting bronze for railroad bearings, high in lead, but practically free from zinc. The metal losses are not much reduced from previous practice in crucibles and open flame oil furnaces, but the furnaces are making savings in melting cost as compared with either the crucible or the open-flame furnaces under present conditions.

The Philadelphia Mint is melting nickel and coinage bronze in a 1000-lb. Rennerfelt furnace. The Gerline Brass Foundry Company, Kalamazoo, Michigan, melts Monel metal, red brass, and brass containing up to about 20 per cent zinc in an 800-lb. Rennerfelt. The furnace at the Gerline plant is run on a 9-hour basis, while the other furnaces mentioned operate 18 to 24 hours a day.

Two other types of furnace designed especially for brass melting have also found commercial use, the Baily and the Ajax-Wyatt.

The Baily furnace uses a single-phase granular resistor, the heat from which is reflected down onto the hearth from the roof. It takes charges of about 1000 lbs. Baily furnaces are installed at the Lumen Bearing Company, Buffalo, N. Y., Hays Mfg. Company, Erie, Pa., Bridgeport Brass Company, Bridgeport, Conn., and the Baltimore Copper Smelting and Rolling Company, Baltimore, Md. The Baily furnace is applicable to alloys of any zinc content, reduces metal losses, avoids crucibles, and gives good working conditions. The main drawback of this type of furnace is that the source of heat is not close to the melt and the heat must be reflected down from the roof. In order not to overheat the roof and cause its prompt failure, as well as to hold the resistor temperature within the limits that allow reasonable life of the resistor trough, the rate of power input is low compared to the size of the furnace and weight of charge. Hence the radiation losses from walls and roof form a large proportion of the total power. The furnace is at its best on 24-hour operation. When 10-hour operation is necessary, it is found that the furnace must be heated empty during all or part of the night in order to give satisfactory output in the daytime. Because of the high heat storage in the walls, a furnace of this type does not respond promptly to changes in power input, and accurate control of the temperature of the melt is difficult.

The Ajax-Wyatt furnace is a single-phase induction furnace in which the secondary ring is in the form of a loop below the level of the hearth proper, so that the hydraulic head of the metal in the hearth opposes the rupturing effect of the "pinch" force, thus avoiding the troubles which make horizontal-ring induction furnaces inapplicable to brass.

The metal heated in the secondary loop is constantly ejected at one part of each opening from loop to hearth, and colder molten metal drawn in at another part of the opening. These fountains of hot metal issuing from the resistor melt the charge in the hearth. The constant circulation of metal is a most desirable feature and gives a product of remarkably uniform chemical composition.

Because of the compactness of the furnace, the generation of heat within the metal itself, and the stirring action, vertical-ring induction furnaces are extremely efficient as regards power consumption. The power factor in the sizes so far built is satisfactory.

The furnace must be started with a charge of previously melted metal, and sufficient metal to fill the loop must be retained when pouring. The metal in the loop must never be allowed to solidify, or the lining will be ruined. These facts make it difficult to change from one alloy to another, and require that the furnace be run 24 hours a day, or else receive enough power at night to keep the metal in the loop fluid. Ramming up and drying the refractory lining of the loop is a job requiring care and experience, as the lining must be perfect or its life will be short. No lining has yet been found which will withstand alloys containing over 3 per cent of lead, and the furnace has been developed mainly for yellow brass.

The furnace is fitted for rolling-mill use, where 24-hour operation on yellow brass is the rule, but is distinctly less suitable for 10-hour runs or for foundries making a variety of alloys.

Several of these furnaces are in use at the Ajax Metal Company, Philadelphia, two at the American Brass Company, Waterbury, Conn., and twenty-eight at the Bridgeport Brass Company, Bridgeport, Conn. The furnace saves zinc, avoids crucibles, and shows so low a power consumption on 24-hour operation that it can doubtless be used to advantage in rolling-mill practice even under normal prices of fuel and crucibles.

FURNACES UNDER EXPERIMENTAL TEST

Besides the four types mentioned above, each of which has found commercial use where conditions were suitable, there are four other furnaces that have reached a semi-commercial stage, but are still under experimental development.

The Bennett furnace at the Scovill Mfg. Co., Waterbury, Conn., is a three-phase furnace, probably of about 750 lbs. capacity, and resembles a direct-arc furnace. However, the voltage between electrodes (which are automatically regulated) and bath is kept so low that there is no true arc and the heat is generated by a sort of contact resistance. This is said to give low metal losses and to show a reasonably low consumption of power.

The furnace has run mainly on yellow brass and is, therefore, probably applicable to all brasses and bronzes. The results of the work have so far been kept secret and no detailed data are available.

The Foley furnace is a single-phase, vertical-ring induction furnace, similar in general design to the Ajax-Wyatt, although differing from it in many points. One such furnace, of about 1000 lbs. capacity, has been in experimental operation at the Bristol Brass Company, Bristol, Conn., and three 3000-lb. furnaces are under construction. From the small amount of data so far available on this furnace, its metal losses and power consumption will be about the same as in the Ajax-Wyatt; due partly to its larger size, its power factor is somewhat lower. It has the same disadvantages as regards starting, changing from one alloy to another, and the necessity for 24-hour operation, as that furnace.

The General Electric furnace is a smothered-arc, one- or two- (normally two) phase furnace, of about 1500 lbs. capacity, having four depending electrodes, two on each side of a hearth. Between the tips of each pair of electrodes is a carbon block to which arcs are drawn, the arcs being smothered by granular coke. The heat thus generated is reflected down onto the hearth by the roof. The electrodes are automatically regulated.

After being tested at the General Electric Company, Schenectady, N. Y., this furnace has been installed for further test at the Chicago Plant of the Crane Company, but is not yet considered ready for general commercial use.

The heat transfer in this type is similar to that in the Baily, and the furnace seems theoretically capable of a performance of about the same order as the Baily with similar advantages and similar drawbacks. As the General Electric furnace takes a higher power input than the Baily, it may be slightly more efficient in power consumption, but the roof is subject to even more severe conditions and will require the use of high-grade refractories to give a good life.

The Northrup furnace, being developed by Prof. E. F. Northrup and the Ajax Metal Company, is an induction furnace, heating the charge by means of eddy currents instead of making the charge, or part of it, the secondary of a transformer. Oscillating current of very high frequency is used instead of alternating current, and is obtained by the use of condensers or of a special generator. A 60-kw. tapping-type furnace is being tried out. The Northrup furnace has a high power factor, and can take multi-phase current. It is being developed in order to produce a furnace suitable for 10-hour operation and for facility in changing from one alloy to another.

Since the heat is generated within the charge itself, the eddy-current furnace should be efficient in power consumption. This type is theoretically very promising, but its development has not yet gone far enough to show what, if any, mechanical limitations the type will have.

Many other types of furnace have been suggested for brass melting, and a number have been tried out more or less thoroughly, but those mentioned above are the most prominent of the types in commercial use or under commercial development. Most of these are either limited in their application, or have some drawbacks, either inherent in the type of furnace, or not yet eliminated by long experience in their design and use, so that no one type or make of furnace is as yet definitely proven the best for any particular set of conditions, and still less will any one furnace meet all the different conditions found in the whole range of the brass and bronze industry.

In particular, none of these types seems quite fitted to that common set of conditions where a furnace may be called upon to melt successive heats of alloys differing widely in composition, to handle both alloys free from zinc and those high in zinc, and to operate cheaply on a 9- or 10-hour day.

ROCKING ELECTRIC BRASS FURNACE

In its study of electric brass melting during the past five years, the Bureau of Mines has tried out a rocking type of furnace, which may perhaps help to fill this gap.

In the ordinary indirect-arc type of furnace, the heat is applied above the melt and as hot metal is lighter than colder metal, there is little circulation in the bath. If the rate of heat input is at all rapid, as is necessary for thermal efficiency, heat conduction from the top of the melt downward does not keep pace with the heat supply. Before the melt as a whole reaches the proper pouring temperature, the surface is much superheated.

On an alloy high in zinc the surface will reach the boiling point of the zinc in that particular alloy while the bottom is scarcely melted; such heating creates a high pressure of zinc vapor within the furnace, so that if the furnace is not tightly closed zinc is lost continually. If the furnace is sealed tight, the pressure may even blow out the roof or door. In case the furnace holds tight and the pressure is not relieved till the spout is opened for pouring a long hissing stream of zinc vapor then shoots out, burning in the air. This local overheating is the cause of the failure of the indirect-arc furnace to handle alloys high in zinc without large metal losses.

The obvious way to overcome this trouble is to stir the melt so vigorously that the temperature of the melt is practically uniform and the superheating of the sur-

face prevented. The most practical way to stir the melt is by the principle of the cement-mixer, by turning the furnace bodily so as to stir the contents thoroughly while being heated. Constant rotation of a cylindrical furnace placed more or less horizontally, but preferably at a slight angle with the horizontal to produce endwise motion of the melt during rotation, with electrodes entering at the ends of the drum and an arc struck between the electrodes, should not only stir the charge thoroughly, avoid surface overheating and thus prevent zinc losses, but should also give a well-mixed alloy. By washing the walls with metal, the heat stored in the walls and roof should be largely taken up in the metal instead of passing out. The power consumption should, therefore, be low. As the walls are washed with metal their temperature can rise little above the temperature of the metal, which should give a good life of lining.

Instead of rotating the furnace through a complete revolution—which would involve difficulty in making brush contacts to the electrodes and in keeping the metal out of the joints between the door and the door opening, as this opening should be on the circumference of the drum rather than on the end—it appears simpler to rock the furnace back and forth so that the molten charge just fails to reach the door at either end of its rocking angle.

A small furnace of this type was built and tried out. This was rocked back and forth by hand on tracks. It was cheaply constructed from materials at hand in the laboratory and was not expected to give very good results on power consumption, as the drum was too small to allow the refractory lining to be of desirable thickness.

The laboratory furnace held about 100 lbs. of charge, and operated on 50 to 75 volts, 500 to 700 amperes, at a power factor of 85 to 90. The usual power input was about 30 kw. Graphite electrodes 2 in. in diameter were used.

A number of different alloys were melted in the rocking furnace. In melting 1092.1 lbs. of yellow brass, made up of 45 per cent ingot, 55 per cent copper and zinc, the calculated analysis being 65.6 per cent Cu, 34.4 per cent Zn, 1080.4 lbs. of ingot were obtained, analyzing 65.9 per cent copper, 34.1 per cent zinc. The metal loss by weight was 1.06 per cent which includes both volatilization and mechanical loss by spatter in pouring. The average pouring temperature was 1080° C.

On manganese bronze chips (40 per cent zinc), the furnace gave a net metal loss of 3.0 per cent, while the same lot of chips melted in oil-fired crucible furnaces in commercial practice gave 7.2 per cent loss.

Yellow brass chips (25 per cent zinc) gave 1.6 per cent net loss, red brass chips (10 per cent zinc), 1.0 per cent.

A fine concentrate (20 mesh) from brass furnace ashes obtained in the manufacture of brass of 80 per cent copper, 20 per cent zinc, analyzed 71.0 per cent copper and 14.3 per cent zinc, the balance being ash, etc., gave on melting in the furnace a recovery of 99 per cent of the copper and 50 per cent of the zinc in the concentrate. This material is usually sent to the smelter and refined in a reverberatory furnace, not all of the copper and none of the zinc being recovered.

Yellow brass ingot (25 per cent zinc) was remelted with 0.5 per cent loss. Red brass (10 per cent zinc) made up from red gates, scrap copper, yellow chips, lead, and tin was melted with 0.5 per cent loss.

Heavy German silver scrap (18 per cent nickel, 56 per cent copper, 26 per cent zinc), which gave 1.8 per cent loss on commercial melting in coke fires, was melted with 1.2 per cent loss.

Sound copper castings were made from metal melted in the furnace.

Red brass of 81.5 per cent copper, 8.5 per cent zinc, 6 per cent lead, 4 per cent tin, made up from red and yellow ingot and scrap copper, was melted in one series of tests with the following results, the furnace being cold at the start.

TABLE I

HEAT No.	Weight of Charge Lbs.	Time Arc was on Min	Pouring Temp. ° C.	Kw. Hrs. Used	Kw. Hrs. per 100 Lbs.
L 34	127.3	57	1140	40	30½
L 35	127.75	50	1180	30½	25
L 36	128.5	50	1220	26½	20½
L 37	126.5	37	1220	22½	17¾
L 38	129 5	36	1220	19	14¾
	Total 639.55	Av. 46	Av. 1200	Total 138½	Av. 21¾

The total elapsed time for the five heats, including charging and pouring, was 5 hours. 630.9 lbs. ingot were poured and 7.45 lbs. metal from spillings, etc., were recovered, giving a gross metal loss of 1.35 per cent and a net loss of 0.2 per cent.

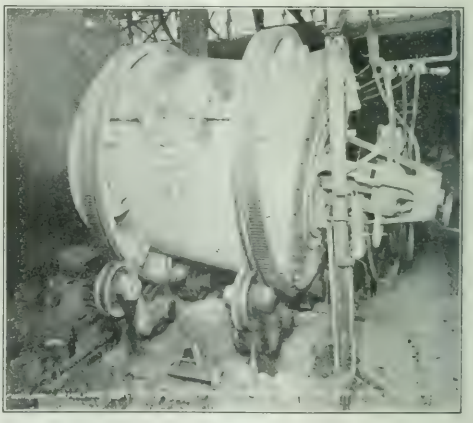


FIG. 1

The power consumption, at the rate of 430 kw. hrs. per ton on a 5-hour run, starting from the cold, and at the rate of 295 kw. hrs. per ton when the furnace is hot, with the metal heated to 1200° C., is surprisingly low for so small a furnace.

The results above show that the rocking furnace is a type capable of giving low metal loss and low power consumption. When the furnace was not rocked while melting alloys high in zinc, pressure built up within the furnace and zinc losses were high.

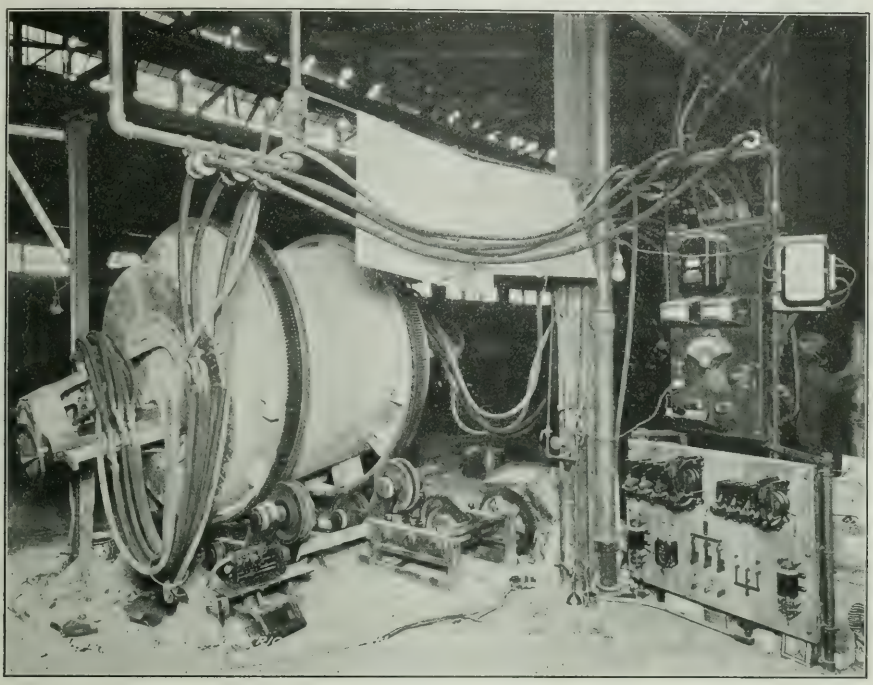


FIG. II

The laboratory tests having demonstrated the probable usefulness of the type, a furnace of commercial size was designed.

The Detroit Edison Company had long been interested in electric brass furnaces as a possible outlet for electric power, and offered to coöperate by constructing a rocking furnace for commercial test without expense to the Bureau of Mines except the salaries and expenses of its representatives while supervising the test.

Sketches of the furnace design were given the Detroit Edison Company, which refined the design, made the working drawings, constructed and erected the furnace.

The furnace is shown in Figs. I and II. The drum is 5 ft. in diameter by 5 ft. long. The lining is 12 in. thick, and consists of silocel brick on the outside, special heat-insulating brick in the middle layer, and corundite brick (a very refractory firebrick high in Al_2O_3) in the actual hearth lining. The hearth is 3 ft. long by 3 ft. in diameter, taking charges of 1300 lbs. and upwards. The electrodes are 4 in. diameter graphite, threaded for continuous feed, and are adjusted by screw-operated supports of the lathe-slide type. Single-phase, 60 cycle current, stepped down to 120 or 130 volts is used, 300 kv. amp. being available. Electrode adjustment is by hand, and to stabilize the arc an external reactance is used which brings the power factor of furnace plus reactance, measured at the furnace switchboard, to about 85. The open circuit voltage falls to about 106 to 116 volts under load. The current varies between 1000 and 2000 amperes, 1650 amperes being about the average. The power input can be varied by altering the length of the arc, and runs from 100 to 200 kw., averaging about 165 kw.

The flexible leads and the water hose for electrode cooling are given slack to allow rocking the furnace, as is clearly shown in Fig. II.

The rocking of the furnace during melting is automatically done by means of the control device shown, with cover removed, in the lower left-hand corner of Fig. II. This can be set to give a "safe rock" of 80°, the limit of motion being such that the metal just does not run into the spout. After the charge has begun to melt, the "safe rock" is started. It is called the "safe rock" because the angle is such that solid charge will not fall on the electrodes and break them. A complete oscillation on "safe rock" takes $13\frac{1}{2}$ seconds.

During the "safe rock" the solid metal is swashed about in the molten part of the charge and is tumbled over, so that fresh surfaces receive direct radiation from the arc. As melting goes on, the rocking angle is increased by turning the handle of the control device from time to time, until, when the metal is all melted, the furnace is on the "full rock" of about 200°. On "full rock" the metal washes the whole cir-

cumference of the hearth save the height of the charging door and a few inches above and below it, so that metal does not splash into the door joint. A complete oscillation takes $33^1/_2$ seconds.

The reversal of the 5 h. p. motor at either end of the rocking angle is done by contactors, operated by solenoids, actuated by the contacts on the control device.

When it is desired to depress the spout past the limiting point of the automatic rock, for pouring, the control device is switched out and the solenoids are operated by a reversing switch.

The furnace is installed at the plant of the Michigan Smelting and Refining Company, Detroit, Michigan, which makes brass ingot to customers' specifications from chips, scrap, and junk of various kinds, by means of strict chemical control. As the firm makes no sand castings, but ingot only, no observations on the comparative quality of metal melted in the electric furnace and in the coke fires were possible. All the metal melted was poured into ingot which went into the regular output of the plant. As far as could be told by analysis and appearance, the electrically-melted metal was of at least as good a quality as from the coke fires. On alloys high in lead there was somewhat less segregation than in the metal melted in crucibles, and on charges high in zinc, the zinc content of the metal from the electric furnace was higher than that from the same charges melted in the coke fires.

As there is generally much oil on the borings and some non-metallic material in the other scrap, the true metallic content of the charge is seldom accurately known. Hence the net metal losses cannot be exactly determined.

The metal losses were, therefore, compared with those of the coke-fired crucible furnaces operating on the same charge.

From 102 tons of metal melted in strict comparison with the crucible furnaces, the rocking electric furnace produced 3626 lbs. more metal from the same charge than the coke fires, or 1.8 per cent. The alloys melted ran from 90 to 66 per cent copper, 1 to 9 per cent tin, 1.5 to 26.5 per cent lead and 0 to 30 per cent zinc.

The comparative metal losses on a few alloys in the electric and the coke fires are given in Table II.

TABLE II

Composition Per cent Cu	Sn	Pb	Zn	Weight Charged Lbs	Per cent Loss (Metal, Oil, Dirt) Coke Fires	Per cent Loss (Metal, Oil, Dirt) Electric
85	5	5	5	6576	4.6	3.2
84	7	8	1	11600	7.0	3.7
84	6	10	0	14300	2.4	1.8
79	9	10	2	11790	3.6	2.1
78	2	10	10	15840	7.1	3.1
76	8	13	3	11805	4.0	2.4
73	4	20	3	14392	3.7	2.9
67.5	4	26.5	2	5224	3.0	2.4
67	1	2	30	7200	8.0	5.1

The rocking furnace gave alloys and analyzed very close to the calculated analyses, especially if the difficulty of calculating the analysis of a scrap charge is considered. Characteristic analyses are given in Table III.

There was no difficulty in draining the metal completely from the hearth, and alloys of different composition can be made one after the other without contamination by metal left in from the previous heat.

TABLE III

	Copper	Tin	Lead	Zinc
Sought	76	8	13	3
Electric	75.9	8.3	13.1	2.7
Sought	76	8	13	3
Electric	76.2	8	12.4	3.2
Sought	85	5	5	5
Electric	85.2	4.9	4.8	5
Sought	83	4	6	7
Electric	82.9	4.4	5.7	6.9
Sought	67	1	2	30
Electric	66.6	1	2	30.4
Coke	66.4	0.5	1.7	29.3
Sought	68	1	7	24
Electric	67.9	...	....	.
Coke	69.9	...	....	
Sought	60	...	3	37
Electric	59.7			

The power consumption on 10-hour operation, with no night heating, is shown in Table IV, which gives a résumé of 5 days' operation.

The power consumption on 24-hour operation is shown in Table V for a 4-day run.

On the basis of power, read on the high tension side of the transformer, per ton of metal poured, the power consumption on 10-hour operation was 336 kw. hrs. per ton, on red brass poured at 1180° C. average. For 24-hour operation, the figure is about 260 kw. hrs. per ton for red brass.

The electrode consumption was 16.3 lbs. while melting 21,660 lbs. of metal, or $1^1/_2$ lbs. per ton, equivalent to about 40 cents at present electrode prices. To this must be added the loss due to accidental breakage. There were nine breakages in melting 72 tons, four of which were due to the charge being so bulky that it fell against the electrodes when rocking started, and five to the electrodes being hit while bulky material was being charged. The design of the furnace has now been altered so as to allow the electrode tips to be withdrawn into the walls during the charging of bulky material. When an electrode does break, if nipple joints are used, the breakage is usually of the nipple only.

In the 24-hour tests tabulated in Table V, and in a 10-hour run just preceding the 24-hour runs, in which the 75.25 Cu, 7.5 Sn, 14.25 Pb, 3 Zn alloy was melted, there was charged, for the 75.25 Cu alloy,

Ingot	25200 lbs.	
Red borings	11200 lbs.	2 per cent oil = 224 lbs. nonmetallic
Medium brass	1540 lbs.	
Scrap Cu	10987 lbs.	
Scrap Pb	3906 lbs.	
Ingot Cu	552 lbs.	
Yellow borings	1400 lbs.	3 per cent oil = 42 lbs. nonmetallic
	54805	266

For the 86 Cu, 6 Sn, 10 Pb alloy there was charged

Ingot	16000 lbs.	
Cu	4704 lbs.	
Pb	96 lbs.	
	20800	
TOTAL CHARGE	75605 lbs.	
	266 lbs. nonmetallic	
	75339 lbs. metallic	

There was obtained

53841 lbs. good ingot 75.25 Cu
20149 lbs. good ingot 86 Cu

73990 total good ingot 1349 lbs. gross loss, or 1.8 per cent
63 lbs. scrap 75.25 Cu
43 lbs. scrap 86 Cu
300 lbs. metallics in 569 lbs. skimmings from 75.25 Cu } 53 per cent metallic in all skimmings by assay
130 lbs. metallics in 246 lbs. skimmings from 86 Cu
365 lbs. metallics in 429 lbs. ladle skulls from 86 Cu, 85 per cent metallic

74891 total metallic recovery, 448 lbs. net loss, or 0.6 per cent

In heats 256–313, on over 37½ tons melted, the electrode consumption, including all broken stubs and scrap, was slightly less than 2 lbs. per ton.

Since the operation was experimental, it is not yet possible to give exact figures on the life of a lining, but as nearly as can be estimated the relining cost for labor and material should be well under 50 cents per ton with a corundite lining, when melting red brass poured at 1150 to 1200° C. If only yellow brass poured at 1100° C., is melted, the lining cost will be still lower. If very hot bronze is to be produced, say at 1300° C., the roof and upper portions of the ends should be lined with zirkite brick.

Accurate temperature control is very easy in the rocking furnace, since at the end of a heat, after the "full rock," the walls are no hotter than the metal, and there is no heating up of the charge from hotter roof and walls when the power is shut off, as is the case with those types of furnace where the heat is reflected downward from the roof. After cutting off the arc, the temperature falls very slowly, about 2 to 3° C. per minute. By running the arc a minute or so every 10 or 15 minutes, a charge can be held at pouring temperature for an indefinite period.

One man can operate the furnace, with the aid of a helper while charging. Were automatic electrode control used, which could easily be done, one man could probably attend to two furnaces.

The output per man hour was greater from the rocking furnace than from the coke fires. The working conditions are much less severe and more healthful with the electric furnace than with the coke fires, and a man of less rugged physique than is required for coke fires can readily operate the rocking furnace.

Various modifications and improvements in design were made during the tests, and others that could not well be made on the first furnace are being incorporated in other furnaces of this type now being built for Detroit firms. The electrodes were at first introduced into the furnace directly through the refractory walls. When making yellow brass from new materials so that addition of much spelter is required, the zinc, vaporized during the addition of the spelter to the molten charge, tended to condense in the clearance between the electrode and the hole through which it entered. This would then freeze, solder the electrode in place, and cause breakage. Such trouble was later obviated by the use of graphite sleeves about the electrodes and by the proper arrangement and operation of the electrode coolers. It was also found feasible to charge the zinc with the rest of the charge instead of speltering at the end of the heat.

Comparing the cost of melting on a 10-hour schedule in the rocking electric furnace and in the coke fires of the plant at which the test was made, the sum of the cost per ton of charge for electric power, interest and depreciation, electrodes, linings, and for heating ladles, is just about one-half of the cost per ton of charge of the single item of crucibles at present prices and at present crucible life. The value of the metal saved by the electric furnace is about twice the cost of the coke used by the coke fires. Hence a huge saving is possible by electric melting under present conditions, and even at pre-war prices for crucibles, coke, and metal the rocking furnace will show a distinct though smaller saving. On 24-hour operation the balance in favor of electric melting is still more marked.

From data at hand on the power consumption of other types of electric furnaces, it appears that, when operated on the same alloy, heating it to the same temperature, and running the same number of hours per day, the rocking furnace is somewhat more efficient than the direct-arc, and unrocked indirect-arc types, very much more efficient than electric furnaces of types in which heat is reflected onto the charge from the roof, and very little less so than the induction furnaces. These conclusions follow not only from the data at hand, but from the method of application of heat in the various types, those with the source of heat at a distance from the charge being less efficient than those where the heat is developed close to the charge. The induction furnaces in which the heat is developed in the charge itself should be the most efficient. On account of the washing of the walls with the metal, the rocking furnace should theoretically come next to the induction type in thermal efficiency.

In magnitude of metal losses, the rocking furnace gives at least as good results as any other type of electric furnace. The only possible loss is from the stream of metal while pouring, as the furnace is sealed tight while running. Volatilization from the stream while pouring is of course about the same in all types of furnaces.

In closeness of control of the temperature of the melt the rocking furnace is superior to any save the induction type. In thorough mixing of the charge, the rocking type is about on the same plane as the induction type, and markedly superior to the other types, where, in large sizes, segregation in the bath may be a serious problem.

For example, the following shows the analysis for copper of the first ingot from the first ladle and of the last ingot from the last ladle, when melting 1200-lb. charges of 60 per cent Cu, 37 per cent Zn, 3 per cent Pb.

Heat No.	First Ingot, First Ladle Per cent Cu	Last Ingot, Last Ladle Per cent Cu
322	59.76	59.54
323	59.78	59.66

In ability to change from one alloy to another, it is superior to the vertical-ring induction type, and in ability to operate cheaply when used but 10 hours a day, without night heating, is ahead of the vertical-ring induction type and of the reflected-heat type.

The rocking furnace can handle alloys of any zinc or lead content, being superior on this score to direct-arc, unrocked indirect-arc, and induction types. The electrode cost compares favorably with other arc furnaces. With equal conditions of operation, and suitable refractories in each type, the cost of lining will probably be about the same as with most other types.

Labor cost should be about the same in all hand-regulated arc furnaces. With automatic regulation, which can be applied if desired, the rocking type should

TABLE IV TEN-HOUR OPERATION

DATE	Heat No.	Per cent Alloy Cu	Sn	Pb	Zn	Nature of Charge	Wt. of Charge Lbs.	Elapsed Time Hrs	Min	Sec. Kw. h. Arc	Kw. h. Motor	Total Sec. Power	Pouring Temp.	Weight Poured Lbs.	Primary Kw. h.	Secondary Kw. h./Cwt. Charged	Primary Kw. h./Cwt. Poured	REMARKS
Nov. 5	192	85	5	9	1	Average	1314	3	40	257	4	261	2000° F. 1095° C.			20	....	Furnace cooler than usual, not run previous two days. No. 192 includes 1 hr. 20 min., 100 Kw. hrs. preheat
	193	85	5	9	1	Average	1314	1	50	219	3	222	2050° F. 1120° C.			17		
	194	79	9	10	2	Little bulkier than average	1304	1	35	196	2	198	2125° F. 1165° C.			15		
	195	79	9	10	2		1304	1	30	190	2	192	2200° F. 1205° C.			14.5		
	196	79	9	10	2		1304	1	40	190	3	193	2200° F. 1205° C.			15		Time includes 20 min charging Heat No. 197
DAY TOTAL	5 heats						6540	10	15	1052	14	1066	2115° F. 1155° C.	6360	1162	16.3	18.3	
Nov. 6	197	79	9	10	2	Little bulkier than average	1304	1	45	235	3	238	2125° F. 1165° C.			18.5		
	198	79	9	10	2		1304	1	30	199	3	202	2175° F. 1190° C.			15.5		
	199	79	9	10	2	Little bulkier than average	1304	1	40	186	2	188	2250° F. 1230° C.			14.5		
	200	79	9	10	2		1304	1	40	176	2	178	2240° F. 1225° C.			13.5		
	201	79	9	10	2	Little bulkier than average	1304	1	30	162	2	164	2100° F. 1150° C.			12.5		
	202	79	9	10	2		1304	1	45	160	2	162	2125° F. 1165° C.			12.5		Time includes 20 min. charging Heat No. 203
DAY TOTAL	6 heats						7824	9	50	1118	14	1132	2185° F. 1195° C.	7571	1236	14.7	16.3	
Nov. 7	203	79	9	10	2		1304	1	35	215	3	218	2125° F. 1165° C.			17		
	204	79	9	10	2	Little bulkier than average	1304	1	40	195	2	197	2165° F. 1185° C.			15		
	205	79	9	10	2		1304	1	30	180	2	182	2175° F. 1190° C.			14		
	206	79	9	10	2		1304	1	35	173	2	175	2140° F 1170° C.			13.5		
	207	84	6	10	0	Very bulky	1304	1	40	165	2	167	2150° F. 1175° C.			13		
	208	87.5	5	0.5	7	Very bulky	1304	2	30	178	3	181	1950° F. 1065° C.			14		Includes 50 min. delay by broken electrode, broken in charging bulky charge, also 20 min. charging Heat No. 209
DAY TOTAL	6 heats						7824	10	30	1106	14	1120	2120° F. 1160° C.	7583	1210	14.4	16.0	
Nov. 8	209	84	6	10	0	Very bulky	1300	3	00	246	2	248	2050° F 1120° C.			19	....	Time includes 1 hr. 10 min. delay due to broken electrode caused by bulky charge Long delay due to nipple being over-size and requiring to be filed down
	210	84	6	10	0	Very bulky	1300	1	40	198	3	201	2175° F. 1190° C.			15.5		
	211	84	6	10	0	Very bulky	1300	2	05	188	2	190	2175° F. 1190° C.			14.5		Includes 25 min. adjusting electrode holder
	212	84	6	10	0	Very bulky	1300	1	30	169	3	172	2175° F. 1190° C.			13.5		
	213	84	6	10	0	Very bulky	1300	1	50	170	1	171	2175° F. 1190° C.			13		Includes 20 min charging No 214
DAY TOTAL	5 heats						6500	10	05	971	11	982	2150° F. 1175° C.	6341	1069	15.1	16.9	
Nov. 9	214	84	6	10	0	Very bulky	1300	1	45	223	4	227	2175° F. 1190° C.			17.5		
	215	84	6	10	0	Very bulky	1300	2	05	198	3	201	2200° F. 1205° C.			15.5		
	216	84	6	10	0	Very bulky	1300	1	00	195	2	197	2160° F. 1180° C.			15		
	217	84	6	10	0	Very bulky	1300	1	45	189	3	192	2250° F. 1235° C.			14.5		
	218	84	6	10	0	Very bulky	1300	1	25	165	2	167	2150° F. 1175° C.			13		
DAY TOTAL	5 heats						6500	8	50	970	14	984	2190° F. 1200° C.	6407	1073	15.2	16.7	

show a labor cost about the same as that of any other type.

From the electrical point of view of desirability of a steady load, the rocking furnace does not have so steady a load and hence, on this score, is not so desirable as the induction furnaces or granular resistor furnaces. It does not require special transformers, as the granular resistor type does. It lacks the electrical advantages of multi-phase furnaces. In very large sizes, two arcs could be used in the rocking type, but in sizes up to one ton, single-phase operation is required, and in a plant so located that the power supply must be of limited capacity, a single-phase arc furnace, with its fluctuating loads, may not be satisfactory from the electrical point of view. Such fluctuation is no drawback in Detroit nor would it be in most cities or large manufacturing towns.

From the results on furnaces of 125 and 1300 lbs. capacity, it appears that the rocking type can be built in a wide range of sizes without showing a great loss of efficiency in the smaller sizes. This type can doubtless be built in as large sizes as the brass industry could normally use.

In first cost, the rocking type should be no more expensive than other electric furnaces.

While further tests in different plants and under different conditions, which will be made at least in part, in the near future, are needed to give accurate

TABLE V—TWENTY-FOUR-HOUR OPERATION

DATE	Conseq. Heat No.	Day Heat No.	Weight of Charge Lbs.	Per cent Alloy Cu	Sn	Pb	Zn	Elapsed Time Hrs. Min.	Melting Time Hrs. Min.	Kw. h. Arc Plus Rocking Motor Read on Secondary Side	Equivalent Kw. h. on Primary Side	Pri. Kw. h. per Ton Charged	REMARKS
Apr. 30	261	1	1305	75.25	7.5	14.25	3	2 : 09	1 : 47	229	....	...	Started at 6 : 30 A.M. Furnace idle since 4 : 30 P.M., Apr. 29
	262	2	1305	75.25	7.5	14.25	3	1 : 53	1 : 28	192	....	...	
	263	3	1305	75.25	7.5	14.25	3	1 : 55	1 : 22	168	....	...	
	264	4	1305	75.25	7.5	14.25	3	1 : 44	1 : 15	152	....	...	
	265	5	1305	75.25	7.5	14.25	3	1 : 44	1 : 15	144	....	...	
	266	6	1305	75.25	7.5	14.25	3	2 : 12	1 : 2	141	....	...	30 min. (included in elapsed time) adding electrode sections and taking fresh grip
	267	7	1305	75.25	7.5	14.25	3	1 : 30	0 : 55	153	....	...	
	268	8	1305	75.25	7.5	14.25	3	1 : 35	0 : 58	156	....	...	
	269	9	1305	75.25	7.5	14.25	3	1 : 41	1 : 00	151	....	...	
Midnight	270	10	1305	75.25	7.5	14.25	3	1 : 33	1 : 02	146	....	...	
	271	11	1305	75.25	7.5	14.25	3	1 : 33	0 : 59	143	....	...	
	272	12	1305	75.25	7.5	14.25	3	1 : 47	1 : 06	149	....	...	
	273	13	1305	75.25	7.5	14.25	3	2 : 01	1 : 02	150	....	...	18 min. (included) replacing broken electrode nipple. End of heat at 5 : 40 A.M.
DAY TOTAL			16965					23 : 17	15 : 11	2074	2270	268	
May 1	274	1	1305	75.25	7.5	14.25	3	2 : 11	1 : 18	143	....	...	36 min. (included) wait for helpers to pour metal
	275	2	1305	75.25	7.5	14.25	3	1 : 49	1 : 12	147	....	...	
	276	3	1305	75.25	7.5	14.25	3	1 : 40	1 : 07	152	....	...	
	277	4	1305	75.25	7.5	14.25	3	1 : 35	0 : 55	147	....	...	
	278	5	1305	75.25	7.5	14.25	3	1 : 45	1 : 12	142	....	...	
	279	6	1305	75.25	7.5	14.25	3	3 : 00	1 : 20	160	....	...	1 hr. 10 min. (included) replacing broken electrode and altering cooling coil
	280	7	1305	75.25	7.5	14.25	3	1 : 32	1 : 02	151	....	...	
	281	8	1305	75.25	7.5	14.25	3	1 : 21	0 : 57	146	....	...	
	282	9	1305	75.25	7.5	14.25	3	1 : 19	0 : 53	145	....	...	
	283	10	1305	75.25	7.5	14.25	3	1 : 23	0 : 55	151	....	...	
Midnight	284	11	1305	75.25	7.5	14.25	3	1 : 31	0 : 56	152	....	...	
	285	12	1305	75.25	7.5	14.25	3	1 : 34	1 : 01	152	....	...	
	286	13	1305	75.25	7.5	14.25	3	1 : 20	0 : 48	141	....	...	
	287	14	1305	75.25	7.5	14.25	3	1 : 35	0 : 53	147	....	...	End of heat 5 : 20 A.M.
DAY TOTAL			18270					23 : 35	14 : 29	2076	2272	249	
May 2	288	1	1305	75.25	7.5	14.25	3	1 : 35	1 : 05	150	....	...	Heat started at 6 : 35 A.M. Furnace idle 1 hr. 25 min. between shifts
	289	2	1305	75.25	7.5	14.25	3	1 : 25	0 : 52	145	....	...	
	290	3	1305	75.25	7.5	14.25	3	1 : 25	0 : 57	143	....	...	
	291	4	1305	75.25	7.5	14.25	3	1 : 20	0 : 55	144	....	...	
	292	5	1305	75.25	7.5	14.25	3	1 : 35	1 : 02	144	....	...	
	293	6	1305	75.25	7.5	14.25	3	1 : 39	0 : 56	141	....	...	Much delay in pouring this heat, no helpers
	294	7	1300	84	6	10	0	1 : 31	1 : 04	140	....	...	
	295	8	1300	84	6	10	0	1 : 18	0 : 50	150	....	...	Between 294 and 295, furnace idle 45 min. at change of shifts
	296	9	1300	84	6	10	0	1 : 48	0 : 59	158	....	...	
	297	10	1300	84	6	10	0	1 : 22	0 : 52	151	....	...	
Midnight	298	11	1300	84	6	10	0	2 : 13	1 : 05	156	....	...	39 min. (included in elapsed time) replacing broken electrode
	299	12	1300	86	6	10	0	1 : 28	0 : 59	162	....	...	
	300	13	1300	84	6	10	0	1 : 37	1 : 10	179	....	...	
	301	14	1300	84	6	10	0	1 : 49	1 : 12	163	....	...	Heat ended at 5 : 20 A.M.
DAY TOTAL			18230					22 : 05	13 : 59	2126	2318	254	
May 3	302	1	1300	84	6	10	0	1 : 43	1 : 14	167	....	...	Heat started 6:45. Furnace idle 1 hr. 35 min. between shifts
	303	2	1300	84	6	10	0	1 : 43	1 : 22	158	....	...	Furnace idle 1 hr. between 302 and 303, operator in conference
	304	3	1300	84	6	10	0	1 : 55	1 : 09	158	....	...	Furnace idle 1½ hrs. between 303 and 304. Broke electrode charging 304, none on hand, wait for one from machine shop
	305	4	1300	84	6	10	0	1 : 44	1 : 17	159	....	...	25 min. patching electrode hole between 304 and 305
	306	5	1300	84	6	10	0	1 : 50	1 : 16	166	....	...	
	307	6	1300	84	6	10	0	1 : 35	1 : 10	162	....	...	
Midnight	308	7	1300	84	6	10	0	1 : 23	1 : 10	162	....	...	
	309	8	1300	84	6	10	0	2 : 15	1 : 05	165	....	...	42 min. delay (included) broke 2 electrode nipples charging
	310	9	1305	75.25	7.5	14.25	3	1 : 19	0 : 55	152	....	...	
	311	10	1305	75.25	7.5	14.25	3	1 : 14	1 : 00	140	....	...	
	312	11	1305	75.25	7.5	14.25	3	1 : 21	0 : 50	142	....	...	
	313	12	1305	75.25	7.5	14.25	3	1 : 36	1 : 13	144	....	...	Last ladle poured 6 : 35 A.M.
DAY TOTAL			15620					19 : 38	13 : 41	1875	2005	262	
4-DAY TOTAL			69085								8865	257	

data on the complete performance of the rocking type of furnace, it would seem from the results so far that it may be of distinct value in the brass industry, especially under present conditions as to crucible prices and quality, fuel supply and prices, and metal prices.

At the conclusion of the tests conducted by the Bureau of Mines, which covered over 300 heats, the experimental furnace was put on regular production by the Michigan Smelting and Refining Company. This company is having four one-ton rocking furnaces built, and two are under construction for the Electro Bronze Company, of Detroit.

The patents taken out by the Bureau of Mines on the rocking furnace have been assigned to the Secretary of the Interior as trustee, and free licenses to operate under them can be obtained by making application through the Director of the Bureau of Mines.

Grateful acknowledgment is made to Cornell University for use of the well-equipped Cornell electric furnace laboratory in the work on the laboratory furnace, to Dr. J. M. Lohr, formerly of the Bureau of Mines, for aid in the work on the laboratory furnace, to the Michigan Smelting and Refining Company for facilities for the test, and to the Detroit Edison Company, and particularly to Mr. E. L. Crosby of the latter firm, for never-failing coöperation.

A more detailed account of the tests of the rocking

furnace will soon be published as *Bulletin* **171** of the Bureau of Mines.

BIBLIOGRAPHY

ADVANTAGES OF ELECTRIC BRASS MELTING
E. F. Roeber, "Manufacture of Brass in the Electric Furnace," *Electrochem. and Met. Ind.*, **3** (1905), 4
G. H. Clamer and C. Hering, "The Electric Furnace for Brass Melting," *Trans. Am. Inst. Metals*, **6** (1912), 95
D. D. Miller, "The Electric Furnace for Heating Non Ferrous Metals," *J. Am. Inst. Metals*, **11** (1917), 352
C. A. Hansen, "Electric Melting of Copper and Brass," *Trans. Am. Inst. Metals*, **6** (1912), 110
BAILY FURNACE
T. F. Baily, "Annealing and Heat Treating of Steel and Melting of Non-Ferrous Metals in the Electric Furnace," *Met. and Chem. Eng.*, **17** (1917), 91
SNYDER FURNACE
F. T. Snyder, U. S. Patents 1,100,994 and 1,167,026
GENERAL ELECTRIC FURNACE
I. R. Valentine, U. S. Patent 1,242,375
RENNERFELT FURNACE
I. Rennerfelt, U. S. Patent 1,076,818
AJAX-WYATT FURNACE
G. H. Clamer, "Melting Brass in the Induction Furnace," *J. Am. Inst. Metals*, **11** (1917), 381
J. R. Wyatt, U. S. Patents 1,201,671, 1,235,628, 1,235,629 and 1,235,630.
NORTHRUP AJAX FURNACE
E. F. Northrup, "Production of High Temperature and Its Measurement," *Met. & Chem. Eng.*, **17** (1917), 685.
PINCH EFFECT
C. Hering, "A Practical Limitation of Resistance Furnaces, the 'Pinch' Phenomenon," *Trans. Am. Electrochem. Soc.*, **11** (1907), 329; **16** (1909), 255.
VOLATILITY OF ZINC IN BRASS
H. W. Gillett, "Brass Furnace Practice in the United States," Bureau of Mines, *Bull.* **73** (1914), 129
J. Johnston, "The Volatility of the Constituents of Brass," *J. Am. Inst. Metals*, **12** (1918), 15
ROCKING FURNACE
H. W. Gillett and J. M. Lohr, U. S. Patent 1,201,224
H. W. Gillett, U. S. Patent 1,201,225.

MORSE HALL
ITHACA, N. Y.

A SUMMARY OF THE PROPOSALS FOR THE UTILIZATION OF NITER CAKE

By JOHN JOHNSTON

Received April 1, 1918

Partly owing to the great shortage of sulfuric acid in Britain, partly in response to an appeal for suggestions made by the Ministry of Munitions, there has been considerable interest in the question of the disposal of niter cake (acid sodium sulfate). Similar interest in this matter will arise here, for there is already a shortage of sulfuric acid; it will consequently be necessary to economize in acid, and to substitute niter cake wherever such substitution is feasible.

Some time ago I made a search through all recent literature available[1] and compiled a summary of the various proposals which have been made for the utilization and disposal of niter cake; and it has been thought desirable to publish this summary as a means of showing the possibilities and arousing more general interest in this direction. Some of the proposals are obviously not very practical—even in war time; but it seemed better not to exclude a suggestion even although it does not appear feasible to us now.

Niter cake, a by-product of the production of nitric acid, is an acid sodium sulfate, usually containing only slight impurities. Its available sulfuric acid content ranges from 35 per cent downwards, but is usually from 25 to 30 per cent; this free acid may cause difficulties in handling and transportation, particularly if water, or even moisture, gets access to it. The annual production of niter cake in the United States was, according to the 1909 census, about 43,300 tons, of which 27,600 tons were reported to have a value of about $2 per ton, the remaining 15,700 tons being reported as of no value; the amount now available is, however, very much greater and is of the order of 600,000 tons at least. The utilization of this material in place of the equivalent quantity of sulfuric acid, in so far as such substitution is possible, would therefore result in a very appreciable economy of sulfuric acid, the demand for which is likely to be in excess of the supply available. The substitution of niter cake for acid would moreover, at the present time, result in a considerable money saving, for it can be bought at a price of about $3 per ton at the point of shipment, equivalent to an acid price of about $10 per ton.

As an example of the expansion of the use of niter cake in Britain since the war we may cite a paper by Kilburn Scott.[1] Before the war it was used to some extent for making hydrochloric acid and sodium sulfate, and a small amount was sold to fertilizer plants and to glass makers. It is now currently used in the following processes: the extraction of grease from wool suds and from piece scouring suds; refining of grease; stripping color from rags, dyeing of rags, and removing cotton from mixed fabrics in the manufacture of shoddy; calico bleaching; paper making; in the mineral water industry; and in making sulfate of ammonia. He also discusses the methods of handling and dissolving niter cake.[2]

Attention is therefore directed to the various proposals outlined below, in the hope that niter cake will be used, wherever feasible, as a means of reducing the shortage of acid. The proposals have, for convenience of reference, been grouped under a number of headings, but it is obvious that these several categories are not mutually exclusive.

AS A PICKLING AGENT—LeChatelier and Bogitch[3] discuss the advantages of using niter cake for removing scale from the surface of iron, and recommend a procedure for its use, namely, to work with a solution at 80° containing 25 per cent niter cake, the acidity of which is maintained by further additions of niter cake. Directions are also given in a recent paper.[4] The use of niter cake for pickling iron or steel is the subject of a patent granted to A. K. Eaton,[5] who claims the process of "removing hammer scale from iron and steel, which consists in subjecting the scale-coated metal to the action of a bath containing sodium bisulfate." It is reported that a large tonnage is already used for this purpose, thus releasing an equivalent amount of acid for other purposes.

H. W. Brownsdon[6] discusses its application in the pickling of annealed brass and states that it works

[1] In the literature citations given subsequently, reference to C. A., in addition to the journal reference, signifies that the original article was not available and that the statements made are on the basis of the abstract in *Chemical Abstracts*.

[1] "Economy of Acids in Metal Trades," *J. Soc. Chem. Ind.*, **36** (1917), 810.

[2] *J. Soc. Chem. Ind.*, **36** (1917), 1216A.

[3] *Rev. Metall.*, **12** (1915), 949; *C. A.*, **10**, 2460.

[4] "Pickling with Niter Cake," *Iron Trade Review*, **1918**, 153. I have been informed that solutions of one half the concentration recommended by LeChatelier and Bogitch are perfectly satisfactory for pickling metals.

[5] U. S. Patent 702,050, June 10, 1902, "Method of Removing Scale Oxide from the Surface of Iron and Steel."

[6] *J. Soc. Chem. Ind.*, **36** (1917), 575.

all right provided that (*a*) the acid strength of the solution is kept up to 5–6 per cent, (*b*) the solution is kept hot, (*c*) matters are so arranged that the work is as clean as possible. The niter cake solution is more sluggish than a sulfuric acid solution of equal acidity, and the difference in price (in England, acid $20, niter cake $5 per ton) on the basis of acid content is not marked. There is therefore no marked direct saving of money by using niter cake for pickling; but Brownsdon considers that the use of niter cake would make better design of annealing furnaces imperative, and so might indirectly result ultimately in considerable economies.

IN THE TEXTILE TRADE—According to a report[1] experiments have shown that niter cake may be substituted for sulfuric acid in various operations of the textile trade; for instance, in the extraction of grease from liquors obtained in scouring, in the refining of grease, the extraction of cotton from mixed rags in the making of shoddy,[2] as well as in stripping color from rags in the latter trade. For these purposes the salt is dissolved in water by the aid of steam and used hot. Hannay[3] states that it can be used as a sour in cotton bleaching. Matos[4] states that in the dyeing of wool niter cake may advantageously replace the mixture of Na_2SO_4 and H_2SO_4, though, since it may be contaminated with some iron, it is less suitable for the light shades.

In the textile trade, moreover, there is (in Britain) a great demand for Epsom salts ($MgSO_4$) which may be made by heating magnesite with niter cake.[5]

AS A SIZING AGENT FOR PAPER—According to a published statement[6] perfect sizing may be secured by using half the usual quantity of alum with 20 per cent niter cake. Haas[7] states that ordinary niter cake is only good for sizing the lower grades of paper, but that the purified salt should be used for the finer grades. Sindall and Bacon[8] also discuss this question and state that 100 parts of rosin require 24 parts $NaHSO_4$ for complete precipitation.

IN THE PRODUCTION OF AMMONIUM SULFATE—In response to a memorandum issued by the British Ministry of Munitions, the Sulfate of Ammonia Association recommend that it be used as a temporary expedient, the maximum proportion of niter cake to be 10 per cent of the sulfuric acid used, and that the solution be kept hot. The use of a greater proportion of niter cake results in the precipitation of Na_2SO_4 and in irregular working of the bath.[9] According to a recent patent,[10] niter cake dissolved in water is treated with excess of gaseous ammonia, after which the solution is saturated with carbon dioxide, and the precipitated sodium bicarbonate washed and dried; the mother liquor, neutralized by the addition of niter cake solution, is diluted and cooled to or below 0° in order to separate sodium sulfate, and the residual solution is concentrated *in vacuo* or otherwise to recover the ammonium sulfate.

IN THE MANUFACTURE OF FERTILIZERS—Strickler[1] digests phosphate rock with a solution of niter cake, concentrates the resulting solution, and cools to crystallize the Na_2SO_4 and separate it from the phosphoric acid. Kochetkov[2] treated phosphate rock with niter cake, dissolved the product in water, evaporated until the Na_2SO_4 crystallized out and concentrated; the resulting solution contained 2 per cent P_2O_5 and readily attacked bone meal, yielding superphosphate.[3] Wakefield[4] states that he has made many thousands of tons of superphosphate of lime containing 20 per cent of soluble phosphate by using niter cake instead of sulfuric acid. Collins[5] suggests mixing one part of leather clippings with two parts niter cake and heating to 300°, when much of the nitrogen is converted into ammonium sulfate; the product is cooled and mixed with one part of rock phosphate, and sold as fertilizer. Some proportion of niter cake could also be used in the fertilizer industry by dissolving it in the sulfuric acid, diluted appropriately.

FOR THE PRODUCTION OF SULFURIC ACID—Benker[6] mixes niter cake with fine sand, or finely divided silicate, or anhydrous sulfates of soda, potash, or lime, in such proportions that the mass does not melt when it is heated. Sulfuric acid is expelled and may be collected; Na_2SO_4 remains behind. The purpose of such admixtures is to minimize the rate of destruction of the apparatus, which takes place rapidly when niter cake is heated alone; but it is questionable in how far Benker's method is really feasible. Zahn[7] claims the process of mixing niter cake with 6 to 7 per cent water, heating, and so expelling part of the sulfuric acid, until the mass becomes pasty, when it can be introduced into a muffle and calcined. The Soc. Dior fils[8] mixes it with bauxite or aluminum sulfate, and heats the mixture in a muffle so as to liberate acid; the residue when extracted with water yields an alkaline carbonate. They also specify the addition of coke dust to the mixture before calcining. Prudhomme[9] claims the process of heating sulfates, with or without the addition of silica, alumina, or iron oxide, in an electric furnace; with the simultaneous formation of anhydrous bases. Nibelius[10] claims the process of recovering sulfuric acid and sodium sulfate from niter cake by treating it with a volatile

[1] *Chem. Trade J.*, **58** (1916), 28; *C. A.*, **10**, 953.

[2] Fort, however [*J. Soc. Dyers Colourists*, **30** (1914), 228; *C. A.*, **9**, 1120], concludes that sodium sulfate injures the luster of wool by reacting with the wool fiber

[3] *J. Soc. Dyers Colourists*, **32** (1916), 65; *C. A.*, **10**, 2151.

[4] *Textile World J.*, **51** (1915), 25; *C. A.*, **10**, 2046.

[5] *J. Soc. Chem. Ind.*, **34** (1916), 1121.

[6] *Papier Ztg.*, **40** (1915), 890; *C. A.*, **9**, 3129.

[7] *Chem. Ztg.*, **40** (1916), 571; *C. A.*, **10**, 2635.

[8] *Paper Makers' Monthly J.*, **54** (1916), 202; *C. A.* **10**, 2799.

[9] *Chem. Trade J.*, **58** (1916), 342; *Chem. News*, **113** (1916), 175; *J. Gas Lighting*, **134** (1916), 74; *C. A.*, **10** (1914), 1705. Compare also Cooper, *Chem. Trade J.*, **58** (1916), 235; *J. Gas Lighting*, **133** (1916), 523; *C. A.*, **10**, 1422, and Gavin, *Gas World*, **65** (1916), 539; *J. Gas Lighting*, **136** (1916), 545; *C. A.*, **11**, 535.

[10] Soc. ind. de produits chimiques, British Patent 109,814 (1917)

[1] U. S. Patent 917,502 (1909); *C. A.*, **3**, 1804.

[2] *Ann. Inst. Agron. Moscow*, **19**, 60; *C. A.*, **8**, 392.

[3] Compare also Petriturin, *Ann. Inst Agron. Moscow*, **19**, 142; *C. A.*, **8**, 194.

[4] *J. Soc. Chem. Ind.*, **34** (1916), 1121.

[5] *Ibid.*

[6] German Patents 204,353 (1906), 204,703 (1907), French Patent 381,863 (1906), British Patent 1,844 (1907), U. S. Patent 899,284

[7] U. S. Patent 921,329 (1909); *C. A.*, **3**, 2040; French Patent 389,898.

[8] French Patent 417,846.

[9] French Patent 400,030

[10] U. S. Patent 873,070 (1907); *C. A.*, **2**, 1199

solvent, such as alcohol, to dissolve out the acid, separating the solution from the undissolved Na_2SO_4, and distilling off the solvent. Uebel[1] exposes niter cake in a finely divided state to the action of hot gases or superheated steam, in a tower, the bottom of which is a calcining hearth. Mackenzie[2] treats niter cake to expel the H_2SO_4 in a salt-cake furnace by first heating the charge in a pot and, when it stiffens, transferring it to a roaster; the vapors from the two stages are absorbed in suitable towers. He states[3] that he has recovered 10 to 12 tons of 94 to 95 per cent acid a week from this source and that there is no trouble in obtaining 700 to 800 lbs. acid and 1200 to 1300 lbs. Na_2SO_4 from each ton of niter cake. Byard[4] proposes the following schemes: (1) Blowing steam or air into the melt and directing the mixture of acid vapors into the sulfuric acid plant. (2) Granulating the melt by pouring it into water and centrifuging to obtain clean Na_2SO_4 and an acid mixture, which can be sprayed into a chamber of an auxiliary acid plant, the acid so obtained being concentrated and used again to make nitric acid, in which process the presence of a little $NaHSO_4$ in the acid is unimportant. In this connection it may be mentioned that Claessen[5] claims the process of briquetting Chile nitrate with 10 per cent ground niter cake.

It is suggested[6] that niter cake be roasted with iron scale to expel the available acid in concentrated form; this requires a high temperature, and the action on the vessels employed is considerable. Llewellyn and Spence and Sons[7] heat niter cake with iron or pyrite, when SO_2 is evolved, leaving a residue from which Na_2SO_4 may be extracted. Stanes and Rogé[8] claim to obtain vitriol by roasting sulfur with twice its weight of niter cake; they also suggest[9] heating niter cake with sulfur in a non-oxidizing atmosphere and utilizing the sulfur dioxide produced. The suggestion has also been made that niter cake be heated with silica alone or mixed with calcium sulfate, the SO_3 produced being passed to a contact plant, the residue to be utilized in the manufacture of glass.[10]

FOR THE PRODUCTION OF Na_2SO_4 (SALT CAKE, GLAUBER SALT)—Most of the possible uses of niter cake yield Na_2SO_4 as a possible by-product; the following specific proposals have also been made. The niter cake is ground and mixed with the proper quantity of common salt; or, better, the still liquid material is run from the nitric acid still into a hot salt-cake pan already containing the requisite quantity of salt. This process for salt cake has been worked on a considerable scale in England, but would hardly be economical here in general. Some patents dealing with this general process follow: Hart[11] and the General Chemical Company[1] introduce a mixture of common salt and niter cake by means of steam into a revolving cylinder, heated almost to redness; the sulfate formed is stated to be free from both free acid and from chloride. In a recent communication Hart[2] proposes to dissolve the cake in water to a solution of density 1.35 and to blow cold air through this solution contained in well-insulated vessels; by this means a pure salt cake containing less than 0.25 per cent free acid, and a solution containing mainly free acid, may be obtained. Meyer and Oehler[3] carry out the reaction between salt and niter cake in an ordinary muffle furnace, and state that no stirring is required if proper conditions are maintained; namely, that the temperature should not exceed 500°, the mass being merely sintered; this process was worked for some time, but was later abandoned. The Verein Chem. Fabriken at Mannheim[4] have patented a mechanical salt-cake furnace, which has proved very efficient in working up niter cake; this furnace has done good work for some years, according to Lunge. The Solvay Process Company[5] grinds niter cake and alkaline soda products in the proper proportion, and heats the mixture above 125°. Pennock[6] mixes niter cake with a combining proportion of soda ash (Na_2CO_3) and a little water, and dries the product. Ramage[7] claims a similar, but more complicated process. Rommenholler and Lohman[8] mix niter cake with coke dust and ignite the mixture in a muffle; they employ the sulfate as such, or convert it into sulfide and decompose this with CO_2. Haack[9] mixes niter cake with common salt and coal, and distils the mixture in a muffle, obtaining sodium sulfide and HCl. The Chemische Fabrik Grünau[10] mixes niter cake with 12 per cent sawdust and 2 per cent coke dust, and heats in a cast-iron retort provided with a stirring arrangement; thus obtaining neutral sulfate and SO_2. The Nobel Explosives Company[11] add to the liquid bisulfate as it is drawn off from the nitric acid plant, a carbonaceous substance, such as sawdust, peat, or the like, which yields large quantities of gas; the mixture sets on cooling to a very porous mass which can be calcined for the production of Na_2SO_4 without melting.

The Phoenix Fabrik[12] claims the process of mixing the molten $NaHSO_4$ with the appropriate quantity of pulverulent oxides, hydroxides, or carbonates of the alkaline earths (which form difficultly soluble sulfates) and separating the resulting sulfates by a crystallization process. Herbert[13] dissolves niter cake in water, runs it into a lead-lined vessel provided with a stirring arrangement, and adds ground limestone;

[1] German Patent 226,110.
[2] British Patent 13,907 (1915); *C. A.*, **11**, 526.
[3] *J. Soc. Chem. Ind.*, **34** (1916), 1121.
[4] *Ibid.*, **34** (1916), 1121.
[5] British Patent 6,102 (1915); *J. Soc. Chem. Ind.*, **33** (1915), 1009.
[6] *J. Soc. Chem. Ind.*, **34** (1916), 1121.
[7] British Patent 103,689 (1916); *C. A.*, **11** 1732.
[8] British Patent 29,254 (1913); *J. Soc. Chem. Ind.*, **33** (1915), 227.
[9] British Patent 18,605 (1914); *J. Soc. Chem. Ind.*, **33** (1915), 961.
[10] See Morgan, *Econ. Proc. Roy. Dublin Soc.*, **2** (1917), 238; through *J. Soc. Chem. Ind.*, **36** (1917), 504.
[11] U. S. Patent 698,704.
[1] British Patent 9,875 (1902).
[2] THIS JOURNAL, **10** (1918), 238.
[3] British Patent 2,856 (1902); U. S. Patent 702,877; German Patent 186,398; *Chem. Ztg.*, **1906**, 1295.
[4] German Patent 137,906; British Patent 16,207 (1902).
[5] U. S. Patent 870,746.
[6] U. S. Patent 922,031 (1909); *C. A.*, **2**, 2040.
[7] U. S. Patent 871,066; *C. A.*, **2**, 1059.
[8] German Patent 63,189.
[9] German Patent 126,601.
[10] British Patent 6,898 (1904).
[11] British Patent 24,604 (1913); *C. A.*, **9**, 1228; French Patent 464,097 (1913); *C. A.*, **8**, 3225.
[12] Austrian Patent 700–12 (1912); *C. A.*, **7**, 1589.
[13] German Patent 28,769.

the CO_2 evolved is collected, the gypsum is filtered off, and the solution evaporated until the Na_2SO_4 crystallizes out. Grossmann[1] claims the process of obtaining niter cake in a porous, friable form which may be readily ground, by adding to the molten material a carbonate such as Na_2CO_3, or any substance which evolves gas or vapor, with or without a diluent such as Na_2SO_4. Barbier[2] has patented the process of cooling a solution of niter cake of density 1.4 down to about 10°, when crystals of Glauber salt separate, and describes suitable apparatus for the purpose. Grossmann[3] treats a solution of $CaSO_3$ with niter cake and after filtration obtains a solution containing mainly NaOH and Na_2SO_4; the Na_2SO_4 is crystallized out and the final liquor used as caustic soda. He obtained, from 100 tons niter cake, 36 tons pure Na_2SO_4 and 15 tons caustic soda; costs of production are discussed. Chatfield[4] uses a solution of niter cake to absorb ammonia from gas liquor, etc., and crystallizes out ammonium sulfate and sodium sulfate. Hipp[5] dissolves the niter cake, precipitates the heavy metals by means of an alkaline sulfide, evaporates the solution, mixes with common salt and ignites. White[6] uses it in the manufacture of soda alum. Collins[7] suggests roasting potash feldspar with niter cake and crystallizing out the alum.

It is reported that in Canada niter cake is now being used to make sulfate pulp, on account of the shortage of the sulfur hitherto used for making sulfite pulp.

FOR THE PRODUCTION OF MISCELLANEOUS SUBSTANCES—In several of the above processes, hydrochloric acid is obtained; likewise when niter cake is heated with calcium chloride, a process which yields gypsum as a by-product. According to Hart,[8] hydrochloric acid made from niter cake always contains some sulfuric acid and often contains nitric acid and iodine. Kerr has patented[9] the process of producing hydrochloric acid, magnesium sulfate and sodium sulfate by heating to 200° a mixture of about 2 parts niter cake and 1 part magnesium chloride, draining off the hydrochloric acid thereby produced, and separating the sulfates by crystallization. Magnesium sulfate may also be made by stirring hot niter cake into magnesite or dolomite, forming a spongy mass from which the sulfate may be extracted with water and crystallized.[10] Bouchard-Praceig[11] and Rollo[12] propose the employment of niter cake as a means of decomposing solutions of bleaching powder, thus obtaining free chlorine and gypsum. Cheeseman[13] claims the process of using it, after neutralizing, by making it react with barium hydrosulfide to produce blanc fixe ($BaSO_4$) and sodium hydrosulfide. Naef[14] suggests neutralizing the free acid, reducing the sulfate by means of fine coal at a red heat, and crystallizing the product. A similar scheme has been patented by the Verein Chem. Fabriken.[15] Parker[16] proposes to neutralize a solution of niter cake with iron, and then to treat with sodium carbonate or hydroxide.

Grossmann[17] proposes to utilize it in the production of an extra quantity of nitric acid by mixing it with niter and charcoal and heating the mixture under suitable conditions.

Its use has also been suggested for the following purposes: To increase the extraction of copper when roasting copper pyrites by charging it into the lower doors of a multiple hearth furnace; alone, or with salt, in the roasting of ores; to replace sodium carbonate in opening up tungsten ores; as a source of acid for leaching copper, zinc, or other metals, in the preparation of sulfates from scrap metal; for converting chromate into dichromate; for the liberation of phenol from its sodium salt in the process of manufacture of phenol; in laundry work, to replace some of the weak acids now used; in reclaiming rubber from scrap; in the refining of petroleum; in the making and glazing of slag bricks; as a weed killer; for flushing drains; and as a possible means of keeping down flies by sprinkling it on manure heaps.

In conclusion, it may be pointed out that the best mode of using a solution of niter cake for any particular purpose could be ascertained from the appropriate solubility data; this involves the investigation, throughout a range of temperature, of the three-component system Na_2SO_4–H_2SO_4–H_2O, and of four-component systems such as Na_2SO_4–H_2SO_4–$FeSO_4$–H_2O, investigations which would not be difficult to carry out with the needful accuracy,[18] and would be of scientific interest as well as of technical importance at the present time.[19]

AMERICAN ZINC, LEAD AND SMELTING COMPANY
ST. LOUIS, MO.

[1] British Patent 110,405 (1916).
[2] British Patent 10,450 (1902).
[3] British Patent 12,832 (1915); *C. A.*, **11**, 878; *J. Soc. Chem. Ind.*, **35** (1916), 155; *C. A.*, **10**, 1408.
[4] British Patent 19,530 (1893).
[5] U. S. Patent 726,533 (1903).
[6] U. S .Patent 714,846 (1903).
[7] *J. Soc. Chem. Ind.*, **34** (1916), 1121.
[8] THIS JOURNAL, **10** (1918), 238.
[9] U. S. Patent 1,203,357 (1916); *C. A.*, **11**, 88.
[10] From *Rev. des prod. chim.*, cited in THIS JOURNAL, **10** (1918), 228
[11] French Patent 221,245.
[12] British Patent 6,898 (1904).
[13] U. S. Patent 714,145 (1902).

CHEMICAL TESTS FOR THE DETECTION OF RANCIDITY

By ROBERT H. KERR
Received March 7, 1918

Numerous tests have been proposed for the recognition of rancidity. None of them seem, however, to have found any wide-spread application. This may be ascribed to two causes: first, there is considerable confusion of ideas as to exactly what is meant by the term rancidity; and second, once a fat has become definitely rancid, its condition is so clearly evident that no chemical test is needed to recognize it.

While it is true that the recognition of rancidity by taste and odor is so easy that there is no need for the use of chemical tests in the case of fats which have definitely become rancid, there are yet many cases

[1] *J. Soc. Chem. Ind.*, **34** (1916), 1121.
[2] German Patent 231,991 (1909); *C. A.*, **5**, 2709.
[3] British Patent 24,639 (1903).
[4] *J. Soc. Chem. Ind.*, **36** (1917), 1035.
[5] Some data on the above system are presented by Le Chatelier and Bogitch, *Rev. métall.*, **12** (1915), 949, who find that a double salt, Na_2SO_4.$FeSO_4$.$2H_2O$, separates under certain conditions.
[6] Work along this line is in progress under the direction of Professor H. W. Foote, of Yale University.

in which a reliable chemical test may prove of value. If the fat has a strong natural odor, or has absorbed an odor by reason of contact with an odoriferous substance, the recognition of the early stages of rancidity may well be interfered with. Mixing of the rancid fat with a fresh fat, particularly if the latter has a strong natural odor, may serve to disguise its condition long enough to permit the marketing of an unfit fat for food. Manufacturers, refiners, dealers, and large users might find it of great advantage in many cases to be able to recognize the onset of rancidity before it became evident to the senses of taste and smell.

Rancidity is a chemical change in the fat due to the action of oxygen. Its development and progress are accelerated by certain accessory factors, notably light, heat, presence of moisture, and contact with certain metals, but oxygen is absolutely essential. Without oxygen there is and can be no rancidity. The reactions involved appear to be complex. The products formed are numerous, and subject to variation, both with the character of the fat and the stage of rancidity. It is not the present purpose to discuss the products formed, but it may be stated that aldehydes, ketones, and acids of less molecular weight than those originally present appear to be constant constituents of rancid fats. Most, if not all, of the chemical tests proposed for the recognition of rancidity depend on the presence of one or all of these classes of bodies, and it is to such bodies that the characteristic odor and taste of rancid fats are due.

Two of the many tests proposed for the detection of rancidity have been studied in the Meat Inspection Laboratory of the Bureau of Animal Industry at Washington, D. C., and both have been found to be of use. These two are the phloroglucin-hydrochloric acid, color reaction of Kreis, and the "oxidizability value" of Issoglio. A modification of the Kreis test has been found to be of greatest value in judging fats suspected of rancidity.

The Kreis test[1] consists in shaking the fat with strong hydrochloric acid and a .1 per cent solution of phloroglucin in ether. If the fat is rancid a red or pink color is developed, the depth of color being proportional to the degree of rancidity. Kreis ascribed the reaction to the presence of aldehydes and ketones in the rancid fats.

Winckel[2] investigated the Kreis test and condemned it on the following grounds: first, that it is not specific, being given by other aldehydes and ketones than those which occur in rancid fats; second, that the depth of color is not exactly proportional to the degree of rancidity; and third, that the test is far too delicate to be used as a means of distinguishing sound from rancid fats.

The Kreis test has been given a very thorough study in the Washington Meat Inspection Laboratory. The difficulty experienced in dealing with fats in which rancidity is present but the characteristic taste and odor masked by "off" or offensive odors and tastes due to other causes and in distinguishing between such fats and similar fats which were not rancid, made the need for a chemical test acute. The Kreis test was chosen as the most promising of the chemical tests described in the literature and was given a thorough and careful study. The results of this study confirmed the objections raised by Winckel and also disclosed the fact that some oils, notably crude cottonseed oil, contain bodies which cause them to give the test when in a perfectly sweet condition. Nevertheless, a field of usefulness was found for the test in dealing with samples in which the characteristic odor and taste of rancidity were obscured. Samples of this character can be definitely and accurately classed as rancid or not rancid by the use of the Kreis test. The test has been in regular use since 1909 for this purpose and for confirmation of judgment based on physical evidence and has been found to be valuable and reliable when used with strict regard to its limitations. As a result of experience and testing against many hundred samples, both of known and unknown character and condition, the following statements regarding the test may be made:

1—All rancid fats react to the Kreis test.

2—The intensity of the reaction is roughly but not exactly proportional to the degree of rancidity.

3—Fresh, sweet fats do not give the reaction except in certain special cases. Such a case is that of crude cottonseed oil which reacts with great intensity. In this case the substance which causes the reaction is removed by refining with caustic soda.

4—The Kreis test is too delicate to be used alone as a criterion of rancidity. If all fats which react were to be pronounced rancid many samples which are not rancid in any sense would have to be condemned as rancid.

5—The Kreis test is not specific for rancid fats. It is given by aldehydes and ketones, other than those which occur in rancid fats, by most of the essential oils, by crude cottonseed oil and probably by other crude oils.

In making use of the Kreis test for the detection of rancidity, it is necessary to guard against a reaction due to the presence of any reacting substance, other than those due to rancidity. If such a substance is present any conclusion drawn from a positive reaction is worthless. While the necessity of guarding against this source of error limits the use of the test to some extent it does not greatly affect its value, as all of the animal fats and all refined vegetable oils are free from reacting substances. These are exactly the classes of fats most likely to become rancid and most likely to required laboratory examination to determine rancidity.

The extreme sensitiveness of the Kreis reaction is not wholly a drawback. It enables one to predict the appearance of rancidity before it becomes evident to the senses. When a fat becomes rancid it undergoes certain definite changes which follow one another in orderly sequence. The time required to pass through each stage is variable and depends on several factors, but the different stages are always the same. The appearance of the Kreis test marks the beginning of an early stage of incipient rancidity and gives warning of the onset of rancidity some time before the changes have progressed to such a point as to be evident to the senses. Under most conditions the interval of

[1] *Verhandlungen der Naturforschenden Gesellschaft in Basel*, **15** (1903-4), 225.

[2] *Z. Nahr. und Genussm.*, **9** (1905), 90.

time between the first appearance of the Kreis test and the appearance of sensible rancidity is sufficient to permit the conservation of the product by immediate use. The practical utility of this is evident.

In the use of the reaction as a criterion of rancidity, however, its extreme sensitiveness becomes a drawback. If all fats which give a reaction are to be condemned as rancid, a great many of which are not rancid in any true sense of the word must be condemned. At the same time it has been found that any fat which gives a positive Kreis test but does not have a rancid smell or taste, is in a state of incipient rancidity, and that the characteristic physical signs will soon develop. For these reasons, the use of the Kreis tests is chiefly limited to the confirmation of suspicions of rancidity based on taste and odor and to reaching a definite decision in those cases in which the odor and taste of rancidity are masked by other odors and tastes. It has proved of great value in this connection. In applying the test to practical use it was found desirable to find a means of judging its intensity. After considerable work, a method was devised and tried out. Trial of this method led to several changes and improvements. The method now in use in the Meat Inspection Laboratories of the Bureau of Animal Industry is based on the original method of the writer and has been modified as a result of suggestions made by Mr. C. H. Swanger and Mr. C. T. N. Marsh of the Meat Inspection Laboratories of the Bureau of Animal Industry located at New York, N. Y., and St. Louis, Mo. The method as now used is as follows:

10 cc. of the suspected oil or melted fat are placed in a large test tube (8 × 1), and 10 cc. of strong HCl (sp. gr. 1.19) added. The tube is closed with a rubber stopper and shaken vigorously for approximately 30 sec. Ten cc. of a 0.1 per cent solution of phloroglucin in ether are then added and the tube closed and shaken as before. It is then allowed to stand. If the fat is rancid, a red or pink color will appear in the acid layer. The depth of this color is roughly but not exactly proportional to the degree of rancidity. To determine the intensity of the reaction the original fat is diluted with kerosene or with an oil or fat which does not react and the intensity judged by the degree of dilution at which a reaction ceases to be observed. In judging this point a recognizable red or pink shade is regarded as a reaction; a faint orange or yellow is not. The intensity of the reaction is reported in terms of the highest dilution at which a reaction is obtained. For example, if a fat is found to react when so diluted that there is 1 part of the fat in 20 parts of the mixture but not in higher dilution, it is reported as reacting in dilution 1 to 20.

In the work of the Washington Meat Inspection Laboratory it is the custom to make two dilutions, one containing 1 part of the suspected fat in 10 parts of the mixture and one containing 1 part of fat in 20 parts of the mixture. Fats are thus divided into four classes as follows:

Class 1—Fats giving no reaction.

Class 2—Fats giving a reaction when undiluted, but no reaction in dilution 1 to 10.

Class 3—Fats giving a reaction in dilution 1 to 10 but none in dilution 1 to 20.

Class 4—Fats giving a reaction in dilution 1 to 20.

Class 1 represents fresh sweet fats. Fats of this class are fit for any use and may be expected to withstand severe exposure before becoming rancid. Class 2 represents fats which have not yet become rancid to taste and smell, but in which those changes which will later manifest themselves as rancidity are already in progress. Class 3 represents a late stage of incipient rancidity. Fats of this class are well advanced on the road toward rancidity and their condition is usually evident to the senses of taste and smell. Class 4 represents fats which have definitely become rancid. One who is familiar with the taste and odor of rancid fats has but little need for chemical tests when dealing with this class.

Kerosene has been found most convenient for use as an indifferent oil for diluting. Some kerosenes have, however, been found which gave red or yellow colors. To avoid error on this account it is recommended that each lot of kerosene be tested and, if necessary, purified. The following method of purification has been found effective:

2000 cc. of kerosene are shaken vigorously in a large separatory funnel with 50 cc. of HCl (sp. gr. 1.19). After separating, the acid is drawn off, a fresh portion of 50 cc. added and shaken again. After separating, the kerosene is shaken with a third portion of the acid. A few drops of the phloroglucin solution used in the test are added before the third shaking. If the separated acid shows a red color it is drawn off and the shaking with successive portions of acid continued until the separated acid ceases to show red. The kerosene is then washed three times in the separatory funnel with 500 cc. of warm water. After the last washing it is allowed to stand some time in a warm place and the last portions of separated water carefully drawn off. It is then transferred to a large beaker and heated to approximately 80 to 90° C., 50 g. of fuller's earth are then added, with stirring, and the oil held at 80 to 90° C. with stirring for 5 min. The fuller's earth is then removed by filtration. Kerosene purified in this way is completely indifferent in the Kreis test and will remain so.

The "oxidizability value" test of Issoglio[1] depends on the presence in rancid fats of volatile organic bodies which are separated by distillation with steam and estimated by titration with a standard solution of potassium permanganate. These substances are produced by oxidation of the fat, are normal constituents of rancid fats, and increase in amount with increasing rancidity.

The method as described by Issoglio is as follows:

From 20 to 25 g. of the sample are mixed with 100 cc. of water and distilled in a current of steam, so that 100 cc. of distillate are collected in 10 min. Ten cc. of the homogeneous distillate are then mixed with 50 cc. of water, 10 cc. of 20 per cent sulfuric acid, and 50 cc. of $N/100$ potassium permanganate solution, the mixture heated to the boiling point and kept boiling for 5 min. in a flask connected with a ground-in condenser. After cooling, the liquid is treated with 50 cc. of $N/100$ oxalic acid and titrated with $N/100$ potassium permanganate solution. If N represents the amount of potassium permanganate required for the oxidation and n that required in a blank test, and P the weight of fat taken, the oxidizability value of the fat may be expressed by the equation

$$X = \frac{(N - n)80}{P},$$

Hence the oxidizability value represents the mg. of oxygen required to oxidize the organic compounds separated under constant conditions from the fat.

[1] G. Issoglio, *Ann. chim. applicata*, **1916**, 1–18.

With regard to the significance of the results obtained, Issoglio states that the oxidizability value of sound, fresh fats varies from about 3 to 10, while rancid fats show much higher values. Oils and fats which show a value of 15 or more are said to be rancid or to have undergone some other change.

Comparison of results obtained by Issoglio's method with the writer's modification of the Kreis tests is shown by the following table:

Sample No.	Material	Oxidizability Value (Issoglio)	Kreis Test
1099	Lard	14.72	Class 1, no reaction
839	Cottonseed Oil	7.92	Class 1, no reaction
1046	Coconut Oil	8.00	Class 1, no reaction
763	Tallow	8.32	Class 1, no reaction
1295	Lard	3.84	Class 1, no reaction
1047	Soy Bean Oil	13.44	Class 2, reaction less than 1 : 10
1188	Lard	4.16	Class 2, reaction less than 1 : 10
1200	Lard	5.44	Class 2, reaction less than 1 : 10
1359	Lard	10.24	Class 2, reaction less than 1 : 10
1376	Lard	12.16	Class 2, reaction less than 1 : 10
923	Lard	10.56	Class 2, reaction less than 1 : 10
924	Lard	12.80	Class 2, reaction less than 1 : 10
889	Lard	19.52	Class 3, reaction between 1 : 10 and 1 : 20
847	Soy Bean Oil	16.96	Class 3, reaction between 1 : 10 and 1 : 20
329	Lard	17.28	Class 4, reaction more than 1 : 20
1360	Lard	10.88	Class 4, reaction more than 1 : 20
XX1	Lard	7.04	Class 4, reaction more than 1 : 20
1412	Inedible Grease	23.36	Class 4, reaction more than 1 : 20
XX2	Lard	18.84	Class 4, reaction more than 1 : 20
XX3	Lard	21.12	Class 4, reaction more than 1 : 20

It is found that the results conform in the main to the standards set. If fats of Classes 1 and 2 with respect to the Kreis test are regarded as sweet, and fats of Classes 3 and 4 are rancid, the oxidizability values of the sweet fats vary from 3.84 to 14.72, and all values above 10, with one exception, are found in Class 2. The oxidizability values of the rancid fats with two exceptions are found to be above 15, the lowest value being in fact 16.96. The two exceptions which were found to have oxidizability values of 7.04 and 10.88, respectively, were rancid beyond any possible question, being strongly rancid to taste and smell, besides giving the Kreis test in dilution 1 : 20. It would appear fair then to regard an oxidizability value of 15 or more as strong confirmatory evidence of rancidity.

In working with Issoglio's method it was noted that the distillate was clear, showing that the oxidizable organic bodies which came over were all soluble in water. Experiments were made to determine the relation between the total amount of water-soluble and volatile oxidizable organic bodies. After some preliminary experiments the following method of extraction was determined upon:

25 g. of the fat are weighed into a 200 cc. Erlenmeyer flask and 100 cc. of distilled water added. The flask is allowed to stand on the steam bath for 2 hrs. with occasional shaking. At the end of this time the water is separated from the fat by filtering through a wet filter paper. The paper is closely fitted to the funnel and thoroughly wetted. The whole contents of the flask are poured on the wet paper. The water containing the soluble matters extracted from the fat runs through, while the fat is completely retained by the wet paper. The filtrate is caught in a 100 cc. graduated flask. After cooling, the flask is made up to the mark, shaken thoroughly and 10 cc. taken for titration. Oxidation is carried out exactly as specified by Issoglio. The results obtained are, therefore, directly comparable, those by the original method representing volatile organic matters separated by distillation and those by the modified method representing total water-soluble matter.

Following are some of the results obtained by the water extraction method:

Sample No.	Material	Oxidizability Value	Kreis Test
4155	Lard	7.96	Class 1, no reaction
4187	Lard	7.36	Class 1, no reaction
4263	Lard	10.24	Class 1, no reaction
3680	Lard	15.68	Class 4, reaction 1 : 20
4154	Lard	19.84	Class 4, reaction 1 : 20
4327	Lard	16.00	Class 4, reaction 1 : 20
4328	Lard	14.40	Class 4, reaction 1 : 20

The results obtained were seen to be similar to those obtained with like samples by the distillation method. The two methods were then compared directly. For this purpose a lot of fat which was being purposely allowed to become rancid was chosen. This had already been under observation by Issoglio's method for some time. As the results are of interest and as the progress of the sample is typical they are given in full.

Date	Oxidizability Value By Distillation	Oxidizability Value By Extraction	Kreis Test
Sept. 6	7.04	. .	Reacts in dilution 1 : 20
Sept. 20	8.32	. .	Reacts in dilution 1 : 20 (increased)
Oct. 4	11.20	. .	Reacts in dilution 1 : 30
Oct. 18	12.80	. .	Reacts in dilution 1 : 30 (increased)
Nov. 1	9.28	15.04	Reacts in dilution 1 : 30 (increased)
Dec. 6	10.88	13.76	Reacts in dilution 1 : 50
Jan. 8	8.96	16.00	Reacts in dilution 1 : 100

It will be noted that the oxidizability value, whether determined by distillation or by extraction with water, does not increase uniformly but fluctuates. This is in sharp contrast to the Kreis test which becomes more intense at an increasing rate. Observations of taste and odor, while they cannot be compared by any standard, leave no room for doubt that the Kreis test shows the true condition of affairs much more clearly than does the oxidizability value. The oxidizability value obtained by extraction with water appears to follow the actual condition of the fat as judged by taste and smell more closely than does that obtained by the distillation method. As shown by the results quoted, the water extraction method gives slightly higher figures. As the extraction method may be carried out more easily and with less close attention than with the distillation method it is regarded as preferable.

The utility of the methods described depends on their application. Both methods must be applied with strict regard to their limitations. The Kreis test shows the presence of certain aldehydes and ketones. We know that such bodies are formed in that type of chemical change that we know as rancidity. When we find such bodies in a fat which is by the circumstances of its origin and handling free from similar bodies of natural origin, or which we know, by test, to have been free from such bodies at a previous time, we may then fairly accept the test as evidence of rancidity. The method of determining the intensity of the reaction by dilution with an indifferent oil enables one to record degrees of rancidity in definite figures, to compare the rancidity of different samples examined at different times, to establish standards of fitness for any purpose, and to determine definitely whether or not any given sample conforms to those standards. The determination of the oxidizability value, either by Issoglio's method of distillation or preferably by the water extraction method, is a measure of the presence of volatile or soluble products of oxidation. It yields less exact and definite information than

is given by the Kreis test, yet has a certain value as a confirmatory test. The products of oxidation on which it depends being water-soluble and volatile, can readily be removed from the fat by washing, or by blowing with steam or air. A rancid fat, freshly washed or blown, would have an oxidizability value little, if any, greater than if fresh and sweet, but would be little less the rancid on that account. A high oxidizability value taken in connection with the usual physical signs of rancidity is to be regarded as confirmatory evidence of rancidity. A low value cannot, however, be held as conclusive evidence of the absence of rancidity. A negative reaction to the Kreis test can be so regarded. Examination of several hundred samples, during a period of over eight years, has failed to disclose a single sample which displayed the physical evidences of rancidity and at the same time failed to give the test.

If adequate precautions are taken to exclude the known source of error and due allowance is made for its supersensitive character, the evidence given by a positive reaction is definite and dependable. The method described above for determining the intensity of the reaction affords a trustworthy and sufficiently accurate means for the measurement of degree of rancidity.

MEAT INSPECTION LABORATORY
BUREAU OF ANIMAL INDUSTRY
WASHINGTON, D. C.

NOTES ON THE COLOR DESIGNATION OF OIL VARNISHES[1]

By F. A. WERTZ

Received January 23, 1918

In the writing of varnish specifications and in the examination of varnish samples, it is often desirable to designate the color of the material desired, or of the sample examined. Thus, the varnish specifications of some of the Government Departments and of some of the other large varnish consumers state that the material submitted shall not be darker in color than that of a standard sample which is held by the consumer.

The varnish manufacturer, however, usually designates the color of his products by a number, representing the color of a varnish in an arbitrarily established color scale. Such a scale is made from a series of varnishes, whose color is permanent to light; the lightest varnish obtainable, usually a white dammar, forms the one end, and the darkest commercial varnish forms the other end of the scale. Such a scale usually consists of ten standard samples, numbered from No. 1, the lightest, to No. 10, the darkest. Any given varnish is then designated, according to its color, as No. 3, No. 7, etc. In practical work, this designation is sufficiently definite for all purposes; but for manufacturing control work, slight differences in the depth and even in the shade of the color often have some particular significance. Many manufacturers, therefore, are not content to designate by the whole numbers, but subdivide the scale, and described a color, for example, as 4.6, indicating that it is lighter than No. 5, darker than No. 4, and somewhat nearer in color to No. 5 than to No. 4. For the use of an individual manufacturer, this scheme is probably satisfactory, but it is doubtful if the color scales of any two manufacturers coincide at more than one point, if at any.

It is desirable, therefore, to have some simple means of designating the color of a varnish which will obviate the necessity of retaining a standard sample of material of satisfactory color, and which will enable the varnish manufacturers to establish the most important points on their color scales.

The most convenient method for this purpose is the use of an easily prepared solution, whose color is fixed by its composition. In attempts to find a suitable solution a large number of colored salts in a variety of solvents were tried, but the most satisfactory results were obtained by the use of potassium dichromate in concentrated sulfuric acid. By varying the quantity of dichromate, the color of almost any varnish, with the possible exception of the very light-colored turbid dammars, can be reproduced, so that it has been found possible to imitate not only the depth of color but also practically the exact color shades of a great variety of commercial varnishes submitted to this laboratory. No difficulty was found in thus producing a color scale by which the color of a varnish can be defined at least as accurately as by a 10-point scale, such as is used by varnish manufacturers. The dilute dichromate-sulfuric acid solutions are decidedly yellow, like the lighter varnishes, and the more concentrated solutions are a deep rich red as are the darker varnishes. A solution of 0.25 g. of dichromate in 100 cc. of sulfuric acid represents a very light colored varnish; 1.0 g., a medium colored; 2.0 g., a dark colored; and over 4 g., a very dark colored varnish.

The method of making the solutions consists in dissolving a weighed quantity of pure powdered potassium dichromate in a measured quantity of pure, colorless, concentrated sulfuric acid of sp. gr. 1.84. The solution and varnish, whose color is being matched, are placed in separate, thin-walled, clear glass tubes of the same diameter (1 to 2 cm.), to a depth of not less than 2.5 cm., and are compared by looking transversely through the column of the liquids by transmitted light. The solutions corresponding approximately to the color scale of one of the large manufacturers are as follows:

Number in scale	Grams of $K_2Cr_2O_7$ in 100 cc. H_2SO_4
1(*a*)	
2	0.10
3	0.25
4	0.35
5	0.50
6	1.00
7	1.50
8	2.00
9	4.00
10	8.00+

(*a*) Is a pale white dammar with which no satisfactory comparison can be made.

Upon standing, the darker colored solutions may tend to deposit crystals of chromic anhydride. To prevent this, it is sometimes necessary to warm the solution and make the color comparison while the solution is perfectly clear. Warming the acid to hasten the solution of the dichromate, or to produce a clear solution

[1] Published by permission of Director of U. S. Bureau of Standards.

at the time of making a comparison, seems to have no appreciable effect on the color. There is always more or less reduction of the chromic acid, if it comes into contact with even very small particles of dust or dirt, so that the safest procedure is to use only freshly prepared solutions. These are easily made and the color given by a definite quantity of dichromate is readily reproducible.

The above-described method has been used in several varnish specifications with very satisfactory results, and there has been favorable comment from all varnish men who have tried the method. It is not intended that the method should give an optically perfect color match of a varnish, but that it should be a sufficiently accurate method of designating the color of a varnish to make it applicable for all practical purposes where the color of a varnish is to be described or fixed.

BUREAU OF STANDARDS
WASHINGTON, D. C.

ADDRESSES

PLANNING A RESEARCH LABORATORY FOR AN INDUSTRY[1]

By C. E. K. Mees

During the last two years the importance and value of industrial research have become widely recognized, and there has been a general awakening on the part of those who control industries to the desirability of including in their organization a research laboratory to act as a nucleus of scientific knowledge for the industry, and to carry out specific investigations which are judged to be of value.

When the executive directing such an industry, however, looks for information as to how to proceed in order to establish a research laboratory, he is likely to find that the specific information which he requires is by no means easy to obtain. While there are many articles pointing out the value of a research laboratory, little has been written as to the steps which should be taken by an industry that has determined to establish one.

Let us take the hypothetical case of the vice president of a company who, as a result of his reading, has become convinced of the desirability of establishing a research laboratory, but who, himself, has no experience in scientific work of any kind, knows only that the greater part of scientific research is done in university laboratories, and has no idea either of the cost of a laboratory, of how it should be established, or of what return he can expect from it. What is he to do in order to present a specific case to his fellow executives, or to proceed in the establishment of a laboratory, should he be empowered to do this?

The object of this paper is to suggest a specific answer to the problem of such an executive, putting the answer in such terms that it may be applicable to a large number of different industries.

In considering the organization of an industrial research laboratory we must deal first with the relation of the research laboratory to the rest of the organization of which it is a part, and, second, with the internal organization of the laboratory itself. The relation of the laboratory to the other departments of the company will be closely associated with the origin of the laboratory.

If there is a technical scientific expert in the executive staff of the manufacturing company, he may have established the laboratory and become its director, and in this case the laboratory will necessarily be very closely associated with the work of the executive who initiated it.

A laboratory may also be established under a separate director, not himself associated with the executive officers of the company, but as a reference department for the executives. In this case also it will be very closely associated with the officers of the company and will tend to be more concerned with questions of policy and the introduction of new products than with any other of the problems of the company.

[1] Address delivered April 12, 1918, before the New York Section of the Society of Chemical Industry, the American Electrochemical Society, and the New York Section of the American Chemical Society.

In a large company a research laboratory may be established as a separate department having its own organization, and be available as a reference department for all sections of the company, in which case its activities will cover a very wide field, but at the same time it will not have as direct an influence upon the policy of the company as will happen if it is closely associated with one or more of the executive officers.

Whatever the size of the industrial concern may be, the organization of the research laboratory should be responsible directly to the management.

The work of a research laboratory almost always involves questions of policy, and not merely manufacturing questions, and frequently close connection with the advertising and selling departments of the company is very necessary. In several cases where research work has been conspicuously successful, this has been the case.

Let us assume, therefore, that on the establishment of the research laboratory we are considering, arrangements will be made in the organization of the company by which the laboratory will be brought into contact not only with the manufacturing sections of the company but with the financial and sales direction.

Turning next to the internal organization of an industrial research laboratory, there are two forms of organization possible. For brevity these may be spoken of as the "departmental" system and the "cell" system.

In the departmental system the organization is that familiar to most businesses. The work of the laboratory is classified into several departments: physics, chemistry, engineering, and so on, according to the number necessary to cover the field, and each of these departments has a man of suitable scientific attainments in charge of it. In a large department each of these men will in turn have assistants responsible for sections of the department, all the heads of departments finally being responsible to the director of the laboratory. Under the alternative or cell system the laboratory consists of a number of investigators of approximately equal standing in the laboratory, each of them responsible only to the director, and each of them engaged upon some specific research. Each such investigator, of course, may be provided with assistants as may be necessary.

Each of these systems has advantages and disadvantages. Under the departmental system the advantages are strict organization, good coöperation throughout the departments, a plentiful supply of assistants for the more able men who form the heads of departments or sections of the departments. The chief disadvantage is that the system tends to stifle initiative in the younger men. While it is true that research men require to serve a considerable apprenticeship to older investigators, there comes a time when every man wishes to try to develop his own line of research on his own initiative and to carry out work by himself, and while it is quite possible to provide for such men in a departmental organization, there is some danger that men who are really capable of original work may not get the opportunity to carry it out. The cell system, on the other hand, provides a good arrangement for men of original initiative and

of the self-reliant type; it enables a man to continue a single line of work by himself for a long time and to bring to a conclusion work which in a departmental organization might have been abandoned because of its apparently unremunerative character. On the other hand, the cell system tends to exaggerate the vices of such men. They tend to become secretive, to refuse coöperation, to be even resentful if their work is inquired into, while if a man who has developed a line of work for himself in a cell leaves the laboratory, it may be difficult for anybody else to take up the work, in which case a great deal of time and money is lost, and work which should have been carried forward is left unfinished. Another objection to the cell system is that men who are good organizers and who are of the type of men that can carry on work requiring many assistants do not easily find a place in it.

In practice, some system between these two systems of organization is essential and will develop in any laboratory. It is not possible to work a rigid departmental system, and, on the other hand, no cell system in its most definite form could be effective. The form of organization which is the easiest in administration is undoubtedly some modification of the departmental system, since only by this means can young students, fresh from college, acquire adequate training and at the same time keep in touch with different branches of their subject and avoid the danger of overspecialization too early. A laboratory should therefore be organized in departments with an intra-departmental arrangement under which a young man who develops the ability to carry out his own work may be able to take up work on his own initiative, still retaining his position in the department and carrying on his work under the general supervision of the chief of his department. There will always be a tendency in the departmental organization for men to desire to split away from the department to which they are attached and become semi-independent in the laboratory, and this tendency must be resisted in the organization and by the director of the laboratory. At the same time, it is important that too rigid a control should not be exercised so that men feel that they are prevented from exercising their own initiative.

A laboratory for a specific industry will generally tend to be of what has been called the "convergent" type, that is, one in which all the different sections of the laboratory representing different branches of scientific work have their energies directed towards the solution of problems relating to the same subject. The problems of such a laboratory will, therefore, all be interrelated and the work of the laboratory will be directed towards one common end.

The organization of such a convergent laboratory has been discussed in a former paper.[1] It is shown there that charts could be prepared illustrating the organization which would be available for almost any convergent laboratory, so that, if we have to work out the organization of a research laboratory which is to study any interrelated group of problems, we can do it by the construction of similar charts. Thus, we may arrange a chart showing the derivation of the branches of the subject considered from the sections of pure science involved. We can place on one side biological, physical and chemical problems, subdividing each section so that each one represents work capable of being handled by one man in the laboratory. It will now be possible to draw a new chart, showing on the circumference the different sections of the laboratory for which accommodation, apparatus and men must be provided, and showing the relation of these sections to the problem as a whole. Having worked this out, it is easy to find the amount of space and the number of men which will be required, or which the funds available will allow for each part of the work.

Now, before applying these charts for laboratory organization to a specific industry, let us look at the question of the physical organization of the laboratory itself: the building and scientific equipment, the cost of building, and the cost of the maintenance and operation. It may be mentioned here that when a laboratory is under consideration by the executive of a company, the matters which usually concern his mind are these physical details, and he is often greatly concerned with the planning and cost of the building and equipment, a matter which is quite secondary to the internal organization of the laboratory, either as regards effect on the work or even from a financial point of view.

The laboratory should be housed in a convenient, special building. It is very advisable that all research work under the same general direction should be conducted under the same roof, since only in this way can good coöperation between the departments be obtained, and the facilities and organization of the whole department be available to all the workers. In technical research, where it is often necessary to install model plants on a small scale, this cannot always be carried out, but, as far as possible, a research laboratory should be a real building and not merely the name for a number of scattered departments at some distance from each other.

It is a mistake for a factory to house a research laboratory in some abandoned building designed for other purposes. The annual cost of research work, as will be shown later, is very high in comparison with the cost of the building itself. The greater part of that expenditure is on the salaries of the men carrying out the work, and any inconveniences or disadvantages which may be caused by their working conditions and surroundings can easily depress the production to an extent which renders such economies very unprofitable. The cost of the research man, in fact, is so high that it is worth while to provide him with the very best facilities for carrying out his work, since, provided money is not actually wasted on useless ornaments, these facilities will always be inexpensive in comparison with the total expenditure on the work.

Research laboratories are almost always too small, and it is really desirable that, in designing such a laboratory, some system of construction should be chosen in which expansion can be obtained by the duplication of units. This is, of course, a very difficult thing to arrange, especially in the details of the laboratory, but, nevertheless, it should certainly be aimed at by the architect, since, whatever the size of the laboratory when it is designed, it is safe to prophesy that, within a very few years expansion will be necessary, and if direct expansion is not possible, this will take the form of detached groups of men working in other places, an inconvenient and uneconomical arrangement.

The cost of moving in research work is not always realized. The cost of moving into a new building may be as much as half the total cost of the building, since the men will actually not be working again at full speed in less than six months, and, as a general rule, the annual expenditure is equal to the cost of the building and equipment. It is important, therefore, in designing a laboratory to arrange, if possible, that expansion may take place without any considerable rearrangement. An aid to this is to make the internal divisions of a laboratory movable as far as is possible, and while the laboratory itself should be of fire-proof construction, it will be convenient to make partitions of composition board and wood wherever the fire risk does not prohibit this. In this way, rooms can easily be subdivided, combined or rearranged.

Everything that has been said as to the necessity for the provision of a satisfactory building applies also to the question of equipment, but with even greater force. It is an economic error to allow expensive men to be short of the apparatus which they require for their work. As a general rule, men will not ask for apparatus which they do not need. There are a very few men who might be considered to be apparatus collectors, and who seem to have a real anxiety to surround themselves with all forms of

[1] THIS JOURNAL, 9 (1917), 1137.

scientific apparatus, whether they have any use for them or not; but with the exception of these men, who are limited in number, it may be taken that when a research worker asks for apparatus he needs it, and must have it in some form or other to continue his work.

The total cost of equipment for a physical laboratory represents about two months' cost of operation, and, if economies are to be made, it is clear they should be made in limiting the amount of work undertaken and the consequent cost of operation, rather than in depriving the employed workers of the necessary tools for their work.

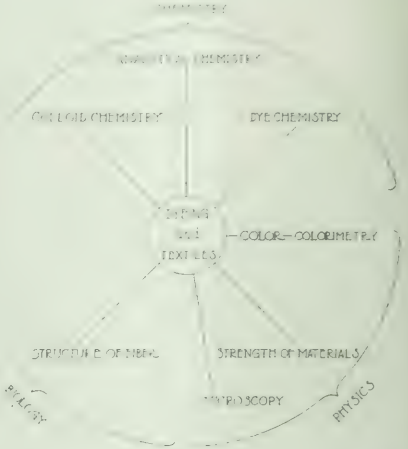
From various sources of published information, as well as from personal experience, it is possible to form an estimate of the cost of a research laboratory per scientific worker employed, taking the term "scientific worker" to cover all graduate men working in the laboratory. It might seem that there would be very great variation in the cost, but, provided that we confine ourselves to laboratories of the physical and chemical type, there is a surprising agreement between the different figures, which show that cost of building and equipment for a laboratory will be between $3000 and $4000 per man; it may be taken, therefore, that the first cost of a laboratory will be about $3500 per scientific worker employed. From the same sources the annual cost of maintenance of such a research laboratory appears to be slightly lower than the first cost. Probably $3300 per man would be a fair estimate of the cost of maintenance, and of this we may take 60 per cent as representing salaries and wages and the other 40 per cent all other expenses.

Let us attempt to apply the principles which have been laid down to the design of an industrial research laboratory applicable to a specific industry, in such a form that they would be available for the directorate of the industry to understand to what they are committing themselves in establishing a research laboratory, and how to proceed in order to do so.

We may select as an example of a specific industry one of a technical manufacturing type dealing with engineering processes, handling chemicals, and also involving certain biological considerations; such an industry, for instance, as textile dyeing or the manufacture of leather goods. Exactly the same principles, however, would apply to industries of quite a different kind. Thus, an industry in which there are no biological considerations will not require some branches of a laboratory; they may need to substitute others in their place. For some industries, physics is of no importance and chemistry is of far more importance.

Let us, however, in order to be specific, consider the question of a plant whose business consists in the dyeing of textiles. Let us suppose that the industry is making a turn-over of $1,000,000 a year, of which 10 per cent is net profit, and that the directors have decided that, in order to improve their product and extend their business, possibly to diminish costs, they will at the outset undertake an expenditure of $15,000 a year on scientific research. Now, let us consider what they can do for this.

In the first place, we can decide at once how many men they can get. On the basis of $3000 per man, they should be able to get five men for $15,000, but with very few workers in the laboratory, the cost per man will be somewhat higher, and it will be safe to assume that only four men can be obtained for the $10,000 available for salaries. The cost of the building will be about $10,000 and equipment about $5000. Taking the basis of $2.00 per sq. ft. for building as a rough approximation, we shall have a building with 5000 sq. ft. of floor space, or, dividing this into three floors, a building about 40 ft. square. The work of the laboratory may be analyzed according to the chart shown herewith. Dividing into the three main divisions of chemistry, physics and biology, we shall get the following sections for the work: In chemistry, we shall require an analyst and dye chemist who must understand organic chemistry, and a colloid chemist who will study the relation between the fiber and the dyes. In physics, we shall have work to do on the testing of the strength of materials and especially on colorimetery and the measurement of absorption. In biology, we shall require a man who understands the vegetable and animal fibers, their structure and their biochemical properties. We shall also require work on the staining of fibers and photomicrography. This will give us the chart shown.



Now, we cannot hope, of course, to represent all these departments by separate men, since we can afford to have only four men, and in addition to the departments shown we must have one practical dyer having actual works experience. Our men may be grouped somewhat as follows: Our organic chemist can look after analytical chemistry as well, that is, we must get a man having experience in organic chemistry and some good knowledge of dyes, who can specialize in the study of dyestuffs and on their analysis, but who also can do what analytical chemistry it becomes essential for the laboratory to carry out We may expect our colloid chemist to be a biochemist and to take care of the microscopy. The physicist may understand colorimetry and, at the same time, know enough general physics to be able to look after questions involving the strength of materials. We have thus accounted for three of our four skilled men, and the fourth must be the practical dyer, who should also be the director of the laboratory and should have a good training in dye chemistry and general chemistry, with a considerable knowledge of colloid chemistry and fibers, and some knowledge of physics. Thus, the staff of our laboratory will be completed by the director, who will be a chemist who has had works experience in dyeing, and who must be given this works experience before the laboratory is commenced if a fully trained scientific research man is not already available from the works. It is of no use to take a man from the works who is not fully trained in research methods and in sympathy with scientific work, and if such a man is not already available with a knowledge of dyeing, then the best available man must be obtained from a university or elsewhere and given the works experience to learn dyeing before the construction of the laboratory is attempted.

The amount available for the salaries of these men will be about $10,000 a year, which must be distributed as seems advisible with regard to the men actually chosen. The sum should be sufficient to obtain fairly good men, as a commencing salary.

We will next consider the structure of the laboratory itself. It must be remembered that we have three floors, each of them containing about 1600 sq. ft. Of these, one will be required for

the library, office and the dye room, which will be a small edition of a works department containing small model machines in which all the works processes of dyeing, washing and drying can be carried out. This may occupy about half the ground floor, the other half being taken up by the library, staircase, and the laboratory office, which in such a small laboratory may be united with the library. The next floor will be devoted to chemistry and may be divided into two or three rooms, while the top floor will be used for physics and will contain rooms for ordinary physical work and for colorimetry. It will also probably be used for microscopy, since it is unadvisable to have microscopes and similar instruments exposed to the fumes of a chemical laboratory.

An exactly similar design to this can be made out for any other industry, the factor of size being determined by the expenditure which it is proposed to make, and the work being dissected in accordance with the demands of the particular industry in question. Space must always be kept for a small replica of those plant operations on the investigation of which the laboratory is working, since it will often be necessary to prove the plant operations under the direct control of the men in the laboratory and under conditions which can be rigidly maintained at any required point.

Now, let us consider what returns may be expected from the work of this laboratory.

The work of an industrial research laboratory may be classified in three divisions:

A—Work undertaken on the initiative of manufacturing divisions for the improvement of operations, for the lowering of cost, or in order to locate manufacturing difficulties.

B—Work undertaken with a view to the development of new materials or of new processes. This may be initiated by the management, by manufacturing sections, by sales divisions who see the need for such materials or processes, or by the director of the laboratory or his assistants.

C—Work which deals with the fundamental theory of the subject, the results of which, if successful, will lay a foundation for the expansion of the industry as a whole, along lines which usually cannot be foreseen when the research work is commenced.

The work classified under Division A is, of course, common to all industrial laboratories, and many research laboratories in connection with manufacturing plants confine themselves almost entirely to problems arising from the manufacturing division.

Division B includes a large portion of the work of industrial research laboratories and the best known successes of such laboratories are included in this division. A typical example is the development of the drawn wire tungsten filament by the research laboratory of the General Electric Company, a research which, although originating from a general research on the properties of rare metals such as would be classified under Division C, developed into a study of tungsten with the direct purpose of obtaining a satisfactory filament lamp from the metal. Another example is the manufacture of indigo by the Badische Company. Such researches usually have their basis in some more fundamental work; the industrial work on indigo, for instance, was made possible by the original chemical work on the structure of indigo carried out in the German universities, which was applied on a manufacturing scale to the preparation of the dye.

More rarely do research laboratories work on subjects classified under Division C, that is, on the fundamental theory of their subject, yet those who do, achieve the most conspicuous successes. The work of Professor Abbé on the theory of the microscope, and, indeed, all the work on applied optics at Jena comes under this heading. The great success of the Zeiss Works is directly due to the attention paid by Abbé to the development of the fundamental theories of optics. At the General Electric Laboratory at present much attention is being paid to the emission of electrons from hot bodies, and from this work there have already developed the Coolidge X-ray tube and the kenotron high frequency transformer, while the possibilities of application are as yet only just beginning to be realized.

In a study of the work of a special research laboratory all the work done during the year was analyzed out from a classification of the work of each part of the laboratory, and the proportionate expense found, which should be charged to each class of the work.

This analysis showed that Division A, that is, work done for the manufacturing departments, corresponded to about 15 per cent of the work of the laboratory; Division B, work on new materials, 47 per cent; Division C, or fundamental work, absorbed 27 per cent, of which $22^1/_2$ per cent was devoted to the scientific work and 5 per cent to the accompanying educational work, while work for the assistance and information of the office force is estimated at $5^1/_2$ per cent.

Now, considering this division of the work of the laboratory, it will be agreed that, if proper coördination exists between the laboratory and the management of the company, work classified under A and B will certainly be reasonably remunerative, although not necessarily so completely so as to pay the dividends on an investment in the research laboratory, which are commonly expected from such an investment. The same may not appear true in the case of Division C, the fundamental work, which in the hypothetical case discussed would represent nearly a third of the total expenditure of the laboratory; nevertheless, it is probable that this section of the work would be likely to prove the most remunerative of all, and the way in which this can best be illustrated is by some examples.

Let us consider graded examples of theoretical work in relation to their application in industry.

First, let us take the case of such work as that done by Professor Abbé on the geometrical laws which govern the formation of images by lenses. The connection between this and the manufacture of lenses is so obvious that it is at once manifest that the discovery of any new principle in the theory of lens optics will react immediately upon construction in some way, either in the form of a new product or in cheaper forms of construction.

Next, let us consider work on improved methods of testing such, for instance, as the work done by the various bureaus of standards or research on analytical methods. Here it can be seen that only the possession of an accurate method of testing will enable the manufacturer to improve his product and to guarantee the similarity of product made at different times. Consider, for instance, the improvements in electrical measuring methods and instruments which have made available the standardized electrical equipment which is now so familiar to every one.

In the third place, we may take as an example such research work as the study of the relation between inductance and capacity in alternating electrical circuits, which has had such an immense influence upon the design of alternating current electrical machinery. At the present time, of course, this is a recognized fundamental portion of electrical engineering.

Lastly, let us consider such work as that of the universities on the photoelectric effect, the diffraction of X-rays by crystals, or the emission of electrons by hot bodies. Of these, the last has already found extremely important commercial application, the second one is being adopted by several industrial research laboratories in making a study of the structure of metals, alloys, and other crystalline substances, while the first, so far as I know, up to the present has not found any industrial application, and yet, it may safely be prophesied, will be of importance to industry within the next ten years.

It is almost impossible to name any class of physical or chemical scientific work, from the physics of the atom to structural organic chemistry, which will not sooner or later have a direct application and importance for the industries.

Work in a research laboratory bears a certain analogy to placer mining for gold. A man washing gold can make a living by steady, hard work, but nobody would take up placer mining

with the intention of making a living by the every day washing. Everybody hopes to find nuggets which will give them a good profit, and possibly even a fortune. In the same way a research laboratory can produce results equivalent to a large amount of its expenditure by steady work, but from a commercial point of view research is undertaken in the hope of the occasional valuable discovery rather than for the steady output of small details.

The analogy can be carried somewhat further. Just as in placer mining it is of no use looking for nuggets, and any miner who neglects the routine washing in search of nuggets is likely to starve before he finds them, in the same way a research laboratory cannot look for discoveries. It can only carry on its every-day work on the problems presented to it, and hope that when some possibility of a valuable discovery presents itself it may recognize it in time to take advantage of the fact.

There is, however, one direction in which this analogy breaks down. When a man finds a nugget, he knows its value and its value is definite and certain; in research work this is not the case. Discoveries which are thought to be valuable when made often prove worthless, while others which appear to be of no value eventually turn out to be profitable, and frequently the value of a discovery is not under control of the laboratory because the adoption and exploitation of it may be in other hands.

It is sometimes thought that in order to put an industry into a state of complete efficiency from a scientific point of view all that is necessary is to establish a laboratory and to employ a scientific staff to carry out research work. It is quite possible, however, for such a laboratory to have no influence whatever upon the general policy of the company, and only a very slight influence upon its manufactures, the value of a laboratory depending very greatly upon the closeness of its coöperation with the other departments of the company.

It is often felt that small industries cannot afford to support scientific research, but this argument is exactly as if it were suggested that small industries cannot afford to support advertising. The object of spending money on research, for a small industry at any rate, is not to support the research but to be supported by it, and it is scarcely an exaggeration to say that the smaller a business is, the more important is it that it should make use of scientific research to the greatest extent possible.

A small business is at a disadvantage in comparison with a large one in regard to all its cost charges. In the purchase of raw materials, in manufacturing, and in selling, its cost per unit of output tends to be larger than in the case of big businesses, but, on the other hand, it is at a real advantage in regard to flexibility and enterprise. Any large business must necessarily be cautious and conservative. The amount at stake is so large that the penalty of error is heavy. Consider, for instance, the mere cost of allotting half a page in a catalogue of which three million copies are to be printed. It is clear that no business man will allow the introduction of a new article into a catalogue for which such an edition is necessary unless he has reason to believe that the demand will be sufficient to pay the cost involved. That is, the machinery of a large business is adapted for the sale of things for which there is a large demand, but it is difficult for it to introduce articles for which the demand will probably be limited and doubtful. Every large business is anxious to improve its goods, since it knows perfectly well that the penalty for failure to do this is extinction, but it necessarily moves with greater caution and more slowly than a small business can do. It is this very fact, rightly grasped, which enables the small business to get its start and grow in spite of the advantage in regard to cost possessed by its larger competitor, and the growth of a small business will depend upon its supply of ideas for new products and new methods to a far greater extent than will that of the big manufacturing concern making staple products. Small businesses can, therefore, make far more use of a research laboratory and get a much bigger percentage return for the expenditure than any big company can hope to do. In the small business, in fact, a research laboratory closely associated with one of the high executive officers should begin to return a profit within a few months of its establishment, whereas in the case of a large company it may be years before a research laboratory can be considered to be financially successful.

The greatest difficulty in the establishment of a research laboratory in a small business is that any research laboratory will depend for its value upon the quality of the men at the head, or, if the laboratory is really small, of the man at the head, and a small business often feels that it cannot afford to pay even one good scientific man. The solution of this in a technical business might be that the research man should also be an officer of the company, so that his cost is borne not only by the scientific work but also by the value of the executive position which he holds.

It may be objected that an investigator would not as a rule prove a capable business man, but there really seems to be no particular evidence for this common belief, and there are many examples of men trained in science who have proved extremely good administrators. The classic example is, of course, the organization of the great Zeiss works under Professor Abbé, but in many cases it will be found that the technical industries are directed by technical men who were themselves directly concerned with development and manufacture rather than with financial or business direction.

When the question with which this paper starts was put to a chemist much experienced in research work, and he was asked what he would say to an executive who requested information as to how to proceed to establish a research laboratory, he answered without hesitation that he would tell him to search until he found a suitable man to be director of it, and then leave it to the man to establish the laboratory. There is no doubt very much truth in this view, and the success of a laboratory must stand or fall in great measure by the quality of the man in charge of it. But it is often desirable for business men to come to some conclusion about research when they have in mind no man suitable to undertake the formation of a laboratory for them, and it is in the hope of aiding technical or business executives in such a position that the present paper has been written.

EASTMAN KODAK COMPANY
ROCHESTER, NEW YORK

THE AMMONIA PROGRAM FOR 1918[1]

By CHARLES W. MERRILL

PRELIMINARY CONSIDERATIONS

I do not need to tell you that ammonia produced in America prior to the war was all consumed in essential industries such as refrigeration, domestic explosives, dry batteries, fertilizers, and so forth. You also know that there were large imports before the war, which, it was realized, would be cut off, and that, furthermore, there would probably be enormous demands for military explosives. These two factors indicated that it might be necessary, not only to provide new sources of supply and to economize in present uses, but also possibly to drastically curtail present uses.

The War Department, fortunately, appreciated this and planned and prepared for new plants: one a cyanamide fixation plant, and another a plant for the conversion of sulfate to nitrate, these both in addition to the small Haber plant already authorized. Both of these larger plants are reported to be *well* under way. They are expected to begin production on a very material scale not later than this Fall. Private enterprise has also been active in an endeavor to meet the increased demands. New by-product coke ovens are being installed, and an aluminum nitride

[1] Address before the Washington Section of the American Chemical Society, April 11, 1918.

plant is being erected with a capacity of 25 tons of ammonia per day.

It is thought that these new sources of supply will relieve what might otherwise develop into a difficult situation during the latter part of this year.

CONTROL

It was early recognized that the refrigeration of perishables was an industry of such magnitude and extreme importance and the supply of ammonia therefor was so vital to it, that both should be brought under control. Therefore, the refrigeration warehouses were licensed, and all of the manufacturers of aqua and anhydrous ammonia were called to a conference with the Food Administration. At this conference, the manufacturers appointed a committee to coöperate, and executed a voluntary agreement with the Food Administration, placing the allocation of their output in its hands. They further agreed not to sell anhydrous ammonia or aqua ammonia at prices in excess of 30 cents and $8^1/_4$ cents per lb., carload lots, respectively, base price at their plants. Through this power of allocation, the War and Navy Department requirements for their refined ammonia products are being taken care of without disturbing the other consumers, and, of course, in view of the above, without creating fluctuations in prices.

Keeping in mind the fact that the present sources of ammonia supply, with the exception of cyanamide plants, are our by-product coke-oven and gas-producing plants, it was thought wise to put these under license by virtue of the control of fertilizer and fertilizer ingredients provided for in the Lever Act, and in accordance therewith, the President, at the request of the Secretary of Agriculture, issued a proclamation to that effect, and the Secretary exercises his control through the Inter-Department Ammonia Committee, consisting of representatives of the Departments of Agriculture, War, Navy and Interior, the Council of National Defense, and the Food Administration.

Fortunately, the ammonia control and program has been very much simplified so far by three factors: first, the broad attitude of the Secretary of Agriculture and Mr. Hoover; second, the exceptional spirit of coöperation and patriotism displayed by the great majority of producers and manufacturers of ammonia; and third, the fact that the raw material supply so largely centers in the hands of one firm which, not only for itself, but for the producers it represents, is uniting in the determination to help the Government, and to prevent profiteering.

THE PROGRAM

Unfortunately, it is not permissible to go into detailed figures covering the program, because all of these involve the War Department's confidential estimates, and, also, these necessarily change as new emergencies arise. Nevertheless, it is possible, and probably interesting to give you the general considerations and principles on which it is being worked out. You will realize, from what has been said, that the possibility of avoiding drastic interference with existing industries depends on the magnitude and urgency of the War Department's ammoniacal explosive program, and the ability of that department to push the early completion of plants to provide new sources of supply and conversion. I say "conversion" because it was early recognized that the requirements of explosives for the immediate future could be most quickly met and with the least disturbance of the most essential industries by drawing from our relatively large supply of ammonium sulfate and converting it into ammonium nitrate. In order to meet the demand for this ammonium sulfate for explosive purposes, it is necessary for the present to secure it by commandeering orders, and the Government has taken it over under these orders at the price of $4^1/_2$ cents bulk, f. o. b. point of production.

However, as the producers, at our request, have refrained from renewing all contracts, most of which have, or will shortly, expire, it will very soon be possible to supply the Government's requirements for sulfate, simply by a *pro rata* allocation among producers, in the same simple manner that has been employed in meeting their very considerable needs for aqua and anhydrous ammonia for purposes other than the manufacture of ammonium nitrate. The ammonia producers, wherever they have alternate equipment for producing ammoniacal liquor, are using it at the present time in place of sulfate equipment. If, however, the demand for ammonium nitrate should develop beyond the conversion capacity, and beyond the supply already arranged for by the neutralization method, a more serious curtailment of supplies of ammoniacal liquor for existing industries will have to be made. In such an event, the Inter-Department Ammonia Committee will probably be compelled to take steps to reduce the amounts now being allocated for ammonium chloride, for domestic ammoniacal explosives, for refrigeration purposes, and for other uses. If it does this, it will advise that the consumption of ammonium chloride for dry batteries, without insuring the return thereof in exhausted batteries up to a certain proportion of the original allotment, will be deemed to be a wasteful practice, and subject to the penalties provided therefor in the Lever Act. Similarly, it will probably advise that the use of ammoniacal explosives for certain unnecessary purposes will be held wasteful, and, furthermore, it will rule against the less essential uses of ammonia in refrigeration.

Other curtailments will be found possible and similarly arranged for in order to provide ammonium nitrate in quantities adequate for the actual consumption possibilities of the explosives program.

CONSERVATION STEPS FOR SAVING AMMONIA IN REFRIGERATION

When it became evident last Fall that the use of ammonia in the ice and refrigeration business should be reduced to a minimum, in order, if possible, to release some ammonia for Government requirements, the Food Administration made a survey of the trade and found that there were upward of 20,000 places in the United States in which ammonia compressors were in more or less constant operation. These range from installations of almost 4,000 tons daily refrigerating duty down to the little half-ton machine installed in a butcher shop. Figures obtainable indicated that these machines used in their operation about 25,000,000 lbs. of NH_3 per year, but the expert refrigerating engineers who were consulted agreed that a large part of this ammonia was wasted, and they were of the opinion that a considerable proportion of this waste could be prevented if only the people owning and operating the plants could be brought to realize the national necessity for saving the ammonia and the ready possibility of its accomplishment. It was evident that a campaign of education was necessary and a small committee of engineers and owners was called to Washington to gather opinions and draft plans. All the leading manufacturers of refrigerating machinery were consulted and the ideas of leading consulting engineers either directly or indirectly obtained. The plan finally agreed upon was to figure a reasonable limit for the use of ammonia based on the size and character of the plant and to have the ammonia manufacturers supply ammonia to concerns only in such quantities as would permit them to operate their plants so effectively as to come within these limits. The manufacturers of ammonia by voluntary agreement with the Food Administration pledged themselves to abide by certain rules and regulations of the Division of Chemicals which specify just how the limits of ammonia allowances shall be arrived at.

Of course, the most important part of the ammonia-saving campaign was to educate the owners and operators of the plants, so the engineers' committee in conference with representatives of the ammonia manufacturers drew up a circular of information and instruction which was issued by the Food Administration to every one of the 20,000 plant operators, on February 15, 1918.

This circular is headed "Urgent Requests to Owners and Operators of Ice Making and Refrigerating Plants for Saving Ammonia," and the interest in it may be judged when we say that close to 100,000 copies of this pamphlet have been distributed and the call for them still continues. It is explained in this circular that ammonia leaks are avoidable; some means for finding them and stopping them are pointed out; and as a practical method for enlisting the interest of the plant employees a bonus system is recommended.

This bonus system was strongly advised by some expert engineers who had been studying for a series of 5 years the ammonia problem under their charge in a system of twelve plants. During that period the consumption of ammonia had been reduced 75 per cent. The plan and results of this particular experience really formed the basis for the ammonia-saving campaign adopted by the Food Administration and is an interesting example of what might be called psycho-economics. The Superintendent of Manufacture of the series of plants referred to resolved that the old ideas of ammonia decomposition in refrigerating systems hardly deserved the dignity of being called "theories," as he believed they simply were excuses which served to cover inattention and carelessness on the part of engineers in stopping ammonia leaks. He concluded that the interest of the plant engineer was necessary, and believed it could be most effectively aroused by a money reward that would be in proportion to the amount of ammonia saved in this particular plant. He then prepared an ammonia consumption standard for each plant and agreed to pay a certain bonus for every pound of ammonia the actual consumption showed less than this standard. It rapidly transpired that the engineers were able to make material savings in ammonia, the theory of decomposition was abandoned, and an involuntary scientific investigation followed. The loss at the compressor piston rods was soon shown to be a prime factor and an improved packing was invented. It seems that the more the saving progressed, the more ways for perfecting it were found. The whole study from an engineering standpoint is an example of the value of aroused attention. This same set of engineers—so it is reported—have declared that this year, because it is not only a money-making chance but also a patriotic duty, they will save more ammonia than ever before.

The last paragraph of the Food Administration's circular describes the system of monthly reports each ice and refrigeration plant must make to the Government. A series of report cards have been sent to each of the larger plants with instructions to mail one to Washington every month. On these cards they state the amount of ammonia originally in their plants, the amount charged into it during the month, and the probable requirements for the ensuing month. A complete file of these cards will be maintained at the Chemical Division of the Food Administration, and where there is evidence of undue use of ammonia by a concern, the ammonia manufacturers selling the supply will be cautioned against furnishing further ammonia, unless satisfactory evidence is given that the wasteful methods will be discontinued.

The response to this ammonia-saving campaign has been most encouraging. If we were asked for evidence of criticism or complaint, we could not point to a single letter in all our files to show it. On the contrary, our mail fairly teems with assurances of loyal coöperation. The ammonia manufacturer, the machine builders, the supply houses, and the members of the Society of Refrigerating Engineers have almost to a man written assuring us that they and all their representatives will carry the ammonia-saving messages wherever they go and not let the pungent smell go unnoticed in any plant they come in contact with. One concern wrote to their traveling men as follows:

As we suggested to you, it would be well for you to step into any plant using ammonia, in any town that you may be in. Lots of time to wait either between trains, or because of the train being late, and in place of going up to the hotel and taking it easy, do your bit and go around and see these plants. Explain to the party who is running the plant just what ammonia means in this war. Tell him how to save it. Show him how to locate a leak, and you can impress the fact that not only is he doing himself a good turn by economizing, but he is doing a part of his share to assist our Government. It will, no doubt, take you some little time to do this, but we are willing to pay for the time that it takes, and we want it done effectively, so that there isn't anybody who is using ammonia in the section of the country we travel in who will not know how to conserve his supply.

However, we feel that the refrigerating engineers will hardly need these reminders, for they all tell us it will be a great privilege to save ammonia for the fighters who are risking their lives to safeguard our liberties.

AMMONIA PRODUCTION BY COAL DISTILLATION DURING 1918

Finally, gentlemen, you will be interested, I am sure, to know that our estimate of the probable production of ammonium sulfate for the current year calls for 236,000 tons, equivalent, approximately, to 58,000 tons of NH_3. Similarly, the production of NH_3 in ammoniacal liquor from by-product coke-oven sources is calculated to be approximately 38,000 tons NH_3. The gas plant production of ammonia is not known, as yet, with definiteness, but in any event is not a material factor. It may be safely concluded, however, that their production added to the above 58,000 plus 38,000 will bring the total NH_3 production from normal sources to 100,000 tons of NH_3.

U. S. Food Administration
Division of Chemicals
Washington, D. C.

AMERICAN CHEMISTS WELCOMED BY THE CERCLE DE LA CHIMIE

The following is a translation of the greeting addressed by the President of the Cercle de la Chimie to Lieut. Col. Bacon at the reception tendered to all American chemists in Paris on March 24, 1918.

Colonel: In these rooms where there are gathered together some of the most distinguished members of the Cercle de la Chimie, it gives me pleasure to greet you, at one and the same time a representative of the great American nation and one of the most distinguished members of the university world of the United States. The first of these two titles would suffice to assure you a respectful welcome among us; the second adds a softening degree of cordiality to our feelings. Chemist yourself, you are here, Colonel, in the home of chemists.

In a Labor Day address in Chicago in 1900 ex-President Roosevelt, speaking of the necessity of association, in those energetic and lucid terms which are characteristic of his eloquence, expressed himself thus:

In other words, the great need is fellow-feeling, sympathy, brotherhood; and all this naturally comes from association. It is, therefore, of vital importance that there should be such association. The most serious disadvantage in city life is the tendency of each man to keep isolated in his own little set, and to look upon the vast majority of his fellow-creatures indifferently, so that he soon comes to forget that they have the same red blood, the same loves and hates, the same likes and dislikes, the same desire for good, and the same perpetual tendency, ever needing to be checked and corrected, to lapse from good into evil. If only our people can be thrown together where they act on a common ground with the same motives, and have the same objects, we need not have much fear of their failing to acquire a genuine respect for one another; and with such respect there must finally come fair play for all.

The Cercle de la Chimie was born of this same need for association to which your illustrious compatriot referred. When we, scarcely twelve months ago, founded the Cercle de la Chimie, we did it with the object of facilitating contact among all classes of individuals interested in the development of French chemical

industry, offering them the opportunity to become acquainted with each other, to consider the progress of our science, to discuss their professional interests, to establish business relations, to manage affairs. The welcome accorded our beginnings has gone to prove that our idea met a real need. You will find here the scholar, the professor from our large colleges, chemical institutes, and national institutions; here you will meet the manufacturers, the representative of our big syndicates; you will find the engineer and the financier who devotes his energy to the marketing of the products of our industry; more particularly you will find the chemist, from the Doctor of Science and the graduate of our colleges to the man taught simply by experience in the laboratory; all of these in my voice bid you welcome to-day.

The Cercle de la Chimie counts itself happy that you, Colonel, and your distinguished collaborators show yourselves ready to accept our hospitality, which though modest is none the less cordial. The presence on the table in our reading room of American journals will prove to you the interest which those who frequent our club take in following the progress of your science and industry. Are they not sure to find in reading these evidences of the keen thought, daring initiative, and talent for organization which are the characteristics of your national spirit?

Is it rash to hope that the reception we have given you this evening may be the beginning between American and French chemists, of continuing friendly relations whereof we know so well how to estimate the worth? It is to the development of these relations, to their contribution to the approaching victory of the allied armies which we all are preparing for in our factories and laboratories that we now invite you, Colonel, to drink of the wine of France.

WILLARD GIBBS MEDAL AWARD

The Willard Gibbs Medal for 1918 was conferred on William M. Burton, Ph.D., in recognition of his distinguished work in petroleum chemistry, at the meeting of the Chicago Section of the American Chemical Society held at the City Club of Chicago, May 17, 1918. Introductory remarks by L. M. Tolman, chairman of the Section, were followed by an aptly phrased presentation of the medal by Dr. Ira Remsen, in which he paid pleasing tribute to his former student. Dr. Burton's address of acceptance and the remarks of Mr. Tolman are printed herewith.

A reception and dinner preceded the meeting at which informal addresses were made by Lucius Peter, president of the Chicago Association of Commerce; Thomas F. Holgate, president of Northwestern University; George N. Carman, president of Lewis Institute; W. E. Stone, president of Purdue University; Julius Stieglitz, director of the Department of Chemistry, University of Chicago.—EDITOR.

INTRODUCTORY ADDRESS

By L. M. TOLMAN

In 1909 Mr. William Converse, at that time chairman of the Chicago Section, had the idea that it would be a good thing to found a medal which should be given as a reward for work in chemistry, and he provided the funds to found the Willard Gibbs Medal.

The first thought was to make it local in character but it was soon decided that it should not have restrictions of any character put upon it. It was provided in the rules for the award of this medal that a jury of twelve eminent chemists, by their vote, could award this medal to any person who, because of his eminent work in or original contributions to pure or applied chemistry, was deemed worthy of such an award. It was not, therefore, limited to chemists of this country, but the jury was given an open field to choose the one they should consider most worthy to honor and, as you will recollect, the first chemist to whom the award was made was Arrhenius, the famous Swedish chemist.

The jury as it is made up at the present time is representative of the American Chemical Society. At one time, it was provided by the rules that at least half of the members of the jury should be from the Chicago Section, but as that seemed to have too much of a local suggestion, it was decided that this restriction on the jurors should be removed and the only restriction now is that of the four jurors elected each year, not more than one shall be from the same Section of the American Chemical Society. As one reads over the present list of jurors and those that have served on the jury in the past, he finds a list of men composed of the most prominent chemists in this country. Out of the twenty-eight names who have served as jurors since the establishment of the medal, we find the names of ten past-presidents of the American Chemical Society, and of the present jury of twelve, we find that five have been presidents of the American Chemical Society. Certainly, it is an honor to have such a body of men give one a vote of confidence.

What is a medal? Generally, a little piece of metal with an inscription upon it: sometimes made of gold, sometimes of silver, and sometimes of iron or copper; but the value of the metal has little to do with the significance or value of the medal. It is what it signifies, what it represents, and who awards it that gives it its value, and as one looks back over the past seven years of the award of this medal, its founder must feel satisfied and the recipients of the medal, proud and honored.

Chemistry is to-day playing a very conspicuous part in the history of the world. A few meetings ago, we heard from Major Auld, of the British Commission, of the advanced organic chemistry that is playing such an important part in the matter of gas attacks and gas defense. We know of many other fields where chemistry in this time of war is taking a most important and conspicuous position, and doubtless many of the chemists now at the front will receive medals of honor for bravery in time of peril and for discoveries of importance, which may be of service; but none, I believe, of these discoveries, while perhaps more spectacular, will be of greater importance to their country or more necessary in carrying out this war than the discoveries of our medalist of this evening. If we look over the various activities of the war, we must realize what a tremendous factor gasoline is playing in this great struggle, and that we, and our allies as well, would be at a tremendous disadvantage, if there should be a shortage of supplies. Had it not been for the processes and discoveries of Mr. Burton and his associates, we might be facing that particular condition at this time. We have but to think of aeroplanes, automobiles, and submarines to realize the effect of a shortage of gasoline at this time.

As I look back again over the illustrious names of the men to whom this medal has been awarded, and over the names of the jurymen who have served in bringing about this award, I know of nothing that I would consider of greater value or honor than to have been voted, under the broad terms of the rules of this award, the honor of receiving the Willard Gibbs Medal

I am sure that Mr. Burton feels as I do that it is a reward, a recognition, paying in part for some of the struggles and disappointments which preceded the final success of his work.

CHICAGO, ILLINOIS

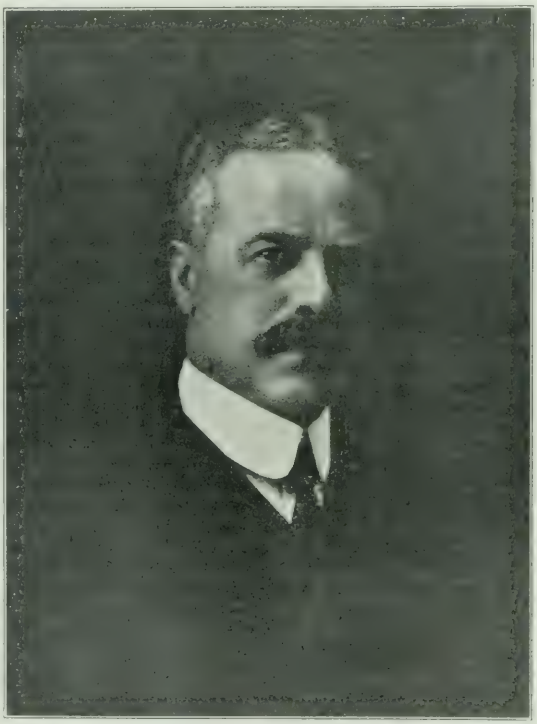
MEDAL ADDRESS

CHEMISTRY IN THE PETROLEUM INDUSTRY

By WILLIAM M. BURTON

Four years ago we assembled to witness the awarding of the Willard Gibbs Medal to Dr. Ira Remsen, of Johns Hopkins University, and one year ago we met for the same purpose in the case of Prof. Edward W. Morley, of Western Reserve University. Both of these gentlemen were honored preceptors of mine, and it was indeed a great pleasure to me to be present on those occasions. I never thought, however, that I would ever be the fortunate recipient of the Willard Gibbs Medal, but the unexpected and improbable very often occurs, and it is so in my case. I, therefore, hasten to extend to the Chicago Section of the American Chemical Society my deepest appreciation of the honor it has conferred upon me.

This event reminds me of a most prominent feature in Dr. Remsen's course of instruction, namely, that the best preparation for a career in technical chemistry is thorough training in the pure science, and I was equally impressed with the introductory sentence of Dr. Morley's address last year, when he said "The best incentive for research work is the work itself." Both of these great teachers have exemplified these principles most happily in their professional careers, and I trust you will find my remarks thoroughly imbued with the influence of their invaluable instruction.



WILLIAM M. BURTON
WILLARD GIBBS MEDALIST, 1918

In considering the part that chemistry has played in the petroleum industry, it might not be unwise to review, briefly, the early history of the industry in this country. You have all heard of the first oil well, drilled by Col. E. L. Drake, near Titusville, Pa., in 1859. Prior to that time petroleum was found in small quantities floating on the surface of springs or small streams of water in western Pennsylvania, and this oil was claimed by the Indians to have marvelous curative properties in the treatment of every manner of disease. The white man, with true commercial instinct, sold the oil in bottles as a general cure-all. The demand for the oil exceeded the supply, and Colonel Drake conceived the idea that if the oil came to the surface of the springs and rivers, there must be large quantities of it in the underlying strata of the earth. He, therefore, with the most primitive machinery, drilled a well near Oil Creek, in western Pennsylvania, and before he had proceeded 100 feet into the ground the oil appeared in such large volume that it was difficult to take care of it.

At that time there was great need for a cheap and convenient illuminating material to supplant the expensive animal and vegetable oils which were used for that purpose. Samples of the petroleum prior to Colonel Drake's discovery were sent to Professor Silliman, of Yale College, who distilled the oil and made separations according to the boiling points of the various fractions. In his report he stated that portions of these distillates might well be utilized for illuminating purposes.

The promoters of the oil business acted upon Professor Silliman's suggestions, and this was the inception of the petroleum refining industry in this country.

For a great many years after Prof. Silliman's investigation, chemistry played a very small part in the practical workings of the refining of petroleum. The refiner learned to treat the illuminating oil distillate with strong sulfuric acid and alkalies, which improved the character of it somewhat, but the methods of refining were crude and wasteful. The only portions of the petroleum which were used at first comprised the fractions boiling between 100° and 300° C., which constituted somewhat over 50 per cent of the total mass of the crude oil. The low-boiling fractions which we now comprise in the generic term of "naphthas" were thrown away, as were also the high-boiling residues, called "tar." The tar, however, was soon utilized for preparing lubricating oils of very indifferent quality. It was not until about 1870, when M. L. Hull, of Cleveland, Ohio, first devised the so-called "vapor stove," that the naphtha fractions of the oil were utilized. But even then the uses for the naphtha fractions did not cause a demand equal to the supply, and much of the naphtha was wasted, a common practice being to throw it into the creeks and rivers, where it evaporated. Millions of gallons of this material, now indispensable for automobiles, were thus lost.

These conditions continued until 1885. Up to this time practically the sole source of petroleum in America was western Pennsylvania. But in 1885, or '86, petroleum was found in western and northwestern Ohio, near the town of Lima, and the fact that this oil contained from one-half to one per cent of sulfur attracted immediate attention. The ordinary refining methods of distillation and treatment with sulfuric acid and alkali were found to be totally inadequate to secure refined illuminating oils of suitable quality. Therefore, the industry turned to the chemist to solve the problem of extracting the sulfur, and producing satisfactory products.

It is very curious that from the early days of the industry until the discovery of Lima oil, there seems to have been prejudice on the part of practical oil men against the chemical fraternity. Why this should have been so is not entirely clear, but I think one reason might be the fact that manufacturers frequently called upon chemists of general training to solve some particular problem connected with their business, ignoring the fact that the chemist probably had had no practical refining experience. The chemist, therefore, probably offered suggestions which were totally impracticable and the manufacturer, seeing this fact, was not particularly impressed with the chemical profession as a possible aid to his business. Whatever the reasons may have been, it was a fact that in 1885, with the discovery of Lima oil, there was scarcely one trained petroleum chemist in the United States. The oil refiners, however, were forced to turn to the chemical profession for the solution of their problems, and the chemists had to become somewhat trained in the refining business before they could offer a practical solution for the elimination of sulfur from the oil.

This was the starting point for a better feeling between the chemical profession and the petroleum industry, and from that time, more and more chemists have been employed in the refining industry, until to-day the larger refineries depend almost entirely upon chemists to manage, not only the refinery as a whole, but the various departments of the same.

In selecting a subject for an address on an occasion like this, it is customary for the candidate to choose as his subject the line of work the results of which have presumably been the reason for his being selected, and I have followed the usual procedure. It is perhaps difficult to describe the work that has been done without appearing to be somewhat boastful. However, the remainder of my remarks will be devoted largely to the results secured by the Chemical Department of the Standard Oil Company of Indiana, and I shall try to recount, briefly, the facts concerning those things which have been accomplished, and eliminate, so far as possible, the personal equation.

I entered the employ of the Standard Oil Company nearly thirty years ago, at the time that the Lima oil problem was very much in evidence, and it was perfectly clear that there was a great field for chemical activity in the petroleum industry, provided the refining companies were willing to educate the chemist in the business, before expecting that the chemist would be of much value to them. The Standard Oil Company signified this willingness, and from 1890 until the present time there have been a great many chemists employed by that company, most of them being in its employ to-day, some as active chemists, some as general managers, and some as managers of various departments. The result has been that the refining of petroleum, instead of being a haphazard process, has been largely systematized and improved, so that when we do certain things we feel confident we will secure certain results, and the great variety of useful products made from mid-continent petroleum to-day indicates the part that chemistry has played in the petroleum industry.

As I indicated a few minutes ago, in the early days the supply of low-boiling fractions of petroleum was largely in excess of the demand. This condition of things existed from the inception of the business until the invention of the internal combustion engine. With the advent of this machine, the demand for low-boiling products, included in the commonly used name of "gasoline," became tremendous.

Prior to 1900 the supply of naphtha products was greater than the demand, and the refiners were compelled to dispose of the surplus for fuel and gas-making purposes.

You will recall that the automobile was devised about that time, and although the use of it grew slowly, we could see a constantly increasing demand for naphtha products to run these machines, until by the year 1910 the demand had more than trebled, and it was perfectly obvious that something would have to be done to increase the supply of these products.

In those days, the average yields of various products of petroleum from mid-continent crude oil were about as follows:

Naphtha products	18 per cent
Kerosene or illuminating products	30 per cent
Lubricating products	10 per cent
Loss	3 per cent

leaving about 40 per cent, which was sold for gas-making or fuel purposes in lieu of coal. It was clear that the problem was to convert the high-boiling fractions existing in the fuel and gas oil into low-boiling fractions needed by the internal combustion engine. It has long been known that superheating the vapors of petroleum at atmospheric pressure caused dissociation of the molecules, producing very low-boiling fractions and very high-boiling fractions, as is evidenced by the ordinary Pintsch gas, with which you are all familiar, but the low-boiling fractions produced by these superheating methods are not suitable for internal combustion engines, and the losses due to fixed gases are very great. It was found that anhydrous aluminum chloride exerted a very marked effect upon the high-boiling fractions, converting some of them into low-boiling fractions entirely suitable for automobile purposes, but the very high first cost of the aluminum chloride, together with the fact that to make the process successful an inexpensive method must be devised for restoring the aluminum chloride, rendered this process out of the question. We worked for almost two years trying to devise a practicable method for securing this most desirable result, first by superheating and dissociation at high temperatures, but at atmospheric pressure, and, secondly, by the employment of various reagents, but our efforts were not successful; on the other hand, we met failure in every direction.

It had been known for a long time that distillation of petroleum products under pressure resulted in their dissociation and production of some low-boiling fractions and some high-boiling fractions, but this process never had been applied in a practical way for the production of motor spirits, because to a practical refiner the distillation of oils under high pressures did not appeal, owing to the extreme hazard due to explosions and fires; but having tried everything else that suggested itself, we decided to attack the problem from the pressure-distillation standpoint.

To the layman, distilling oils under pressure would present no particular difficulty; the distillation of water is done every day in our steam boilers, and why should one fear to do it in the case of oil? But when you consider that the distillation must take place at temperatures ranging from 350° to 450° C., where the tensile strength of steel begins to diminish very rapidly, and when you consider that steel, at such temperatures, in the presence of carbonaceous matter (and even free carbon, which often comes as the result of pressure distillation) is very likely to absorb such carbon, become crystalline, and lose its tensile strength, you can readily see why the practical refiner shivered at the prospect of doing work in this way. We consulted refiners who had been in the business a great many years. We advised with mechanical engineers for whatever suggestions they might offer, and it must be confessed we did not receive very much encouragement.

Since we found, early in our work, that we would require a pressure of about five atmospheres, you can easily see that we approached with considerable respect the problem of building practical apparatus that would stand this pressure in actual daily service. One refiner, for whose opinion I had the utmost respect, said he did not believe we could build a practical still that would stand more than one pound pressure per square inch. Another refiner suggested the probability of explosions, due to

polymerization of the vapors under heat and pressure, such as occur when acetylene is compressed.

However, we were able to secure a very liberal sum of money to try the scheme on a large scale, and the worst that could happen would be to burn up our plant and fail in our efforts. So we went ahead.

The first large still we built had a charging capacity of 6,000 gallons of heavy oil, and about the first difficulty we encountered was serious leaks around the rivet heads and along the seams. The workmanship in building the still was good and it would have been satisfactory as a steam boiler. We found that oil at high temperatures and pressures leaks worse than water, and a leak always causes a fire of an intensity directly proportional to the amount of the leak. It was difficult at first to secure boilermakers who would calk these leaks while the still was under pressure. In many cases when we calked one leak another would form. Finally nature came to our aid and we were gratified to observe that as the still continued in service the leaks became less serious. The oil carbonized under the influence of the high temperature and the carbon deposits stopped the leaks.

There were many puzzling problems to be solved. We had to devise a safety valve that would operate freely in spite of the intense heat and presence of carbonaceous matter. The entire apparatus had to be constructed in such a way as to insure ease of operation and freedom from excessive repairs. Distilling the oils under pressure resulted in the production of so-called "fixed gases." The disposition of these gases, at first, was troublesome. We found that in some cases the heavy oil with which we started evolved more gas than was needed to maintain the desired pressure in the apparatus, whereas other oils evolved an insufficient amount of gas for this purpose. This was an embarrassing situation, but we converted an obstacle into an aid by arranging a large number of stills in parallel so that the superfluous gases from some stills were conducted to others that needed them and this plan gave us a perfect method for securing uniform pressure and control, a most essential feature in the work.

The first large still we built, as I have mentioned, had a capacity of 6,000 gallons, and by starting with fuel oil products having boiling points ranging from 200° to 350° C., we were able to secure a very substantial yield of a product having boiling points ranging from 50° up to 200° C., and to our great gratification the losses incurred thereby were trifling, averaging less than 3 per cent. We were astonished, also, to find that the high boiling residues thus produced yielded a product almost identical with the natural asphalt which is mined in large quantities in the island of Trinidad. Evidently we are doing artificially what Nature has done in ages gone by, *viz.*, distilling petroleum under pressure.

It would require a long time to describe how we solved some of the various problems that arose in connection with this process. From the single 6,000 gallon still we first built, we now have over five hundred stills of a larger capacity. At first our practical men were very loath to accept these pressure stills as a going proposition. They were afraid of them. The minute the slightest thing happened they would be likely to run. But, fortunately, we had no fires or serious accidents for the first two or three years, and when we finally did have a rather bad fire, the men had secured enough self confidence to stand by their guns, and the damages were repaired quickly and the work went on, so that to-day the work of pressure distillation is carried on in our refineries in connection with the regular routine work, and most of us have forgotten that a few years ago we were met with discouraging protests when we proposed making naphtha products in this manner.

During the last five years there have been made in this country over 20,000,000 barrels of gasoline or naphtha products by the use of these stills, and we trust that the future will show a largely increased production (by this process) of this indispensable material.

Although we know very little about the reactions that occur when petroleum is distilled under pressure, it may be interesting to speculate a little on this subject.

Let us start with the paraffin $C_{14}H_{30}$ and see what might happen.

$$C_{14}H_{30} = C_{13}H_{28} + CH_2$$
$$C_{14}H_{30} = C_{12}H_{26} + C_2H_4$$

$$C_{14}H_{30} = C_{14}H_{28} + H_2$$
$$C_{14}H_{28} = C_{13}H_{26} + C_2H_2$$

$$C_{14}H_{30} = 4C_3H_8 + 4CH_4 + C_2H_6 \text{ all gases}$$

$$2C_{14}H_{30} = C_8H_{18} + C_{20}H_{42}$$
$$C_{20}H_{42} = C_8H_{18} + C_{12}H_{24}$$
$$C_{12}H_{24} = C_{11}H_{22} + C_2H_2$$

$$2CH_4 + C_2H_2 = C_3H_8$$
$$3CH_4 + 2C_2H_2 = C_7H_{16}$$
$$C_2H_6 + 2H_2 = C_2H_8$$

We feel confident that the finished gasoline contains such paraffins as C_8H_{18}, $C_{10}H_{22}$, and $C_{12}H_{26}$, but one of the most interesting results is the formation of free hydrogen as shown in one of the above equations.

The fixed gas formed in pressure-still work gives the following analysis:

	Per cent
CH_4	56.3
C_2H_6	25.8
Unsaturated hydrocarbons	8.5
CO	0.8
H	7.4
Condensible vapor	0.6
Undetermined	0.6
	100.0

It would seem almost impossible for hydrogen to be set free under the conditions mentioned above, but the analysis of the gas proves this to be a fact. It also seems probable that, under the influence of heat and pressure, the gases of the different series polymerize to form saturated products that are useful.

It is perhaps to be regretted that the chemists engaged in the petroleum industry have contributed so little to the purely scientific side of the subject. Others have done considerable work along this line, but, for various reasons, the petroleum chemists have not.

The chemistry of petroleum offers a most inviting field for scientific research, and I trust the time will come when this subject will receive the attention it deserves, and when that time does come, I sincerely hope the chemists who have been trained in the practical work will be in a position to do their bit for the advancement of our knowledge of the chemistry of petroleum.

It would be most unjust and unfair for me to accept at your hands the award of the Willard Gibbs Medal without acknowledging to you the invaluable assistance that I have received from my associates, several of whom I see before me in this room. They are fully entitled to their share in the honor that goes with this medal. Some of these gentlemen are chemists and some, although not having a thorough chemical training, are worthy to be called chemists.

It has fallen to my lot to be the director of the work I have just outlined, but it never could have been brought to a successful termination without the valuable suggestions, indefatigable labor, and loyal support of my associates.

STANDARD OIL COMPANY
CHICAGO, ILL.

CURRENT INDUSTRIAL NEWS

By J. McMillan, 24 Westend Park St., Glasgow, Scotland

A NEW COPPER AREA

In a paper read recently before the Royal Society of Arts, London, Mr. W. Frecheville said that in the northern part of Canada there is evidence of the existence of copper over a large area. Specimens or nuggets of native copper were first obtained from the Esquimaux who used the metal for their implements and the occurrence was subsequently confirmed by the few travellers who have been in that region; and it is interesting to note that the specimens of rock which have been collected point to the occurrence being geologically similar to that of the highly productive and profitable copper mines of the Lake Superior district.

The new copper district referred to is situated east of the Great Bear Lake and along the course of the Coppermine River which runs north from about 65° latitude into Coronation Gulf in the Arctic Ocean. Evidences of the occurrence of copper are also reported as far east as Bathurst Inlet and on Victoria Island.

There appears to be no doubt as to the above facts and consequently the present position may be summed up by saying that there may be a great copper field somewhere in that region awaiting development and that the locality is worthy of being carefully examined both from a Canadian and Imperial point of view.

ELECTRIC ZINC FURNACE

According to the *Bulletin Technique de la Suisse Romande*, a Côte-Pierron plant of four furnaces, each of 500 h. p. for 4,500 kg. of ore per 24 hrs., was to be opened at Maurienne, near Epierre, at an early date. The ores, blende and galena, do not require roasting. The ore is charged with lime and coal into the compound furnace which is a combination of an arc resistance and an indirect resistance furnace. The former is the smelting furnace from which the vapors and drops of liquid metal pass into the second furnace at once to be redistilled and condensed. Although the particulars given are not very full, it is stated that a liquid metal of 92 to 93 per cent zinc is gained with a loss ranging from 6 to 9 per cent and that the electrode consumption is 12 kg. per ton of ore.

ELECTRICAL ENERGY FROM THE VOLTERRA "SOFFIONI"

Some time ago reference was made to the experiments made by Prof. Luigi in central Tuscany, on the generation of electric energy from the steam emerging from volcanic fissures in that locality. Some additional details are given in a recent issue of *Engineering*. These steam blasts contain borax and were originally used only for the recovery of this material. The chief problem in the utilization of the steam for developing energy has been to avoid corrosion from its ingredients. This has been met by applying the steam, not directly in turbines, but to heat groups of low-pressure boilers whence steam from pure water feeds the turbines. Borax is collected from the condensed heating steam. The turbines are each 4000 h. p. coupled to 3000 kw. alternators, current being distributed at 36,000 and 16,000 volts to Volterra, Massa, Leghorn, and Florence. It is now proposed to take this source of energy further in order to supply the important steel works at Alti Forni and the Magona d'Italia, at present using coal raised steam. A scheme of treatment for the recovery of helium and other rare gases is also under consideration. While it is too early to judge of the economical results of the scheme, it is stated that the company has sold more power than it at present conveniently produces and that the power available will be largely increased in the future.

UTILIZATION OF FISH OIL

The *Rheinisch Westfalische Zeitung* states that the competent authorities in Germany have prohibited the supply of herrings to the trade except with the heads removed in order that these may be utilized for the production of oil, albumen and phosphate of lime. Fish offal is now utilized in Germany to produce food for human beings as well as for animals. Offal collected from fish-preserving factories, restaurants, etc., is dried and, after the extraction of the oil, ground. The meal so obtained frequently contains 50 per cent and upwards of albumen and phosphate of lime, the latter being obtained from the bones and heads. By chemical methods, the albumen is extracted from the fish-meal and rendered available for human consumption. From the oil, phosphate of lime for animal fodder is obtained by means of benzine, benzol, and other fat solvents. The oil is also used for various technical purposes. Specially good kinds can be hardened by hydrogenation and rendered suitable for production of eatable fat. The hardened fat looks like tallow and is almost odorless.

AUSTRALIAN GELATINE, GLUE AND SIZE

The British Commissioner at Melbourne states that, having recently acquired 17 acres of land at Botany, a company is completing arrangements for the immediate erection there of large works for the manufacture of gelatine, glue and size. The estimated expenditure includes $75,000 for factory buildings and $100,000 for plant and machinery. It is expected that the factory will be working in April and that the products will be on the market in the following month. The average quantity of gelatines and glues of all kinds imported into the commonwealth each year is about 1,400,000 lbs. The capacity of the new factory at Botany, it is expected, will be such that the whole of this trade will be captured. At present, the company has two factories for the production of the same goods operating in New Zealand from whence it is exporting a portion of its output to Canada.

PURE CYANAMIDE

The *Chemical Trade Journal*, 62 (1918), 228, quoting from a contemporary, gives the following as a method for the preparation of pure cyanamide. The starting material was calcium cyanamide having a nitrogen content of 20 per cent. The yield was 55 g. pure cyanamide per 200 g. calcium salt, corresponding to a yield of 92 per cent. 200 g. calcium cyanamide were mixed with 1,500 cc. water in a 3-liter flask. Into this, carbonic anhydride (CO_2) was passed until a neutral or only slightly alkaline action was reached. The flask was kept immersed in cold water as the reaction causes a slight rise of temperature. If the temperature is kept below 40° C. there seems to be little loss of the ether-soluble product due to polymerization to dicyanamide. The precipitated calcium salt is filtered off and the filtrate evaporated *in vacuo*, the evaporation being continued until a crystalline mass separated out on cooling. This mass was extracted three times with absolute ether. On distillation of the ether, the solution which remained was concentrated over sulfuric acid *in vacuo*. In this way, 55 g. pure cyanamide in the form of deliquescent needles were obtained. The substance gave a melting point of 43° C. and was perfectly soluble in ether. On analysis the percentage content of nitrogen was found to be 66.67, the theoretical calculated from the formula being 67.00.

INDIGO CROP OF INDIA

The official Indian *Trade Journal* of December 28 last published a final general memorandum of the acreage and yield of the indigo crop in 1917–18. The report is based upon reports received from provinces containing practically the whole area under indigo in British India. The figures refer to the crop which was then marketed. The total area is estimated at 690,600 acres, 10 per cent below the area in 1916–17 which was 770,000 acres. The total yield of dye is estimated at 87,000 cwt. as against 95,700, the yield for the previous year, or a decrease of 8 per cent. The season was not altogether favorable. Heavy rainfalls and floods affected the crop in Bihar and Orissa and in parts of the United Provinces. In Sind, the crop suffered from low inundation in the beginning of the season.

GYPSUM DEPOSIT IN A BOILER

With regard to the discussion on the setting of plaster and the importance of the hydrates of $CaSO_4$ in this problem, it may be of interest to mention a recent case of deposit of practically pure gypsum, *i. e.*, $CaSO_4.2H_2O$, in a boiler. The case is reported by Professor Goldberg in the *Chemiker Zeitung*. The boiler water had been run off and a little water had been left and had been concentrated to a mud and crystalline deposit in the course of half a year during which the boiler was not used. Over this crystalline deposit were found close, well-defined crystals of gypsum, colorless or slightly yellow and containing only 0.06 per cent of iron oxide and alumina. The crystalline deposit underneath also consisted largely of calcium sulfate but together with magnesia, oxide of iron, and silica. The occurrence of the hemi-hydrate $2CaSO_4.H_2O$ in a boiler instead of the usually observed anhydrous salt was reported as long ago as 1838. In boilers at pressures of several atmospheres, the $CaSO_4$ is deposited as anhydrous salt; the gypsum crystals seem only to be formed at ordinary temperatures.

REACTIONS OF ACETYLENE

In a paper on "Some Reactions of Acetylene" read before the Society of Chemical Industry, London, Prof. W. R. Hodgkinson described the effect particularly on iron, cobalt, and nickel of passing acetylene and acetylene mixed with ammonia over the metal. With so-called pure gas the iron was not much affected but there was a great physical effect on nickel and cobalt. They became brittle and showed decided corrosion and pitting. With iron there was more or less deep carburization, this effect being slight in the case of the other two metals. The carbon from the acetylene was found to have actually entered the ferro-metals. The carburization was peculiar, the carbon showing distinct diffusion into the metal. When the acetylene was diluted with ammonia, an almost smokeless flame was produced and iron, nickel, and cobalt were more rapidly carburized than with acetylene alone. Unfortunately, on subsequent heating, the metals remained brittle.

MAGNESITES

In the course of a paper read by Mr. W. Donald at the meeting of the Ceramic Society held at Stoke-on-Trent, England, the author stated that Greek magnesite has usually more silica and lime but much less ferric oxide than Australian magnesite. In the finely crystalline Greek magnesite, the mineral impurities more especially oxide of iron and alumina are distributed very irregularly. This increases the difficulty of satisfactorily calcining throughout in single firing. Canadian magnesites are even more irregular. In the author's opinion by the careful selection of material, Greek magnesite could be made to compare more favorably with Australian magnesite as regards lime and silica content.

WATER LUBRICATION OF GAS EXHAUSTERS

Mr. Guillet, in an article in *Journal des Usines à Gaz*, recommends, from his own experience, the use of water in place of oil for the lubrication of exhausters. A steam-driven Beale exhauster put into use new in October 1910 has been lubricated in this manner and, without having once been out of service, manifests no appreciable wear after having passed over 1000 million cu. ft. of gas. The lubrication has been effected by siphons delivering town water of great purity, but in general practice, according to Mr. Guillet, it is better to use ammoniacal liquor, since a hard water under the influence of ammonia and carbonic acid gas forms a deposit in the circular passages, causing a block and allowing for dismantling and scraping. With ammoniacal liquor the nuisance does not occur. Exhausters lubricated in this way have kept in excellent condition, the interior surface taking a high polish.

UTILIZATION OF WASTE SULFITE LYE

The disposal of the waste sulfite liquor in the manufacture of wood pulp or cellulose has long been a perplexing problem. Recent experiments, says the *Pulp and Paper Magazine*, have demonstrated that this waste sulfite liquor can be evaporated to dryness and the solid substance thereby obtained may be subjected to calcining and burning. The gases coming off may be trapped and the ashes treated for the recovery of the sulfur as well as the basic substances present in the original bisulfite liquor. Incidentally, and of great economic importance, it may be mentioned that the dry residue produces a fuel containing approximately 6000 B. t. u. per lb. A mill with a capacity of 50 tons of pulp per day will discharge 500 tons of waste sulfite liquor daily containing 10 per cent of organic matter which may be thus reclaimed. The fuel available would have a heat value equivalent to that of 25 tons of high-grade (24,000 B. t. u.) coal. With a view to eliminating entirely the disadvantages of burning over grates, tests have recently been made of burning the material in suspension.

COAL SAVING

The February number of the monthly publication of the British Commercial Gas Association deals with the use of gas coke for steam raising. It contains an article giving a large number of particulars which go to prove the economy alike from an individual and a national point of view, effected by the use of coke instead of crude coal in steam-raising plants. Illustrations are given which show the number, variety, and importance of commercial and other undertakings which have already made the change to great advantage. An interesting section of the article deals with the use of coke as a fuel for road transport in which capacity it is being largely employed to-day.

BRITISH BOARD OF TRADE

During the month of March, the British Board of Trade have received inquiries regarding sources of supply for the following articles. Firms able to give information about these things are requested to communicate with the Board of Trade, 73 Basinghall St., London, E. C.

Bead necklaces, ladies
Celluloid clear transparent sheet form
Cigarette holders (tortoise shell)
Copper asbestos washers
Combined pens and pencils
Corset steel twisted wire
Flat-pencils with sheath
Ink pots with soluble safety lids
Map cases (for officers)
Metal fittings for hair slides
Petrol and tinder lighters
Spangles for dress decoration
Sprinklers for perfume bottles
Steel strip (3/4 in. to 1 1/2 in. wide × 20 to 28 B. W. G. put up on reels)
Sulfite pitch
Thermostats, automatic for electric incubators
Upholsterer's springs
Wheels for tinder and petrol lighters
MACHINERY AND PLANT FOR MAKING
Screw parts of cork-screws
Snuff
Shellac and sticklime
Starch
Stencils

SCIENTIFIC SOCIETIES

ANNUAL MEETING OF THE CHEMISTS' CLUB

The annual meeting of the Chemists' Club was held at the clubhouse on Wednesday evening, May 1, 1918. The treasurer reported that out of the surplus funds $15,000 had been invested in the Third Liberty Loan. Announcement was also made of the acceptance of $10,000 given by Mrs. Herman A. Frasch for the erection of a conservatory in memory of her late husband. The conservatory will adjoin the club dining-room.

Dr. Milton C. Whitaker, the retiring president, was presented with a silver tea and coffee service, the presentation being made by Dr. Charles F. McKenna on behalf of the officers and trustees.

Election of officers for the ensuing year resulted as follows:

President: Ellwood Hendrick.

Vice Presidents: Resident, Charles H. Herty; non-resident, Charles L. Parsons.

Secretary: J. R. M. Klotz.

Treasurer: H. M. Toch.

Trustees: T. R. Duggan, H. G. Mackenzie.

ADDRESS OF PRESIDENT-ELECT HENDRICK

We are receiving in this Club, from the retiring administration, a great estate. It now becomes our duty to conserve it and to administer it to good purpose.

The achievement of establishing this unique institution has been in large part of a social nature, and we must not lose sight of the fact that our function as a Club must continue to partake of this quality. Unless we maintain our house as a chemists' headquarters, as a place where good chemists feel particularly at home, we shall fail in our purpose.

People feel at home according to their individual tastes, but men of discrimination are disposed to favor that which is admirable. Therefore it behooves us to keep the place attractive and, in so far as it is given to do so, distinguished. We are now custodians of the only Club known to the profession of chemistry, and the development of the war has thrown this profession singularly into focus of the public eye. Whatever we say or do, irrespective of the measure of our modesty, straightway becomes a matter for discussion. Less than five years ago a great part of the public seemed to think that chemistry was something principally made in Germany. Without stultifying ourselves, and in full appreciation of the fact that the German language, which we forbid in conversation in the Club, is still the richest of all in chemical literature, we hold that the science is also native in America. Let us endeavor to prove that it is free from German frightfulness, in word as well as in the deeds of peace.

The trustees have seen to it that there shall be no ground for suspicion of any stain of German sympathy in war among us. All members whether American-born or not, who are not in hearty sympathy with the United States and its allies in the great war, have been requested to resign—speedily to resign. The retiring board insisted that the Club be one hundred per cent American, and an intimate acquaintance with the incoming members warrants me in saying that the temper of the new board will be the same. We are in the heat and passion of war and there is no room, anywhere in this building or on our roll of members, for anyone who is against us or even neutral in the present great fight. On the other hand, we must avoid persecution or unkindness of any sort toward good Americans who are of German origin or descent. We must remember that every man is himself and that there is no greater mistake than to get a man mixed up with his grandfather.

A thing that we need, seriously need, is an answer to the question: What is a chemist? I despair of any terse phrase that will tell it, and I am sure that it is not a quality achieved by an academic degree. I know self-educated men who are ripe scholars in the science as well as in the arts and the humanities; and we all know men, academically certificated, who should not be classed as anything better than laboratory helpers. I do not desire to intimate that the Club should find an official answer to the problem; I only have in mind that we should help to establish the meaning so that the right words may be found. I also venture the opinion that if we set a high standard for our membership requirements, we shall be taking a step in this direction and thus do more for the profession than by any other means at our disposal. We are fortunate in having most of the leaders in American chemistry as our fellows. Let us keep up the standard and see to it that this house shall continue to be their real headquarters.

I can hardly trust myself to discuss the great debt we owe to the retiring president, Dr. Whitaker, and I bespeak his aid during the coming year. We are under sincere obligations to the many members who helped us to take over the adjoining building for additional quarters, and to those who have donated their stock in the building company. Our thanks are due to Dr. Weston for assistance in more ways and at more times than there is opportunity to enumerate. To Mrs. Herman Frasch, whose late husband contributed largely, by his invention, to halt the march of Prussian madness in 1915, we are not only indebted for the living portrait of him, but for the conservatory which is now about to be constructed back of the dining-room, which will make our Club unique among those of New York in this special point of attractiveness. It will also provide for our members a place of delectable resort.

I ask members of committees to continue in office until the trustees shall have passed upon the nominations for the ensuing year, in which I hope but few changes will be necessary. And I earnestly request all members to work together during the coming year with the same good-will that has characterized our organization in the past. It is only by the hearty coöperation of the membership as a whole that we can make of this Club the great institution that it deserves to be.

139 East Fortieth Street
New York City

AMERICAN ELECTROCHEMICAL SOCIETY[1]

On Sunday, April 28, at 6 P.M., 126 members and guests of the American Electrochemical Society left the Union Station at Washington for a tour of the Appalachian South, having in view a survey of the resources, water power, facilities and opportunities which that section of the country affords to manufacturers and industrial interests. The cities visited were Johnson City, Kingsport, Knoxville, and Chattanooga in Tennessee, Sheffield (Muscle Shoals), Birmingham, and Anniston in Alabama.

The first stop was at Johnson City on the morning of April 29, where the members were guests of the Chamber of Commerce for breakfast at the Hotel Windsor. Lee F. Miller, president of the Chamber of Commerce, made an address of welcome. The members were then given an opportunity of viewing the town and some of its industries by an automobile tour through the city. An hour later the members reached Kingsport, and were escorted by the reception committee to the Kingsport Inn, where brief addresses were made by V. V. Kelsey, resident manager of the American Wood Reduction Company, and J. Fred Johnson, president of the Kingsport Improvement Corporation. The address of welcome by J. J. Cox, ex-Governor of Tennessee, was responded to by Presi

[1] It is expected that a more detailed description of the plants visited will be published in a later issue of THIS JOURNAL.

dent C. G. Fink for the Society. At noon a luncheon complimentary to the Society was served at Rotherwood Farm, about 4 miles from the city, on the terrace in the shadow of the stately columned portico of the century-old farmhouse now used as an inn. The farm attracted many of the members: it is a model one supplying not only many of the local demands but shipping its products to other parts. The afternoon was spent in visiting plants in the city as follows

KINGSPORT PLANTS

At the Kingsport Extract Corporation, making hemlock and chestnut extract, 24,000,000 lbs. per year capacity, the members saw the entire operation, from the "hogging" to the dried extract, and the pumping of the liquid extract to the Kingsport Tanning Corporation

This tanning company produces 125 hides per day and here again the complete process was viewed—from the liming of the hides and the de-hairing by machinery to the finished leather leaving the tanning vats and drying rooms, ready to go out for ultimate manufacture elsewhere.

The wood chips residue from the extractors of the Extract Corporation are sent to the Kingsport Pulp Corporation, where, in conjunction with other wood treated by the soda process, 60 tons of pulp per day are produced. In this plant the Dorr classifier and thickener are used

The Kingsport Paper Company reduces the pulp to paper, the product now being a soft paper like blotting paper, and also paper board.

The Kingsport Hosiery Mills, built within the year, where 2100 dozen pairs of hose are being produced daily, were of interest. The plant is so built that it can be easily doubled in capacity in the present building.

The Clinchfield Portland Cement Corporation, producing 400 barrels of Portland cement per day, was visited. At this plant the Cottrell system for the precipitation of dust is being installed and it is expected that a recovery of potash amounting to 9 per cent of the dust will be made. The product is to be converted into potassium carbonate and potassium sulfate, and it is expected that 4 tons of these salts will be produced daily. Adjoining this plant is that of the Kingsport Lime Corporation, built by Richard K. Meade, and producing 50 tons per day. Nearby also is the power plant of the Kingsport Utilities Corporation, supplying power to all the industries in the Kingsport Valley. Clinchfield coal is used and 15,000 h. p. are produced

The Kingsport Brick Corporation, where drain tile, sewer pipe, common building brick, face brick, etc., are being produced, and the Federal Dyestuff and Chemical Company were visited. The latter has the largest installation of Allen Moore cells in the country, there being 105 with a capacity of 20 tons of sodium hydroxide and 20 tons of chlorine per day. The Hebden process is used for dehydration of the chlorine and for the chlorination of the products in the plant

The Kingsport Wood Reduction Corporation plant, a government subsidized plant being built by the American Wood Reduction Company, was visited, together with the cantonments built for the workmen who are at present employed there

During the day an exhibit of the minerals of the Clinchfield region was to be seen at the Kingsport Inn. In the late afternoon motion pictures of the Clinchfield region, taken over the Clinchfield line from Elkhorn City, Ky., to Spartanburg, S. C., were shown in the local motion picture theater to the members of the Society. Dinner complimentary to the members of the Society was served at the Kingsport Inn, after which a business meeting of the Society was held. The Committee reported the election of officers as follows

President, F. J. Tone; *First Vice President*, Acheson Smith; *Second Vice President*, H. W. Gilbert; *Third Vice President*, R. Turnbull; *Treasurer*, Pedro G. Salom; *Secretary*, Jos. W. Richards. *Managers*, Chas. F. Burgess, E. J. Crosby and C. G. Schluederberg.

EN ROUTE TO KNOXVILLE

Leaving Kingsport at midnight, Mascot was reached early the morning of April 30. The members of the Society were the guests of the American Lead and Zinc Company at breakfast, after which its plant was visited. Wemlev and Deister-Overstrom tables and the Minerals Separation, Inc., oil flotation process are used in this plant for the concentration of the ores. The ore which, when mined, contains 3 per cent. is concentrated to 60 per cent with the loss of a very minute fraction of zinc sulfide.

Arriving at Knoxville, the party transferred to another train and left for Cheoah, N. C., where the Aluminum Company of America is building a dam 200 feet high (90 ft. higher than Niagara Falls), and from a 180-foot head plans to operate 4 wheels of 18,000 kw. each (25,000 h. p.) with an efficiency of 92.5 per cent. They expect to have the power on the busses at Alcoa in 9 months, generating at the station 13,000 volts, transmitting 150,000 voltage of 25 cycle. The company is planning nine dams along the river, two large and seven small ones, giving them a total fall of 1800 feet. At Alcoa, several miles downstream from Cheoah, it is intended to build another dam to be at least as high as the one at Cheoah. These water-power developments are carried on through subsidiary companies, the one operating in North Carolina being known as the Tallassee Power Company and the other, operating in Tennessee, as the Knoxville Power Company.

Returning to Knoxville the party proceeded at once to the University of Tennessee, where a technical meeting was held, at which Mayor J. E. MacMillan welcomed the members to the city, and Dr. Brown Ayres, president of the University, welcomed them to the University. The following papers were read:

Hydroelectric Power Possibilities in the Provinces of Quebec and Ontario, Canada. LOUIS SIMMEN.
The Calculation of Storage Battery Capacities. C. W. HAZELETT.
The Sign of the Zinc Electrode. W. D. BANCROFT.
Electrical Resistivity of Porcelain and Magnesia at High Temperatures. P. H. BRACE.
Precision Method for the Determination of Gases in Metals. H. M. RYDER.
Nitrogen Fixation Furnaces. E. K. SCOTT.

The Society went from the University to the Agricultural Experiment Farm of the University of Tennessee, where the lysimeter with which Dr. MacIntyre and his staff are carrying on valuable soil studies is located. At a complimentary dinner at the Cherokee Country Club, in the evening, Hugh M. Tate, as toastmaster, made an address in the course of which he argued that the Electrochemical Society had been brought to Knoxville by the exhibit made by the city at the Chemical Exposition last Fall and that, therefore, the city should neglect no opportunity to exhibit at any future National Exposition of Chemical Industries. Dr. Fink made a stimulating response. C. G. Schluederberg spoke on "The Part the United States Industries Must Perform to Enable the Allies to Win the War." Yogoro Kato made a brief address, followed by John A. Switzer, upon "The Industrial Water Powers of Tennessee."

CHATTANOOGA

Arriving at Chattanooga the next morning, May 1, the party breakfasted at Hotel Patten, after which the local committee escorted the members to the plant of the Southern Ferro-Alloys Company, where every 24 hours 2,000 pounds of 50 per cent ferrosilicon are being made in Fitzgerald electric furnaces. This is the first ferrosilicon plant in the country ever opened to any society, and this was done through the kindness of Paul J. Kruesi, president of the company and a member of the Society. Members then visited the plants of the Burdette Oxygen Company and Wilson & Company. At the latter plant

coconut, cotton, peanut, and soya bean oils are being refined. The hydrogenation plant was not open to the members.

The Chattanooga Chemical Company and the Semet-Solvay ovens of the Chattanooga Gas and Coal Products Company were visited. Here 24 Semet-Solvay ovens using 450 tons of coal per day have replaced 12 Roberts ovens. The members then motored to Crystal Springs Bleachery. The return trip to Chattanooga was made by the Crest Road, along Missionary Ridge. An hour was spent at the Chattanooga Manufacturers' Association exhibit in the Association Building before the Society left on a river steamer for Anthony N. Brady's $11,000,000 power plant at Hale's Bar, operated by the Chattanooga-Tennessee River Power Company, whose power is marketed through the Tennessee Power Company. This is a low-head development, having 14 vertical wheels of 3,000 kw. each (4,000 h. p.), 6600 volts of 60 cycles, and 120,000 volts of 60 cycles.

SHEFFIELD AND MUSCLE SHOALS

On Thursday morning, May 2, the Society arrived at Sheffield, Ala., where, after a breakfast at which Col. J. W. Worthington gave an address of welcome, the members were taken in automobiles to visit the town of Sheffield and thence to Government Nitrate Plant No. 1, in charge of Capt. R. W. Hempill. This is the plant using the General Chemical Company's synthetic process. The plant location was accepted September 10, 1917, the company organized October 1, contract signed with the J. G. White Company on October 2. On October 23 the first load of construction material arrived and work on the buildings began. The buildings were almost complete as the members of the Society saw them and the installation of machinery was going forward rapidly. The plant, costing $20,000,000, consists of a gas works, a process building housing the General Chemical Company's process, and a power house, also the concentration, oxidation and absorption plants, for which the Chemical Construction Company have the contract. There will be a nitrating plant and an experimental laboratory. There is also under consideration the erection of a battery of coke ovens. One-half of this plant is expected to be completed by June 15, 1918.

At Nitrate Plant No. 2, work was started on November 17, 1917. The plant construction was contracted for with the Westinghouse, Church, Kerr Co., J. G. White Engineering Company, and the Chemical Construction Company, and consists of a lime plant which will burn 350,000 tons a year (the largest lime plant in the country), a coke drying plant with 100,000 tons yearly capacity, a liquid air plant with a capacity greater than all other plants in the United States and Canada combined, a power house which will produce 45,000 kw., and as needed, 35,000 kw. more will be secured from hydroelectric plants in the vicinity. J. W. Young welcomed the Society to the plant and E. J. Pranke of the Cyanamide Company gave a descriptive address. Those in charge of operations are Captain S. L. Coles for the Government; J. W. Young for the Air Nitrate Corporation; G. W. Burpee, M. T. Thompson, and T. C. Oliver for the contractors.

Leaving Plant No. 2, the party motored to Lock 6 on the Tennessee River at Muscle Shoals, where the members viewed the Muscle Shoals canal. After a barbecue luncheon, served by the Society's hosts, an informal meeting was held, at which C. W. Ashcraft of the local committee was chairman. The speakers were Col. J. W. Worthington, C. G. Fink, C. A. Winder, N. T. Wilcox, J. W. Richards, W. G. Waldo, Stewart J. Lloyd, and Col. A. H. White. Leaving Lock 6, the return to Florence was made on a Government steamer and barge, from which a fine view of the surrounding country and of the site of dam No. 2, just above Florence, was obtained.

BIRMINGHAM

Friday, May 2, was spent at Birmingham, where a local reception committee made up of members from the Alabama Technical Association, the Alabama Section of the AMERICAN CHEMICAL SOCIETY, and the Chamber of Commerce provided autos, and a visit was made to the Tennessee Coal, Iron and Railroad Company's Ensley plant where duplex steel is being made. In the afternoon a visit was made to the by-product plant of the company, which has four batteries of Koppers ovens. Passing through the mine property at the Fairfield Works, the party had a view of the new plate mill which is to produce steel plate for the shipbuilding plant located at Mobile, both of which are now under construction. The American Steel and Wire Works at Fairfield were also visited. In the evening the hosts entertained with a dinner at the Hotel Tutwiler, Arthur C. Crowder, president of the Chamber of Commerce, acting as toastmaster. The speakers were ex-Governor Emmet O'Neil, C. G. Fink, J. V. N. Dorr, and H. Morrow. This was followed by a technical meeting held in the ball room of the hotel at which Eugene A. Smith, State Geologist, spoke on "The Mineral Resources of Alabama," and the following papers were read and discussed:

The Electrolytic Behavior of Manganese in Sulfate Solutions. G. D. VAN ARSDALE AND C. G. MAIER

The Effect of Iron Sulfate in the Electrolytic Precipitation of Copper from Sulfate Solution with Insoluble Lead Anodes. E. F. KERN.

Experiments with the Copper Cyanide Plating Bath. F. C. MATHERS.

Load-Carrying Capacities of Magnesia-Silica Mixtures at High Temperatures. O. L. KOWALKE AND O. A. HOUGEN

Electrolytic Refining of Tin. E. F. KERN.

Thermo-Electric Force of Some Alloys. M. A. HUNTER AND J. W. BACON

Why Busy Rails Do not Rust. O. P. WATTS.

A New Electric Furnace. C. H. VOM BAUR

The Booth-Hall Electric Furnace. W. K. BOOTH

Electric Steel Casting. R. F. FLINTERMAN

ANNISTON

The morning of Saturday, May 4, was given over to Anniston. After breakfast at Anniston Inn, an impressive address on the development of their ferromanganese plants in Anniston was made by Theodore Swann, president of the Southern Manganese Corporation, after which the members visited the ferromanganese furnaces of the Southern Manganese Corporation, the ferromanganese and Héroult furnaces of the Anniston Steel Company. The return from Anniston to Washington was made in 24 hours, in the special train occupied by the members for the entire tour, in the operation of which the Southern Railway took great pride. The geologist of their Industrial Department, J. H. Watkins, was one of the members of the Society on the trip and was always ready to give any desired information.

CHARLES F. ROTH
Chairman, Committee in Charge

SIXTH NATIONAL TEXTILE EXPOSITION

The Sixth National Textile Exposition was held at the Grand Central Palace, New York City, April 29 to May 11, 1918. The exhibition occupied all four floors of the Palace, a fact indicating its large size, and included exhibits of cloths and yarns, machinery and accessories for their production, aniline and other dyestuffs used in their coloring, and in addition a fashion show was given each afternoon and evening, of gowns and costumes designed and made in America of American-made textiles, and dyed with American dyes.

The main and second floors were almost wholly given over to exhibits of textile machinery and such accessories as oils, lubricants, beltings, paints, air conditioners and moisteners, temperature controllers, etc.

The exhibits of special chemical interest were those by the dyestuffs manufacturers. The two largest were those of the

Marden, Orth and Hastings Corporation and the National Aniline and Chemical Company. The exhibit of the latter attracted much attention on account of the practical demonstrations of the merits of American dyes as compared with those of German make. Samples of cotton, silk, and wool dyed with corresponding American and German dyes were exhibited, showing very graphically how these had stood tests for fastness to light, fulling, scouring, and weather, with the results gratifyingly in favor of the American-made dyes. Approximately fifty colors were shown in the comparative samples, including blues, browns, greens, purples, reds, and yellows, and comprising direct, acid, basic, chrome, and sulfur colors as well as some developed ones. An interesting feature of the exhibit of this company was the working unit of a fully equipped color testing laboratory in which the work of making these comparative tests was actually being carried on.

The Marden, Orth and Hastings Corporation exhibited jointly with the Calco Chemical Company and showed samples of the dyestuffs, coal-tar intermediates, and chemicals entering into the manufacture of the colors which they displayed, these including their new line of "orthamine" colors. They also displayed suitings, overcoatings, yarns, and raw stocks dyed with their products and especially featured their khaki colors in this connection.

Other exhibitors of dyestuffs and chemicals were the du Pont Companies, Frank Hemingway, Inc., John Campbell and Co., Stamford Extract Manufacturing Company, Southern Dyestuffs and Chemical Company, Sterling Color Company, Williamsburg Chemical Company, Oakley Chemical Company, American Alkali and Acid Company, and the American Dyewood Company.

The Dicks David Company, of New York City, made a special feature in their exhibit of various fabrics dyed by American dyers using this Company's products and demonstrating conclusively that American dyes are fully the equal in purity and strength of those imported.

An interesting exhibition of starches, gums, and dextrines was that of Stein, Hall and Co.

The Takamine Laboratory showed their product, "Polysime," a de-sizing and de-gumming agent. A very illuminating part of their exhibit was the demonstration they gave of the progress of chemical industry in Japan within the past few years.

NEW YORK SECTION, AMERICAN CHEMICAL SOCIETY

The recent investigation by the city administration of the work of the Bureaus of the Department of Health of New York City has resulted in the suspension of the Director of the Bureau of Food and Drugs, Dr Lucius P Brown Following the appointment of Dr. Royal S. Copeland as Commissioner of Health, the Chairman of the Civil Service Commission, Mr. James E. MacBride, filed charges against Dr. Brown, and these charges were simultaneously given to the public press. Accordingly Director Brown answered the charges through the press, and for this action was suspended by the Commissioner of Health, pending a public hearing on charges which are now being prepared

At the regular meeting of the New York Section of the American Chemical Society on May 10, 1918, the following resolutions were unanimously adopted by the Section

Whereas the importance of chemistry and the work of the chemist has been brought clearly home to the people of this country, particularly since the outbreak of the war, and has resulted in largely increased numbers of industrial laboratories for the careful control of manufacturing processes and especially for the maintenance of standards of purity of products, and

Whereas the increased demand for chemists through this industrial expansion and through the large number called into the service of the Government for the purpose of the successful conduct of the war has created a serious shortage in the available supply of chemists, and

Whereas it appears that there is a possibility of a serious impairment of the efficiency of the Bureau of Food and Drugs of the Department of Health of New York City through the lessening of its activities or change in its present efficient direction,

Therefore be it Resolved:

First: That we urge upon the duly constituted authorities to preserve in every way possible, for the full benefit of the people of this city, the protection of the public health so largely dependent upon the work of this Bureau.

Second: That we are convinced that in the present incumbent of the office of Director of the Bureau of Food and Drugs, Dr. Lucius P. Brown, the city has a most valuable administrative, technical, and scientific official, selected on the basis of these qualifications by the impartial method of Civil Service Examination, experienced in his work through long service as Food and Drug Commissioner of Tennessee, a recognized leader among the food and drug officials of the nation, as witnessed by his presidency of their association and constant prominence upon important committees charged with the solution of fundamental food and drug problems, a man whose integrity is beyond question and whose marked faithfulness in administering the work of his present position assures to the people of this city thorough protection against adulteration of its food and drug supplies.

Third: That we commend the Commissioner of Health for his stand that any questions which have been raised regarding the administration of this important Bureau in the Department of Health shall be given a full and public hearing, for we are confident that through such a medium the usefulness and high standard of the Bureau will be continued without impairment.

NORTH CAROLINA ACADEMY OF SCIENCE AND NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

The Seventeenth Annual Meeting of the North Carolina Academy of Science was held jointly with the Spring Meeting of the North Carolina Section of the American Chemical Society at the State Normal College, Greensboro, N. C., on April 26 and 27, 1918.

PAPERS PRESENTED BEFORE THE ACADEMY

The War Work of American Physicists. C. W. Edwards

Some Important but Largely Neglected Scientific Facts. George W. Lay

Symptoms of Disease in Plants. F. A. Wolff.

The Sun's Eclipse, June 8, 1918: Question. John F. Lanneau.

Entrance Requirements in Science at the State Normal College. E. W. Gudger

Extension of the Range of *Prunus umbellata* into North Carolina. J. S. Holmes

Eliminations from and Additions to the List of North Carolina Reptiles and Amphibians. C. S. Brimley

A New Species of Azalea. W. C. Coker

Notes on the Magnetic Compass. T. F. Hickerson

Variations Within the Individual Sponge Towards Types of Structure Characteristic of Other Species and Genera. H. V. Wilson

New or Interesting North Carolina Fungi. H. C. Beardsley.

Herpetological Fauna of North Carolina Compared with That of Virginia. C. S. Brimley

Further Consequences of Cross Conjugation in Spirogyra (Lantern). Bert Cunningham

A Visit to Smith's Island Lantern. W. C. Coker

Some Methods and Results of a Plankton Investigation of Chesapeake Bay Lantern. J. J. Wolfe and Bert Cunningham

Mineral Fertilizers; Their Mode of Occurrence and Distribution in North Carolina. Collier Cobb

Notes on Buds. E. W. Gudger.

Recent Changes in Currituck Sound. Collier Cobb

PROGRAM OF THE N. C. SECTION, A. C. S.

Report of Investigations on the Cause of Death of Matured Chicks in Shell in Artificial Incubation. H. R. Arkwright

Effects of Fertilizers on Hydrogen-Ion Concentration of Soils. J. K. Plummer

Action of Heat on Para-Sulfamido-Ortho-Toluic Acid. J. W. Nowell

Toluol from Spruce Turpentine. A. S. Wheeler

The Question of the Recovery of Tin from Scrap and Cans in North Carolina. Carlton F. Miller

NATIONAL FERTILIZER ASSOCIATION

The Twenty-fifth Annual Convention of the National Fertilizer Association will be held at Hotel Traymore, Atlantic City, N. J., the week beginning July 15. Meetings will be held as follows:

JULY 15TH AND 16TH: Meetings of the Soil Improvement Committee of the National Fertilizer Association.

JULY 16TH: Meeting of the Southern Fertilizer Association.

JULY 17TH AND 18TH: Meetings of the National Fertilizer Association.

The Convention Committee appointed by President Bowker of the National Association to take entire charge of the details of all convention arrangements is as follows: *Chairman*, John D. Toll, Philadelphia; C. M. Schultz, New York; W. Dewey Cooke, Savannah; Irvin Wuichet, Dayton, Ohio; Horace Bowker, New York, *ex-officio*. The committee will announce later the details of the program, names of speakers, and arrangements for entertainment.

ALABAMA TECHNICAL ASSOCIATION AND THE ALABAMA SECTION OF THE AMERICAN CHEMICAL SOCIETY

A joint meeting of the Alabama Technical Association and the Alabama Section of the AMERICAN CHEMICAL SOCIETY was held in Birmingham, Ala., on May 2, 1918.

PROGRAM

Experimental and Extension Work in Agriculture in Alabama. PROFESSOR DUGGAR.

Some of the Relations of Chemistry to Agricultural Progress. DR. B. B. ROSS.

The Alabama Technical Association was formed last year, its object being to maintain an organization among the technical men of Alabama to stimulate the development of the natural resources of the State, to foster public interest in all things beneficial to the State, to advance the interests of the technical profession in the State, and to encourage social intercourse among its members.

The membership is made up of members of the following national societies: American Society of Mechanical Engineers, American Institute of Mining Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Architects, and the AMERICAN CHEMICAL SOCIETY. The officers are: *President:* Karl Landgrebe, Ensley, Ala.; *Vice President:* H. B. Battle, Montgomery, Ala.; *Secretary-Treasurer:* F. G. Cutter, Ensley, Ala.

AMERICAN LEATHER CHEMISTS' ASSOCIATION

The Annual Meeting of the American Leather Chemists' Association was held at Hotel Traymore, Atlantic City, N. J., on May 16 to 18, 1918, in conjunction with the National Association of Tanners.

The program included reports and addresses as follows:

COMMITTEE REPORTS

Determination of Free Sulfuric Acid in Leather. J. S. ROGERS.

Testing of Coal-Tar Dyes for Leather. H. R. DAVIES.

Testing of Dyewood Extracts. C. R. DELANEY.

Effect of Hard Water on Tannins. T. A. FAUST.

Comparative Analysis. R. W GRIFFITH.

Small's Modification of the Hydrochloric Acid-Formaldehyde Method of Separating Tannins, with Special Application to Chestnut Oak Bark and Chestnut Wood. T. G. GREAVES.

ADDRESSES

Problems for the Consideration of the American Leather Research Laboratory. F. H. SMALL.

Upper Leather for Army Shoes. FRED A. VOGEL.

Sole Leather for Army Shoes. ALLEN ROGERS.

The Work of the Bureau of Standards in Leather. R. L. WORMLEY.

Description of Purifying Plant for Treating Tannery Effluent. C. L. PECK.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The Summer Meeting of the American Institute of Chemical Engineers will be held at Gorham and Berlin, N. H., June 19 to June 22, 1918. Headquarters: Mt. Madison House, Gorham.

PROGRAM OF PAPERS

The Human Element in the Mill. HUGH K. MOORE.

Maintenance, Construction and Organization of Sulfite Mill. WALTER H. TAFT.

The Seeding Method of Graining Sugar. H. E. ZITKOWSKI.

The Manufacturer and Fuel Situation. WM. M. BOOTH.

War Pyrotechnics. G. A. RICHTER.

Food Conservation. EDWARD GUDEMAN.

Chemical Stoneware and Its Properties. A. MALINOVSZKY.

Symposium on the Coal-Tar Industry

Expansion of the Coal-Tar Industry in the United States. F. E. DODGE.

Expansion of the By-Product Industry of Coal and Water-Gas Plants in the United States. W. M. RUSSELL.

Manufacture of Phenol. A. G. PETERKIN.

Multiple Tangent System for the Manufacture of Sulfuric Acid. L. A. THIELE.

The following plants of the Brown Company will be visited under the leadership of Mr. Hugh K. Moore: Sulfite Mill, the largest sulfite mill in the world; Saw Mill and Photographic Department; The Cascade Paper Mill; Chemical Plants, including Electrolytic and Caustic Plants; Fiber Tube Mill; Carbon Tetrachloride Plant; Chloroform Plant; and Hydrogenated Oil Plant.

A joint meeting with the local section of the AMERICAN CHEMICAL SOCIETY will be held on Wednesday evening at the Mt. Madison House. A unique feature of the program will be an entertainment by the employees of the Brown Company.

RESEARCH AS AN AID TO INDUSTRIAL EFFICIENCY

The first joint meeting of the American Cotton Manufacturers' Association and the National Association of Cotton Manufacturers was held in New York, May 1 to 3, 1918, in conjunction with the Textile Exposition.

On Friday, May 3, a session was devoted to the consideration of "Research as An Aid to Industrial Efficiency," the program having been arranged by the committee on industrial research. The principal speakers were Dr. George E. Hale, chairman of the National Research Council; Dr. Charles L. Reese, chemical director of E. I. du Pont de Nemours & Co.; Dr. Edward R. Weidlein, associate director of the Mellon Institute; and Dr. C. E. K. Mees, of Eastman Laboratory.

Dr. Hale's subject was "Development of Research Work." He traced the growth of industrial research in this and other countries, illustrating it with interesting specific instances, and offered the assistance of the National Research Council in any movement the cotton manufacturers may undertake looking toward the establishing and carrying on of research in connection with that industry.

Dr. Reese, speaking on "The Value of a Chemical Organization," classified the various functions of the chemist in a well-organized industry, distinguishing carefully between those of the routine analytical and the research chemist.

In his address on "Science and Industry," Dr. Weidlein outlined the method of development of the Industrial Fellowship System at the Mellon Institute and gave an account of the services which the Institute is rendering to the Government at the present time.

The addresses of Dr. Hale, Dr. Reese and Dr. Weidlein are given in full in the May 4 issue of the *Textile World Journal*. The address of Dr. Mees is printed on page 476 of this number of THIS JOURNAL.

CALENDAR OF MEETINGS

American Society of Mechanical Engineers—Worcester, Mass., June 4 to 7, 1918.

American Institute of Chemical Engineers—Annual Summer Meeting, Berlin, N. H., June 19 to 22, 1918.

American Society for Testing Materials—Atlantic City, N. J., June 25 to 28, 1918.

National Fertilizer Association—Annual Convention, Atlantic City, N. J., week of July 15, 1918.

American Pharmaceutical Association—Annual Convention, Chicago, August 12 to 17, 1918.

American Chemical Society—Fifty-sixth Annual Meeting, Cleveland, Ohio, September 10 to 13, 1918.

National Exposition of Chemical Industries (Fourth)—Grand Central Palace, New York City, September 23 to 28, 1918.

ANNUAL MEETING OF THE AMERICAN CHEMICAL SOCIETY

The officers of the A. C. S. have decided upon September 10 to 13, 1918, as the date of the Fifty-Sixth Annual Meeting, which is to be held this year in Cleveland, Ohio.

NOTES AND CORRESPONDENCE

WOMEN'S NATIONAL LEAGUE FOR THE CONSERVATION OF PLATINUM

The National Chairman of the League is Mrs. Ellwood B. Spear, 27 Walker Street, Cambridge, Mass. The Council is made up as follows:

Arizona
Mrs. Henry D. Ross

California
Miss Julia George

Colorado
Miss Louise J. Eppich
Mrs. C. M. Lillie

Connecticut
Mrs. Charles L. Alvord
Mrs. James R. Bolton
Mrs. Percy T. Walden

Illinois
Mrs. Julius Stieglitz
Miss Marion Talbot

Maine
Mrs. Mary Stone Burnham
Mrs. George C. Frye
Miss Deborah Morton

Maryland
Mrs. Frank C. Mathews
Miss Mary L. Titcomb

Massachusetts
Miss Bertha M. Boody
Miss Abbie Farwell Brown
Mrs. Samuel V. Cole
Mrs. George W. Coleman
Mrs. Arthur F. Coolidge
Miss Ada Comstock
Mrs. Frank D. Ellison
Miss Ethel Hale Freeman
Mrs. Walter L. Jennings
Mrs. Arthur E. Kennelly
Mrs. Kenneth L. Mark
Mrs. Harold Murdock
Mrs. Robert W. Neff
Mrs. James F. Norris
Miss Ellen F. Pendleton
Miss Helen Leah Reed
Mrs. Henry P. Talbot
Miss Caroline Ticknor
Mrs. William H. Walker
Mrs. Austin C. Wellington
Mrs. True Worthy White
Miss Helen M. Winslow
Miss Mary E. Woolley

Minnesota
Miss Gertrude H. Beggs

Missouri
Mrs. N. W. Hopkins
Miss Eva Johnston
Mrs. Philip North Moore

New York
Mrs. Henry Altman
Mrs. Wilder D. Bancroft
Miss Blanche E. Hazard
Mrs. Charles H. Herty
Mrs. B. C. Hesse
Miss Isabel Ely Lord
Miss Annie Louisa Macleod
Miss Margaret E. Maltby
Mrs. Roy Martin

North Carolina
Mrs. Thomas W. Lingle
Mrs. F. R. Venable

Ohio
Mrs. Cornelius Selover

Oregon
Mrs. Vincent Cook

Pennsylvania
Miss Florence Bascom
Mrs. E. W. Clark, Jr.
Mrs. Theodore W. Cramp
Mrs. L. Webster Fox
Miss Margaret B. MacDonald
Mrs. J. Willis Martin
Mrs. Howard M. Phillips
Mrs. Alfred S. Weill

Rhode Island
Miss Sarah E. Doyle
Mrs. Maud Howe Elliott
Mrs. George H. Fowler

The Pennsylvania Chairman has issued 10,000 copies of the following letter:

TO THE WOMEN OF PENNSYLVANIA

This League is asking you to refuse to purchase, or accept as gifts, jewelry and other articles made in whole or in part of platinum, for the following reasons

Ninety-five per cent of the world's supply of platinum comes from the Ural Mountains. Present conditions in Russia make this source of supply extremely uncertain. Moreover, in 1916, Dupare in a French report on the Ural deposits stated that, at the present rate of working, these would be exhausted in 12 years.

The United States Geological Survey Report on Platinum and Allied Metals in 1917 shows that the total amount mined since its discovery in 1843 is 10,000,000 ounces. Of that amount, one-third has been used unproductively in jewelry; one-third has been used in dentistry, much of which has returned to the earth by burial, one-third has been used in physical and chemical apparatus, in chemical industry, and electrical devices.

Our Government needs platinum to make nitric and sulfuric acids, which are necessary in the production of explosives.

Platinum is absolutely essential in the manufacture of pyrometers which are necessary in all steel treatments—no gun can be made without the use of pyrometers.

Some essential signal instruments are dumb without platinum.

Platinum is essential in the composition of certain delicate gun mechanisms.

Our country's electrical defense is dependent on iridium, a rare metal occurring with platinum and used to harden platinum used in jewelry and electrical apparatus.

Our industries need platinum in their control laboratories for the manufacture of nitric and sulfuric acids, drugs, dyes, and fertilizers.

Our educational institutions cannot afford to pay the exorbitant price for the platinum essential to train men for these industries.

The control lever of all chemical industries is analytical chemistry, and platinum is indispensable in that line of work.

Platinum is used in making nitrates from the air for fertilizers and munitions.

Without platinum all experiments in gases would be greatly handicapped.

In other words, while our Government, our industries, and our educators all have serious use for this rare metal, one-third of the world's entire supply has been used unproductively in jewelry.

When the price of platinum was less than gold, women had no desire to use it in jewelry except as a setting for gems. Now that its price is five times that of gold, over fifty per cent of the country's supply is used annually for jewelry. Ask yourselves the reason. Would any woman wear a lead-colored ring or bracelet or adorn herself with lead-colored jewelry except that its artificially produced *high price* has been made to give it a false value in her eyes? When women cease to demand platinum jewelry, platinum jewelry will no longer be made. If you want to have jewels set in a white metal, ask your jeweler to make the settings of rhotanium or white gold. These alloys closely resemble platinum and are just as well suited to the setting of stones. Rhotanium cannot be distinguished by sight from platinum, even by chemists. By using these alloys, you can have your jewelry, save money, and at the same time serve your country by conserving this rare metal for productive uses in the war program.

This League asks that you coöperate in this most important branch of conservation.

Very truly yours,

LOUISE S. Y. WEILL
Pennsylvania Chairman

WEST CHESTNUT AVENUE
CHESTNUT HILL, PA.

SEARLES LAKE OPEN TO LEASE APPLICATION

Secretary of the Interior Lane has announced that the public surveys have been extended over the lands known as Searles Lake, in San Bernardino and Inyo Counties, California, and the township plats forwarded to the United States Surveyor General with direction that the requisite copies be promptly furnished to the United States Land Office at Independence for filing.

Aside from lands patented years ago and lands embraced in subsisting mining claims, there are about 8 sq. mi. of the potash brine zone that are now open to applications for leases, pursuant to the act of October 2, 1917, and the regulations thereunder of March 21, 1918.

The United States Land Office at Independence, Cal., has been instructed to receive applications for leases as soon as the township plats are received, and when the plats have been formally filed 30 days later, to forward the applications to the General Land Office for action. In the meantime publication of notice of application may proceed as required by the regulations.

Parties desiring to lease the Searles Lake potash lands can therefore now file their applications in the United States land office at Independence, Cal. Copies of the regulations may be procured from the Commissioner of the General Land Office, Washington, D. C.

The Searles Lake deposit is recognized as a large and available source of commercial potash, and two plants are manufacturing potash from this source at present. Saturated brine deposit is the source of potash now being produced.

A number of parties have already filed applications for leases in the Searles Lake region.

Several applications have also been filed for leases to the potash deposits in Wyoming. The potash leasing bill provided that the Secretary of the Interior may issue leases for deposits of potash in public lands in Sweetwater County, Wyoming, which also contains a sub-deposit of coal, on condition that the coal be restored to the United States.

It should be clearly understood that there are two classes of leases allowed under this bill—one is for leases on the two known deposits, Searles Lake and Sweetwater County, Wyoming, and the other is to hunt for deposits where it is not known that there are potash deposits.

Under the part of the act which permits exploration for undetermined deposits of potash a number of permits have been issued for exploration of lands in California, Nevada, and Colorado.

A LETTER FROM FRANCE

GAS SERVICE
A. P. O. No. 717, A. E. F.
April 5, 1918

DEAR DR. HERTY:

I am in receipt of your interesting letter of March 13. Be sure to continue to write me occasionally, for any home chemical news is welcomed by us all. So far, no copies of the Industrial Journal have been received, so I enjoyed the editorial separates.

Colonel Bacon and I are now located about 150 miles from Paris, and are engaged in the organization of a strong Technical Division for the Gas Service, A. E. F. Col. Bacon is Chief, and I, Assistant Chief, of that Division, which attends to all matters chemical, medical, engineering, and ordnance. Capt. Hildebrand is acting director of the Gas Service laboratory, a section of ours which is doing splendid work. So far our laboratory equipment has not been received from the States, but all necessary apparatus and chemicals have been purchased here because of the pressing importance of many of the problems submitted to us. Our officers and men are doing fine work under the conditions and to date about twenty reports have been issued. Copies of these are, of course, sent to Washington. The French scientists are coöperating with us in every way possible, and you will be glad to know that a Paris section of the A. C. S. is under petition.

Colonel Bacon and I have had luncheon with Lieut. Engel several times. At present he is engaged in preparing his American report. His wife is a charming American lady, active in child welfare work here.

All of us are well and working hard.

Kindest regards to you,

Sincerely yours,

(Signed) W. A. HAMOR

Best regards to you and my other friends around the Chemists' Club in New York. Wish we could drop in there for a day.

(Signed) R. F. BACON

THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS

Editor of The Journal of Industrial and Engineering Chemistry:

The attention of my Council has been called to a certain misapprehension which exists in the minds of the public as to the body entitled to speak on behalf of the Chemical Manufacturers of the United Kingdom. In this connection, I would call attention to a paragraph in the Report of the Committee appointed by the Minister of Reconstruction to advise as to the procedure which should be adopted for dealing with the Chemical Trade, which reads as follows:

We are, however, of opinion that the Association of British Chemical Manufacturers is the most representative Association of the Chemical Trade at present in existence in this country, and that it does, generally speaking, represent the Trade as a whole.

The address of the Association of British Chemical Manufacturers, is 166, Piccadilly, W. 1.

Thanking you for giving publicity to this letter, I am,

Yours faithfully,

(Signed) G. MOUNT, *Secretary*

LONDON, ENGLAND
APRIL 26, 1918

CONSERVATION OF ALCOHOL, GLYCERIN, AND SUGAR AS USED IN MEDICINES

According to the *Official Bulletin* of May 2, 1918, Dr. Franklin Martin, member of the Advisory Commission and chairman of the General Medical Board of the Council of National Defense, has issued the following statement:

During the past several weeks there has been considerable discussion throughout medical and pharmaceutical circles relative to the conservation of alcohol, glycerin, and sugar as applied to medicinal products.

Governmental and other authorities interested, realizing that careful consideration should be given the subject, recently met and debated the advisability and necessity of conservation measures from the standpoint of medical needs. In view of the importance of alcohol, sugar, and glycerin in the manufacture of pharmaceutical preparations and of the limited possibilities for the conservation of alcohol and sugar therein, it was deemed advisable to refrain at this time from recommending conservation of sugar and alcohol in so far as their use in pharmaceutical preparations is concerned.

The amount of glycerin used in medicine when compared to the available supply was found to be relatively large, and a committee was appointed to investigate formulas, manufacturing processes, etc., requiring glycerin and to submit plans for the curtailment of the quantity now used in case future developments should make it necessary to adopt conservation measures in relation to medicines.

HIGH-GRADE TECHNICAL MEN AND SKILLED OPERATIVES WANTED FOR UNITED STATES ARMY ORDNANCE

An urgent call for high-grade technical men and operatives to fill war positions in industrial establishments was made today, through the Civil Service, by the United States Army Ordnance.

Salaries ranging from $1600 to $6000 a year will be paid the men who qualify for the places.

Chemists and chemical engineers; men experienced in the manufacture of gas; mechanical engineers on high pressure apparatus; engineers to take charge of power houses; and foremen of machine shops are needed. Persons of military age accepting appointment will not avoid the obligations of the Selective Service Law.

The Army Ordnance, in issuing its call for these men, is insisting on one point. No applications will be accepted from Government employees or employees of firms or corporations engaged in contracts for the Government or its Allies unless written assent to such application is given by the head of the establishment that might be seriously handicapped in its war work by the loss of the man

MANUFACTURING CHEMISTS

Superintendents for plants engaged in chemical manufacturing processes, especially those connected with nitrogen fixation and the manufacturing of acids and explosives, will be paid salaries ranging from $2400 to $6000 a year. Assistant superintendents of nitrate and chemical plants will be paid $1600 to $2400 a year.

Applicants for superintendents must have a standard high school education or its equivalent, and at least five years' operating experience involving chemical processes in a manufacturing plant, or they must be college or university graduates with at least three years of such experience. They must have been in responsible charge of operations involving important chemical processes for at least two years and must have earned a salary of at least $2000 a year.

Assistant superintendents of nitrate and chemical plants must have had at least three years' operating experience if they are high school graduates, or one year's experience if college or university graduates. In either case they must have earned at least $1200 a year. These superintendents and assistant superintendents will be assigned to duty at the Ordnance Department in Washington or elsewhere.

CHEMICAL ENGINEERS

Chemical engineers, to be paid $2400 to $6000 a year, are wanted for duty at the Ordnance Office in Washington, and for duty at various plants throughout the United States. These men will have complete supervision over one or more chemical manufacturing processes incidental to the war. They must be thoroughly experienced and of proved executive ability. A college or university degree in chemistry or chemical engineering and at least three years' experience in a chemical or mechanical industry, or a high school education or its equivalent, and at least six years such experience in a supervisory capacity are required.

Chemical engineers, with salaries ranging from $1600 to $2400 a year, and assistant chemical engineers, with salaries ranging from $1200 to $1600 a year, also are needed by the Ordnance Office. The positions paying $1600 to $2400 are open to men who have graduated in a course of chemical engineering from a college or university and who have had at least one year's operating experience in some chemical or mechanical industry, or who with a high school education or its equivalent have had at least four years' such experience. The positions paying from $1200 to $1600 a year are open to college or university graduates in chemical engineering who have had at least six months' operating experience, or with a high school education have had at least three years' such experience.

GAS MANUFACTURE EXPERTS

Operatives in gas manufacture—men to operate and control the processes of production of water gas and producer gas—are urgently needed by the Ordnance Office. Applicants for these positions are paid $1600 to $2400 a year, and must have at least five years' experience if high school graduates, or ten years' experience if their education has been a common school education.

MECHANICAL ENGINEERS

Salaries ranging from $1600 to $2400 will be paid junior mechanical engineers on high pressure apparatus who wish to do their bit toward winning the war by working for the Ordnance Department. Experience in the operation and control of high pressure hydraulic and gas machinery is necessary. At least one year of such experience will be required of graduates in mechanical engineering courses from recognized colleges. Four years' experience is required of high school graduates.

POWER HOUSE ENGINEERS

Power house engineers will be paid $1800 to $2400 a year while working for the Ordnance Department. Supervision of operation of water-tube boilers, condensers, pumps, steam turbines, and alternating and direct current generators and motors are among the duties of these men. Machine shop foremen with salaries from $1800 to $2400 also are wanted by the Army Ordnance. Ten years' experience as machinists—three years in a responsible supervisory capacity—is required.

Assistant operatives in the manufacture of water gas and producer gas, mechanics experienced on high power apparatus, and operatives of acid and chemical apparatus are wanted by the Army Ordnance. Many positions are open. The needs of the service, the Ordnance Department announces, are so imperative, that applications will be received indefinitely. Further information regarding the Army Ordnance positions that must be filled is obtainable of the Civilian Personnel Section, U. S. Army Ordnance, 1330 F Street, Washington, D. C.

WASHINGTON, D. C.
May 13, 1918

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

Legislation which is almost as important to many chemical and mineral industries as the Lever Act is to the agriculture, coal mining, and petroleum industries, has been before Congress during the past month. The War Minerals Bill (H. R. 11259) provides a more drastic control over certain mineral substances than that exercised by the fuel and food administrators. The minerals involved are antimony, arsenic, ball clay, bismuth, bromine, cerium, chalk, chromium, cobalt, corundum, emery, fluorspar, ferrosilicon, fullers' earth, graphite, grinding pebbles, iridium, kaolin, magnesite, manganese, mercury, mica, molybdenum, osmium, sea salt, platinum, palladium, paper clay, potassium, pyrites, radium, sulfur, thorium, tin, titanium, tungsten, uranium, vanadium, zirconium. The bill specifies that it is to cover chemical compounds, alloys, and intermediate metallurgical products of each of the substances enumerated

The bill was drafted originally by the War Minerals Committee which is composed of a representative of the American Institute of Mining Engineers, the Geological Survey, the Bureau of Mines, and the State Geologists' Association. It was intended to centralize authority, so as to permit the Government to handle the mineral situation more effectively. Hearings were conducted before the Committee on Mines and Mining of the House of Representatives. The Committee reported the bill favorably and it was passed by the House with the elimination of the price-fixing power and with the reduction of the appropriation from $50,000,000 to $10,000,000. As soon as the bill had passed the House, the Senate Committee on Mines and Mining embarked upon an exhaustive hearing. The hearing before the Senate Committee took on a most interesting aspect almost immediately, due to the fact that those opposing the bill seemed to have reserved their comment until the measure was taken up by the Senate.

President Wilson is very much interested in securing the passage of the bill but, despite the weight of his influence behind it, the Senate apparently is reluctant to give its approval to legislation which will permit governmental interference with industry unless it can be shown with greatest clearness that some form of control is necessary

The greatest interest, naturally, centers around manganese and iron pyrites, although quicksilver, antimony, platinum, bromine, arsenic, graphite, tungsten, and others of the minerals have come in for extended discussion. At this writing, the opinions of the members of the Senate Committee have not crystallized sufficiently to forecast the form that the bill will have when they complete their work upon it. The price-fixing power and the licensing feature are the main points upon which the Senators seem most anxious to secure expressions of opinion.

The situation with regard to manganese ore for chemical purposes was laid before the Senate Committee by Horace H.

Lamson, of John S. Lamson & Bro., New York. The firm is engaged in importing high-grade manganese ore. While Mr. Lamson expressed the most earnest desire to see the development of domestic manganese mines, he recited numerous instances showing the difficulties at present in securing even small quantities of high-grade ore from domestic sources. He urged that imports be allowed to continue until it is proved that domestic producers can furnish uniform grades of chemical ore. He is of the opinion that 60,000 tons of high chemical ore will be required by American manufacturers during the next twelve months.

Charles H. MacDowell, of the Chemical Section of the War Industries Board, told of the arrangement between the Government and the Dow Chemical Co., of Midland, Mich., whereby the Government put down seventeen additional wells on the Dow property in order to assist in increasing the output of bromine. As a part of the contract, the Dow Company was to increase its bromine plant so as to take care of the additional product. Arrangement provided for a price of thirty-five cents a pound for the supplies used by the Government. Instead of turning out the product as a liquid, it was agreed to turn it over to the Government in the form of mineral salt, so as to make shipment easier. The Government is using bromine in the preparation of poison gas.

Platinum is the source of no little worry to Government officials, Mr. MacDowell told the Committee. He told how some platinum is still being secured in Russia. The thoroughness of the efforts being made is attested by the fact that shoes and other much-needed articles are being bartered for platinum among the Russians. Mr. MacDowell's testimony carried a measure of relief to many of those who have been anxious with regard to platinum supplies. He declared that there is enough platinum in the country to meet requirements if the worst should come, but he pointed out the great difficulties that would be met in reclaiming the platinum used in jewelry and in other forms. Mr. MacDowell stated that it has been necessary recently to issue 1,000 additional commandeering orders for platinum. He is hopeful, however, that needs can be met by restricting all non-essential uses of platinum and by securing as much as possible of the production in Russia and Colombia. It is Mr. MacDowell's opinion that there is enough manganese in the United States to meet requirements for three months, even if no further imports are permitted. Mr. MacDowell favors the bill.

Another revelation made at the hearing was that the Government expects to commandeer sulfur. This step has been found necessary in order to permit of the allocation of sulfur among the various consumers and to conserve, as far as possible, the supplies of nearly pure sulfur produced in Louisiana and Texas.

Some expansion has been found necessary in the Chemicals and Explosives Section of the War Industries Board. The work is under the direction of L. L. Summers. In addition to his administrative duties, he pays particular attention to explosives. Charles H. MacDowell, the assistant chief, has charge of nitrates. Other members of the staff and their assignments are as follows:

J. H. ADAMS, mica; A. BRUNKER, R. S. HUBBARD, and A. E. WELLS, acids and heavy chemicals; C. H. CONNER, wood distillation products, platinum commandeering and requisitioning; E. J. HALEY, tanning materials, greases, tallows, vegetable oils and waxes; J. M. MOREHEAD, coal-gas products and rare gases; I. C. DARLING, toluol distribution; A. G. ROSENGARTEN, fine chemicals; H. W. SANFORD, ferromanganese, chromite, tungsten, and ferrosilicon; R. M. TORRENCE, chemical glass, carboys, and chemical stoneware; W. G. WOOLFOLK, brimstone and pyrites; H. R. MOODY, S. A. TUCKER, and E. R. WEIDLEIN, inorganic chemicals, electrolysis, electrometallurgy, ceramics, refractories, organic compounds, and dyestuffs.

Associated with the Chemical Section are several representatives of the Navy Department. Their names and assignments are as follows:

D. RILEY, alcohol, explosives, nitrates, alkalies, chlorine, electrochemicals, dyestuffs, and organic chemicals; S. R. FULLER, manganese, chrome, and ferro alloys; C. K. MCDONALDS, mica; S. I. MARKS, tin.

Army representatives and their assignments are as follows:

CAPT. GELSCHEN, alcohol, nitrates, alkalies, chlorine, acids, sulfur, and pyrites; MR. LOCKHART, wood-distillation products, platinum, and formaldehyde; C. RICE, electrochemicals, dyestuffs, and organic chemicals; LIEUT. COL. SPRUANCE, explosives and nitrates.

Major Seth Williams is the chemical representative of the Marine Corps attached to the War Industries Board.

Among the additional commodities added to the conservation list May 17 are the following: alpaca metal and articles containing it; paper stock, sand, and shingle stock asbestos; spelter; numerous articles containing tin; face creams containing salts of mercury.

Final figures on production of sulfuric acid have been obtained by the Geological Survey. The results of its exhaustive calculations are in part as follows:

The production of sulfuric acid in 1917, expressed in terms of acid of 50° Bé., was 5,967,551 short tons, valued at $71,505,536, to which must be added 759,039 short tons of acids of strengths higher than 66° Bé. (which cannot be calculated for comparison with acid of 50° Bé.), valued at $16,034,545. The increase over 1916, in the production of acid expressed as 50° Bé., was therefore more than 325,000 short tons in quantity and $8,800,000 in value, and the increase in the production of stronger acids was more than 315,000 short tons in quantity and $5,225,000 in value. The value of the total production of sulfuric acid in 1917 was over $14,000,000 more than in 1916.

Other final figures are as follows: lithium minerals, 2062 tons; aluminum salts, 198,452 tons; phosphate rock, 2,584,287 tons.

Numerous important matters were discussed by members of the Chemical Advisory Board of the Bureau of Mines in a conference last month with Charles L. Parsons, chief chemist of the Bureau of Mines. The chemical advisory board consists of Dr. Wm. H. Nichols, New York; Prof. S. P. Venable, Chapel Hill, N. C.; Prof. E. C. Franklin, Stanford University; Mr. Wm. Hoskins, Chicago; Prof. H. P. Talbot, Boston; Dr. Ira Remsen, Baltimore; Prof. T. W. Richards, Cambridge.

To prevent the useless consumption of materials and labor in making articles for export, the War Trade Board has announced that written approval of war missions of the country to which exportation is intended must be secured. Exporters of certain articles would be required to obtain the written approval of the Food Administration or the War Industries Board before export license would be extended. Among the articles in the latter class are:

All acetates, acetic anhydride, acetone, all arsenic compounds, carbon disulfide, chrome compounds, cyanides, all dyestuffs, ethyl methyl ketones, explosives, formaldehyde, glycerin, all manganese compounds, nitrobenzol, all potassium salts, pyrites, saccharine, chromium ore, ferro alloys, graphite, manganese ore, mercury, mica, nickel, metallic sodium and any metal or alloy thereof, tin, tungsten, and wolframite.

D. W. Brunton, chairman of the War Committee of Technical Societies, is the head of a Board to which the War Department will refer all inventions of a mechanical, electrical, or chemical nature.

In the United States Tariff Commission's investigations of the chemical industries, special attention has been given to the manufacture of oxalic acid. American laundries, which before the war used large quantities of oxalic acid as a bleach, have been compelled in many cases to rely upon the less satisfactory mineral acids. A number of other businesses, especially in the textile and tanning trades, consumed considerable amounts of the acid, but in most instances these industries have now found suitable substitutes.

Before the war the greater part of the oxalic acid used in the United States was imported from Europe, chiefly from Germany, where the industry has been firmly established for half a century. In 1913, Germany exported 12,500,000 lbs. of oxalic acid and slightly over 6,000,000 lbs. of this were consumed in the United States. The balance of the American imports, amounting to about 1,000,000 lbs., came from Norway and England. A great decrease in imports was noticeable early in 1915, when we received only 3,500,000 lbs. from Germany in comparison with almost 7,000,000 lbs. in the preceding year. In 1916, imports from Germany dropped to a scant 80,000 lbs.

Until 1909, according to the statements made before the Committee on Ways and Means, there was but a single American producer of oxalic acid and the output of this firm was practically negligible until 1911. In that year its production reached 2,000,000 lbs., or slightly less than one-third of the amount imported during the year. The number of manufacturers of oxalic acid has always been so small that figures on production could not be published without revealing the operation of individual firms. However, the statistics compiled by the Tariff Commission indicate that in general there has been

no great increase in production, although in 1914, when the price suddenly trebled, a number of firms were reported to have begun the manufacture. The price of oxalic acid was about 7 or 8 cents in 1913, but it increased very rapidly until April 1916, when it reached a maximum of 50 cents a pound. Since then the price has dropped and during the last year it has remained fairly constant at about 45 cents. This is due in large part to the increasing imports of Norwegian, Dutch, and English acid.

The process of manufacture employed in this country requires the use of caustic potash and before the war the American manufacturers depended entirely upon Germany for this material. When hostilities shut off this source of supply, the manufacturers turned to the American producers of potash from wood ashes. The greater supplies of Nebraska and Utah could not be utilized as these deposits yield chloride of potash which must be further treated before caustic potash is obtained. In Germany oxalic acid is made from producer gas and caustic soda, and as the gas is a waste product in several industries this process offers a very profitable method of manufacture.

Indications are that the American manufacturers of oxalic acids will not be able to compete with the German producers after the war unless a cheap supply of caustic potash becomes available. As far as present experiments show, the sawdust process now used in the United States will not give satisfactory results without the use of caustic potash. The producer-gas process appears more practicable, but it involves certain engineering difficulties which American manufacturers have not yet solved.

OBITUARIES

ARTHUR HENRY ELLIOTT

The recent death of Dr. Elliott is deeply regretted by a large circle of professional and other friends, who valued highly his friendship and were always pleased to meet him. He left the impress of his personality on the Societies to which he belonged, and on all who came in contact with him. He was always ready to lend a helping hand, and many young members of the chemical and engineering professions are deeply in his debt for assistance which he gave them in beginning their careers.

Dr. Elliott was born in London, England, in July 1851. He died at Peekskill, N. Y., on February 28, 1918.

His family name was originally Aylot and came from Normandy with William the Conqueror. He was taken to France when he was a child and received his early education in a Convent school near the Belgian border, learning French before he learned English. On returning to England, at the suggestion of his father, who was a physician, he took up the study of medicine.



ARTHUR HENRY ELLIOTT

He was so impressed, however, by the lectures of his professors of chemistry (Tyndall and others) that he dropped medicine, and in 1866 entered the School of Chemistry in South Kensington, graduating in 1869. He also attended lectures at the School of Mines in Jermyn Street.

While still a student he obtained a reputation as an iron and steel analyst, reading on March 18, 1869, an article on the determination of carbon in cast iron, before the London Chemical Society, which was afterwards published in the Journal of the Society.

Soon after his graduation he was appointed chemist to the Spence alum works in Manchester where acids, alum, and other chemicals were manufactured and the by-products of gas works were handled.

In 1870 he entered the service of Prentice Brothers, at Stowmarket, where he had to do with the manufacture of acids, fertilizers, and especially guncotton.

In 1872 he started on a trip around the world, with a view of joining an uncle in Australia, and perhaps going to China. Arriving in New York he presented letters to several chemists, among them one to Prof. C. F. Chandler, who induced him to stay in America and became his life long friend.

During the next few years he was connected with two different works, one in Baltimore, the other, the Highland Chemical Works, near Peekskill, where he made sulfuric acid from a local deposit of pyrites, as well as from imported sulfur.

In 1879 Prof. Chandler induced him to extend his chemical studies by entering the School of Mines of Columbia University. He joined the third class and graduated in 1881, receiving the degree of Ph.B. in chemistry. He then took a post-graduate course and received in 1883 the degree of Ph.D. with a major in economic geology and a minor in the chemistry of explosives.

From 1880 to 1888 he was associated with Prof. Chandler in his lectures at the College of Physicians and Surgeons and at the N. Y. College of Pharmacy.

In 1886 he was appointed demonstrator in chemistry, and in 1888 professor of physics and chemistry and director of the laboratories in the College of Pharmacy.

In 1889 he relieved Prof. Chandler of his lectures on inorganic chemistry entirely, lecturing on both physics and chemistry to juniors and seniors, as well as giving laboratory instruction in analytical chemistry and practical pharmacy, Prof. Chandler retaining organic chemistry.

Dr. Elliott continued to discharge these duties until 1897 when he resigned.

In 1903 he was made emeritus professor of chemistry and physics, and in 1905 he was elected a trustee, which position he filled until his death.

In May 1880 he became connected with the Municipal Gas Lighting Company and in 1884, when the consolidation of the New York gas companies took place, he became engineer-chemist to the Consolidated Gas Company, which position he retained until his resignation in 1910.

He was retained however as consulting chemist until his death. In 1885 he became associated with Prof. Chandler in the editorship of *Anthony's Photographic Bulletin*, a position which he held until the end of 1893.

In 1887 he married Miss Kate P. Uglow, daughter of Dr. James Uglow, a surgeon in the Civil War. He is survived by his widow, three daughters, and a granddaughter.

He belonged to the following Societies and Clubs:

London Chemical Society	American Gas Institute
American Chemical Society	Society of Gas Lighting
Society of Chemical Industry	Illuminating Engineering Society
American Institute of Chemical Engineers	New York Academy of Sciences
The Chemists' Club	Columbia University Club
American Institute of Mining Engineers	Fireside Club, Flushing
	The Masonic Order

PUBLICATIONS

1. "On the Determination of the Total Carbon in Cast Iron," *J. Chem. Soc.*, **1869**.
2. "On the Determination of Sulfur in Cast Iron," *Chem. News*, **1870** and **1871**. *Dingler's Journal*, **199**, 536.
3. "Apparatus for the Rapid Analysis of Gas Mixtures," *Chem. News*, **1881**.
4. "Report on the Methods and Apparatus for Testing Inflammable Oils," 2nd Annual Report of the N. Y. State Board of Health, **1882**, p. 449.
5. Apparatus for Rapid Gas Analysis, *Chem. News*, **1883**.
6. "On Oil of Vitriol," about 1876.
7. "Table on Sulfuric Acid, Showing Physical Properties of All Strengths Published by Mfg. Chemists Assn. of U. S."
8. "On Nitro Saccharose and Nitro Glycerin," about 1881.
9. Elliott's Qualitative Analysis, **1892**, 120 pages.

Besides many other papers on industrial and sanitary topics. This is certainly the record of a most industrious and useful life.

C. F. CHANDLER

JAMES HENRY SHEPARD

James Henry Shepard, B.S., professor of chemistry in the South Dakota Agricultural College and chemist of the South Dakota Agricultural Experiment Station, died February 21, 1918, at St. Petersburg, Florida, from heart failure following pneumonia.

He was born at Lyons, Michigan, April 14, 1850, and was graduated from the University of Michigan in 1875. The next thirteen years were given to natural science teaching in high schools of his native state and to the writing of an elementary textbook on chemistry (1885), which was quite widely used, and "Notes on Chemistry" (1886). In June 1888 he married Miss Clara R. Durand, of Ypsilanti, Michigan, and in the fall of that year accepted the chair of chemistry and the affiliated experiment station position in which he remained until his death. From 1890 to 1900 he carried the added responsibilities of the College vice presidency, and from 1895 to 1901, that of the Station directorship; also, for a decade or more, beginning in 1890, he served as chemist to the State Food Commission.

Teaching chemistry was his chief life-work. His sympathy, alertness, enthusiasm and information made him a loved guide and leader. His work as Station chemist was that of a pioneer in a new territory, where a survey of resources was the first need. His principal bulletins deal with the drinking and artesian waters of South Dakota, with its native and introduced forage crops, with durum wheat and its values for bread and macaroni making, and especially with the improvement of the sugar richness of the sugar beet.

As a food chemist, he made two studies of especial note. The first was upon the "constants of whisky." It led to his appointment as a representative of the State Food Officials at President Taft's hearing, June 1909, upon the meaning of the term "whisky." The second related to the bleaching of flour and its influence upon the wholesomeness of the product. This work resulted in his being called by the United States upon the occasion of various hearings and trials relating to the product; and later by the English government in the celebrated case against Andrews. In these trials his knowledge of the subject, resourcefulness, logical mind, psychological insight, and strength of conviction made his services invaluable.



JAMES HENRY SHEPARD

By his death, South Dakota has lost a pioneer in higher education and one who has done much for the development of her agricultural resources; the pure food cause, an earnest advocate and helpful investigator; and his friends, one of the most lovable men they have known.

WILLIAM FREAR

PERSONAL NOTES

Mr. R. C. Burt, formerly with the Barrow-Agee Laboratories, Memphis, Tenn., has enlisted in the Sanitary Corps, Gas Defense Service, and has been assigned to the Gas Defense Detachment, Astoria, Long Island.

Mr. John C. Trimble, formerly a student in the Philadelphia Textile School, has joined the Chemical Service Section, National Army, and is stationed near Yonkers, N. Y.

Mr. Jerome D. Stein has resigned his position as chief chemist of the American Zylacq Co., of Newark, N. J., to accept a position with the Air Nitrates Corporation, Agent of Ordnance Department, U. S. A., for the manufacture of ammonium nitrate by the cyanamide process at Muscle Shoals, Ala.

Mr. Frank P. Drane, consulting chemist of Charlotte, N. C., died of pneumonia on April 28.

Mr. Russel B. Munroe, formerly stationed in Springfield, Ill., as chief inspector for the U. S. Army at the plant of the Western Cartridge Co., has been transferred to the Engineering Bureau, Ordnance Department, Washington, D. C.

Mr. R. F. Tissot, formerly employed as assistant chemist at the Tropical Paint and Oil Co., Cleveland, Ohio, has accepted the position of assistant superintendent with the R. C. Cook Paint Co., Kansas City, Mo.

Mr. A. M. Lynn has been transferred from the Ordnance Training Camp at Camp Sheridan, Ala., to the Ordnance School at the proving grounds, Aberdeen, Md.

Dr. Lina Stern, privatdozent in the University of Geneva, has been appointed professor extraordinary of physiological chemistry.

Miss Mildred P. Stewart has resigned her position as instructor in physiology and chemistry at Pratt Institute, Brooklyn, N. Y., to take charge of the work of the Dutchess County (N. Y.) Public Health Association, with headquarters at Poughkeepsie, N. Y. Miss Stewart took the degree of M.A. in public health work at the University of California in June 1917, while on a year's leave of absence from her work at Pratt Institute.

Miss Lillian E. Baker, for the past four years instructor in chemistry at Pratt Institute, Brooklyn, N. Y., has resigned her position there to accept that of instructor in chemistry at Wellesley College.

Mr. J. H. Devine, formerly superintendent of Morton and Maguire, paint and varnish manufacturers, Paterson, N. J., has been engaged by the Pennsylvania Linseed Products Co., Pittsburgh, Pa., for demonstration work in connection with their product, "Linotol."

At the commencement exercises at Colgate University on May 7, 1918, the honorary degree of D.Sc. was conferred upon Charles H. Herty, editor of THIS JOURNAL.

Mr. L. C. Mazzola has accepted the position of assistant superintendent at the Jersey City factory of the Metal and Thermit Corporation, having direct supervision of the manufacture of metallic tungsten.

Mr. H. R. Dunbar, formerly teacher of chemistry at the Sutton High School, Sutton, W. Va., is now employed as a chemist in the fuel department of the Bureau of Mines, Washington, D. C.

Dr. Graham Edgar of Throop College, Pasadena, Cal., has been appointed technical assistant to the newly established Research Information Committee, and has entered upon his duties at the office of the National Research Council.

Mr. Alex. C. Nixon, Jr., formerly with the Solvay Process Company as a technical assistant in the Soda Ash Department, is now at the American University Experiment Station, Washington, D. C., engaged in chemical research on war problems.

Mr. Carl Otto, formerly with the 136th Field Artillery, United States Army, has been transferred to the Ordnance Corps at Washington, D. C., and has been detailed to the American University Experiment Station for work in chemical research.

Mr. H. J. Morgan, of the General Chemical Company, has been transferred from the Delaware Works at Marcus Hook, Pa., to the main laboratories of the company at Laurel Hill, Long Island, where he will be chemist in charge.

Mr. W. J. McGee, of the Bureau of Chemistry, U. S. Dept. of Agriculture, and formerly stationed at Savannah, Ga., has been transferred to San Juan, Porto Rico, where he is engaged in the inspection of food and drugs.

Captain W. H. Ransom, Ordnance Reserve Corps, formerly located at Wilmington, Del., has been transferred to the Washington office of the Inspection Division as head of the powder and explosives sub-section.

Mr. E. J. Casselman, formerly engineer of tests, Washington Steel and Ordnance Co., Washington, D. C., has accepted the position of assistant chemist with the Hygienic Laboratory, Washington, D. C.

Mr. W. J. Terpenny, for a number of years connected with the Celluloid Zapon Company of New York and more recently manager for the chemical department for Anderson Gustavson, of Chicago, has been engaged by Innis, Speiden and Company to manage their Cleveland branch

Mr. Arthur Hough has accepted the position of consulting chemical engineer with the Duriron Castings Company.

Miss Phyllis M. Borthwick, lecturer in physics at the Ladies' College, Cheltenham, England, has been appointed assistant professor of physics and chemistry at the Lady Hardinge Medical College for Women, Delhi, India.

Mr. Joseph L. Turner, head chemist of the Bristol-Myers Co., Brooklyn, has been unanimously elected first vice president of the New York Branch of the American Pharmaceutical Association.

At the annual meeting of the Chemical Society, London, on March 21, the Longstaff Medal for 1918 was presented to Lieutenant Colonel A. W. Crossley, for his work in the field of hydroaromatic compounds.

Mr. L. T. Anderegg, in charge of the department of chemistry in the high school at Decatur, Ill., has accepted the position in the Kansas State Agricultural College chemistry department left vacant by the resignation of R. C. Wiley.

Dr. Sidney Liebovitz has suspended his consulting work in New York City to take up some special research work at the Mellon Institute of Industrial Research at Pittsburgh, in collaboration with Prof. M. A. Rosanoff, head of the department of research in pure chemistry at that Institute.

Dr. Gerald L. Wendt has been appointed assistant professor of chemistry and curator of the Kent Chemical Laboratory at the University of Chicago. He has charge of the instruction in quantitative analysis and in radioactivity.

Mr. Percy G. Savage of the Norton Company has been transferred from the Worcester plant, where he had the direction of the refractories products, to the Niagara Falls plant where he will be engaged in electric furnace problems.

Mr. Robert Howe, formerly with the New York and Richmond Gas Co., has taken up the duties of assistant chemist at the Laurel Hill plant of the General Chemical Company.

Mr. C. G. Atwater, manager of the agricultural department of the Barrett Company, has been asked by the Ordnance Bureau of the Navy to act as consulting engineer in connection with the proposed Navy nitrate plant and has reported for duty at Washington. Mr. Atwater is an engineer by training and has had long experience in the practical end of ammonia production as well as in its utilization.

Mr. George H. Brother has resigned the position of assistant analyst, Laboratory of the Inland Revenue Department, Ottawa, Canada, and has accepted the position of chief chemist with the Atlantic Loading Co., where he will direct the research and control tests on modern explosives.

Dr. A. E. Dubin, formerly in charge of the chemical laboratories of the Montefiore Home and Hospital, New York, has resigned his position to accept an appointment as research chemist with the Herman A. Metz Laboratories, Inc., New York City.

Mr. H. T. White, formerly with the British Cordite Co., of Nobel, Ontario, is now connected with the laboratory of the Sherwin-Williams Company of Chicago.

During the past year, twenty-one members of the Mellon Institute of Industrial Research, including the director, Lieutenant Colonel Raymond F. Bacon, and assistant director, Major William A. Hamor, have entered the Government service in response to their country's call. The following is a list of Industrial Fellows who have gone direct from the Institute into Service:

F. O. Amon, First Lieutenant, Sanitary Corps.
H. S. Bennett, First Lieutenant, Sanitary Corps.
C. O. Brown, Captain, Ordnance Department.
A. S. Crossfield, First Lieutenant, Sanitary Corps.
R. F. Ferguson, Private, Ordnance Department.
G. F. Gray, Captain, Signal Corps.
R. B. Hall, Second Lieutenant, Chemical Service Section
W. J. Harper, Second Lieutenant, Sanitary Corps
C. E. Howson, First Lieutenant, Sanitary Corps
C. S. Ivy, Second Lieutenant, Engineers Corps
E. H. Loeb, Second Lieutenant, Ordnance Department.
R. W. Miller, First Lieutenant, Sanitary Corps
L. H. Milligan, Second Lieutenant, Ordnance Department
R. V. Murphy, First Lieutenant, Sanitary Corps
B. H. Nicolet, Captain, Chemical Service Section
A. H. Stewart, Cadet, Aviation Section
H. L. Trumbull, First Lieutenant, Ordnance Department.
W. E. Vawter, First Lieutenant, Sanitary Corps
C. L. Weirich, First Lieutenant, Sanitary Corps.

Lieut. Hamilton Merrill, of the Sanitary Corps, is now connected with the manufacture of gas masks at the Gas Defense Plant, Astoria, Long Island.

Miss Edith Tapley, of Bayside, Long Island, a graduate of Barnard College, who has been employed in the laboratory of the General Chemical Company in Long Island City, has been appointed chief chemist of the General Chemical Company's plant at Kingston, Ontario, Canada.

Mr. G. F. McMahon of the Western Electric Company has been transferred from New York to the company's Hawthorne plant, Chicago, Ill., where electrochemical work will be under his supervision.

Dr. H. E. Wells, professor of chemistry at Washington and Jefferson College, has been commissioned Captain in the Chemical Service Section of the National Army.

A new chemistry building is to be erected on the campus of the University of North Dakota. The ground has already been broken and contracts to the amount of $62,438 for the construction of the building have been let by the State Board of Regents.

Dr. R. H. Jesse, Jr., head of the department of chemistry at the Montana State University at Missoula, has been appointed dean of men for the institution.

Mr. Walton B. Scott has been appointed junior gas chemist in the Offense Chemical Research Division of the Bureau of Mines Experiment Station and assigned to the Worcester Polytechnic Institute to work under the direction of Prof. W. L. Jennings.

On Thursday, May 2, 1918, Miss Grace MacLeod, assistant editor of THIS JOURNAL, addressed the students who are majoring in chemistry at Simmons College and at Wellesley College on "The Opportunities for Women in Industrial Chemistry."

Mr. William C. Meyer, formerly chief chemist for the National Refining Co., Coffeyville, Kansas, has enlisted, and is stationed at the post hospital, Fort Omaha, Nebraska.

Prof. H. V. Tartar, who for the past five years has been station chemist and associate professor of agricultural chemistry at the Oregon Agricultural College, has accepted a position in the department of chemistry of the University of Washington at Seattle.

Dr. Allen Rogers has been appointed a Major in the Chemical Service Section of the National Army. He will be in charge of the Industrial Relations Department.

Mr. Joseph W. Hawthorne, of the Miner Laboratories, Chicago, Ill., has joined the U. S. Naval Reserve Force Training School.

Mr. Kenneth L. Fox, member of the Chicago Section, A. C. S., has been commissioned Lieutenant of Engineers, Tank Service, and is now at Gettysburg, Pa., with the 65th Engineers.

Mr. William J. Hajek, formerly a member of the metallurgical staff of Crane and Co., Chicago, is now a cadet at the School of Aviation, Rockwell Field, San Diego, Cal.

Dr. E. N. Bunting, formerly of the Chicago Section, A. C. S., has accepted the position of chemist with the Bausch and Lomb Co., Rochester, N. Y.

The U. S. Civil Service Commission announces open competitive examinations for chemical engineer and assistant chemical engineer, for men only. The register of eligibles resulting from the chemical engineer examination will be divided into two grades, as follows: Grade 1, at salaries ranging from $2,400 to $6,000 a year; and Grade 2, at salaries ranging from $1,600 to $2,400 a year. The salary for assistant chemical engineer will range from $1,200 to $1,600 a year. On account of the urgent needs of the service, applications will be received until further notice. Applicants should apply at once for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

The following additions have been made to local transportation sub-committees: Committee for Chicago: Frederick Rayfield, of Swift and Co., C. A. Alling, of Darling and Co., and Dewitt Brown, Armour Fertilizer Works. Columbus, O.: S. J. Martenet, of Farmers' Fertilizer Company, has been added to complete the list at this point. Mt. Pleasant, Tenn.: Ray P. Hoover, of Hoover and Mason. A. E. Sheldon, of the Federal Chemical Co., Columbia, Tenn., and E. W. Faucett, Mining and Manufacturing Company, Charleston, S. C.

Mr. Paul Gross, tutor in chemistry at the College of the City of New York, has been commissioned Second Lieutenant in the United States Army and has reported for duty in Washington.

Mr. John M. Ekert, assistant engineer in the gas and oils department of Underwriters' Laboratories, has entered the Ordnance Department, United States Army, as supervisor of tests at steel plants in the vicinity of Chicago and also in Ohio, Indiana, Wisconsin and adjoining States. Physical tests, chemical analysis, heat treatment at plants, and the instruction of inspectors for this territory will come under Mr. Eckert's direction.

Dr. Rudolph Gahl has resigned from the position of metallurgist in charge of concentrator at the Inspiration Consolidated Copper Company, Miami, Arizona, to devote his time to consulting practice. Mr. Guy H. Ruggles, formerly mill superintendent of the Humboldt plant of the Consolidated Arizona Smelting plant will succeed Dr. Gahl.

Mr. N. J. Gebert, director of the metallurgical laboratory, Standard Roller Bearing Division of the Marlin-Rockwell Corporation, has resigned his position and joined the staff of Mr. Herman A. Holz, New York. Mr. Gebert will be in charge of the metallurgical and magnetic laboratory which Mr. Holz is equipping in the Metropolitan Tower, New York City.

Professor J. H. Ransom, for eighteen years in charge of the work in general chemistry at Purdue University, has resigned, to take effect at the end of the present year.

Dr. A. W. Homberger, who has been head of the chemistry department of Wesleyan University for the past seven years, will leave Wesleyan at the end of the Spring term to become dean of the chemistry department of the University of Louisville, Kentucky.

Assistant Professor F. E. Breithut of the College of the City of New York on leave of absence for the duration of the war, has been commissioned as Captain in the U. S. Army and has reported for duty.

Dr. B. G. Feinberg, tutor in chemistry at the College of the City of New York, has been appointed Research Chemist in the Ordnance Division of the United States Army.

Mr. D. L. Williams, instructor in chemistry at the College of the City of New York, has been called into the national service to be in charge of the Division of Supplies of the Research Department of the Gas Warfare Section of the United States Army.

Dr. Earl C. H. Davies will resign at the close of the present academic year as instructor of physical chemistry and electrochemistry at Washington University, St. Louis, Mo., to accept the appointment as professor of chemistry and head of the chemistry department at Butler College, Indianapolis, Ind.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE TRADING "WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANTS
1915	1,139,031	Fritz Gössel, Frankfort-on-the-Main, Germany	.....	Manufacture of artificial milk	Albert B. Moses, 909 Eighth Avenue, Seattle, Washington
1902	711,377	Max Bazlen, Ludwigshafen, Germany	Badische Anilin & Soda Fabrik, of Ludwigshafen, Germany	Solid alkaline hydrosulfites and process of making same	E. C. Klipstein & Sons Co., 644 Greenwich St., New York, N. Y.
1905	795,755	Max Bazlen, Ludwigshafen - on - the - Rhine, Germany	Badische Anilin & Soda Fabrik, of Ludwigshafen-on - the - Rhine, Germany	Process of making stable dry hydrosulfites	E. C. Klipstein & Sons Co., 644 Greenwich St., New York, N. Y.
1912	1,043,349	Heinrich Ostwald, of Cologne, Germany	.....	Ball mill	F. L. Smidth & Co., 50 Church St., New York, N. Y.

.....

The Shepard Chemical Corporation has applied for a Delaware charter to deal in and with chemicals, etc. It has a capital of $1,825,000.

The toluol plant of the People's Gas Light and Coke Co., of Chicago, which was recently completed, is now running at capacity. It is reported that the output of the plant will be valued in excess of $1,000,000 a year.

Orange growers in California are finding a market for all the dried orange peelings that can be secured, the demand coming from the eastern manufacturers of tobacco. Until recently the only demand for peelings has been for the manufacture of citric acid or confectionery, but tobacco manufacturers are calling for tons of the dried article to be used in the manufacture of chewing tobacco. Growers are preparing to press the juice from their cull fruit and dry the rinds to supply the new demand.

According to *Drug and Chemical Markets* several large German and Austro-Hungarian concerns, including the German Oriental Company, the North German Lloyd Steamship Company, and the Lohmans, have formed a huge combine, to be known as the "Europäische Handelsgesellschaft," at Bremen, to control and centralize the import trade in war products of all kinds, and in raw materials from Russia, Persia, Manchuria, China, Turkestan, Rumania and Finland. It is intended to form a union of all exporters in these countries who had pre-war business relations with Germany and to exclude neutrals who deal with Entente countries from all products handled and from all commerce with the Central Powers.

Construction work has already begun on a nitric acid plant costing $1,000,000 to be erected at New Castle, Pa., by the Grasseli Chemical Company.

A large wood chemicals manufacturing plant to supply the Government will be built at Lyles, Tenn., by the Bon Air Coal and Iron Corporation of Nashville. The initial investment is to be $1,300,000 and it is planned to consume 200 cords of wood each day. The charcoal from this wood burning will be used for fuel in the company's charcoal iron furnace at Lyles. The plant will have a daily capacity of from 40,000 to 50,000 pounds of acetate of lime, 2000 to 3000 gallons of crude alcohol, and 10,000 to 20,000 bushels of charcoal.

With a capital of $4,000,000, the Alphano Humus Company has been incorporated at Boonton, N. J., to engage in the manufacture of fertilizers. The incorporators are John N. Hoff, Boonton, N. J., Richard Sellers, Bellevue, Del., and James E. Mantee, Portland, Me.

Among the countries making a pronounced effort to attain material freedom from dependence upon the German dyestuff industry, Sweden is now to be enrolled. The consumption of synthetic colors is not very large, about 900 short tons annually. It is felt, however, that it is sufficient to warrant the establishment of a domestic industry, and a company has already been organized to finance the project. Sweden lacks the raw material as the country has no coking coal. It is, however, richer in chemicals than Switzerland which possesses a flourishing dyestuff industry despite her poverty in material. The plans of the Swedish Company embrace competition in foreign markets.

With a capital of $4,500,000, the Independent Chemical Company has been incorporated at Dover, Del., to manufacture chemicals and allied products. The incorporators are W. B. Walsh, Brooklyn, N. Y., J. A. Lyon, New York City, and V. Harris, Pelham Manor, N. Y.

The United States Government is said to be considering the construction of a large new plant at New Haven, Conn., to be located at the works of the New Haven Gas Light Company for the production of toluol from the gas manufactured by the New Haven Company. The gas will be washed to extract the benzol, which product will then be refined, producing toluol. The new plant is estimated to cost in the neighborhood of $100,000.

The New England Potash Co., of Hartford, Conn., which has taken over the holdings of the International Feldspar Co., at Maromas, Middletown, Conn., will erect a ten-unit plant for the manufacture of potash, Portland cement, and super-phosphate from feldspar.

Alcohol is being produced in Mexico from a plant called sotol which grows abundantly in Northern Mexico and Western Texas. It is said that the plant can be gathered at a cost of from $2 to $5 a ton, and that one ton produces from 18 to 25 gal. of 180 proof alcohol.

The War Industries Board has just fixed the Government price of $1.50 per gallon for toluol in tank cars and $1.55 per gallon in drums for all toluol to be released for non-military purposes, and announces that the Board will be glad to have its attention drawn to any instances where a higher price is demanded. No release will be granted for shipment of toluol where a price in excess of the above is asked and all releases granted for other than military uses will be stamped "Released only upon condition that price does not exceed $1.50 per gallon in tank cars, $1.55 in drums."

According to *Drug and Chemical Markets*, when the National Aniline and Chemical Company and E. I. du Pont de Nemours and Company applied for licenses to manufacture dyes under German owned patents, it was found that in many instances insufficient descriptions were given to enable any one to follow the correct formulas. In some cases when attempts to combine the ingredients were made, explosions or failures from other causes resulted. In other cases the formulas worked without a hitch when tried in a laboratory, but were a failure when an effort was made to produce the dyes in commercial quantities. After the proper combinations for the mercantile production of dyes were established, further careful experimentation was necessary to discover which patented formula or formulas it was necessary to follow in order to introduce the dyes into faorics. It was not until these problems were solved satisfactorily that the licenses were approved.

According to the *Manufacturers' Record* a company with a capitalization of $50,000 has been organized to manufacture dyes out of weeds, and glycerin out of sugar. Officers of the company are A. T. Thompson, *President;* John J. Blijdenstein, *Vice President;* George F. Seeman, *Secretary-Treasurer;* and William Ficker, inventor of the processes, *Manager*. The Food Administration declined to give Ficker a permit to buy sugar for his process until Government chemists were satisfied as to the truth of his claims. Accordingly, Ficker gave a public demonstration on March 18, at which demonstration he apparently extracted 125 lbs. of glycerin from 300 lbs. of sugar. The glycerin was later analyzed and found to be 53 per cent pure. This has not satisfied the Government men and they have asked for another demonstration. In the dye process Ficker claims he has discovered a way of extracting from common weeds a product equal to the best anilines.

Prior to the summer of 1914 the greater part of the chemical laboratory glassware used in this country was imported from Germany and Austria. The cutting off of imports from these countries caused a very serious shortage of glassware in this country, which is not yet entirely overcome. However, within the past two years a number of American manufacturers have increased their production of such ware, or are manufacturing grades of chemical glassware that they did not produce before. It is probable that practically our whole available supply at this time is of domestic manufacture, much of which is ware sold under brand names which were unknown a short time ago. In order to furnish the chemists information regarding such domestic brands, it was decided by the United States Bureau of Standards to compare them with those of foreign make. The results of these tests indicate that all of the American made wares tested are superior to Kavalier and equal or superior to Jena ware for general chemical laboratory use.

An important discovery has been made as a result of a series of experiments carried out by the Forest Products Laboratories of the Canadian Government at Montreal to ascertain whether pine oil, hitherto imported from the Southern States, could be produced from Canadian pine. Pine oil has latterly been much used by silver mining companies for the treatment of ore by the oil flotation process, but owing to the growing demand for it in the United States, Canadian operators were threatened with a shortage. The Canadian Government commissioned the officials of the Forest Products Laboratories to experiment with the view of establishing the possibility of producing pine oil from Canadian red pine, which is a much less resinous wood than the Southern pine. The investigation proved successful, not only in producing pine oil, but in the discovery that a cheaper substitute for flotation purposes could be found in creosote oil produced as a by-product in wood distillation. The oils obtained at the laboratory were tested by the Mines Branch at Ottawa and found well suited to the flotation process for reducing metallic ores. This will provide a new market for the wood distilling industry in addition to relieving a situation that was becoming serious in connection with silver mining.

Extensive experiments in Sweden have shown that wood cellulose is an excellent cattle feed, and the Government is pushing its manufacture as much as possible.

One of the largest seizures of enemy alien property made by the Alien Property Custodian, A. Mitchell Palmer, is that of the Bayer Company, Inc., producers of a wide range of chemicals for medicinal and technical uses, as well as of some coal-tar intermediates and dyes. The company is capitalized at $2,500,000, but its business and property rights are estimated to be worth $10,000,000 easily. Among the new directors are Nicholas F. Brady, son of the late Anthony P. Brady; George H. Carnahan, president of the Continental Rubber Co., Frederick B. Lynch, of Minnesota, and Democratic National Committeeman from that State, who is now in business at 14 Wall St., N. Y. City, and Martin H. Glynn, of Albany, one time Governor of New York State.

An American strontium industry is in the process of formation. Several of the older chemical companies are making small quantities of strontium compounds, chiefly the nitrate, and two or three plants in the Southern part of California have been established especially for this purpose. These plants do not entirely take care of the present domestic demand. This demand is largely due to war conditions, as the use of signal lights on both land and sea has been enormously increased. The most important purpose for which strontium salts are used abroad has never been developed here, namely, the strontia or Scheibler process for the recovery of sugar from beet-sugar molasses. Germany at the time of the outbreak of the war was using annually in the sugar industry from 100,000 to 150,000 tons of strontium hydroxide. In Russia, also, where the beet-sugar industry is well established, probably as great an amount was used. In Italy, Great Britain, and the United States, however, the lime or Steffens process is the one usually employed. It is generally conceded that the strontia process is more efficient than the lime process and that the principal difficulties connected with its establishment in this country have been the cheapness and facility with which lime could be obtained on the one hand, and the expense and difficulty of obtaining strontium hydroxide on the other. In the case of lime, too, this is generally discarded after being used, while, owing to the expense, strontia must be recovered. Because of the present high price of sugar and the need of employing the most efficient process for its recovery, this would seem to be an excellent time to introduce the strontia process into this country. With the introduction of this process, the need for strontia would increase enormously over the present demand.

The entire exhibit of the National Aniline and Chemical Company, Inc., which formed a part of the Sixth National Textile Exhibition in Grand Central Palace, New York, was transferred to the "Made in U. S. A. Exposition" of the Jordan Marsh Company of Boston which was held from May 15 to 25, 1918.

The Canadian Advisory Council of Scientific and Industrial Research, a body of experts organized under government auspices to promote industrial development and the utilization of natural resources, has granted a sum for the carrying out of an investigation as to the waste of sulfite liquors by the Canadian pulp mills, and the feasibility of its being utilized as a by-product. The Council also has under consideration the waste of ammoniacal liquor from gas works, and its utilization for the manufacture of ammonia as a fertilizer.

War has encouraged the production of citric acid in the United States, according to a preliminary report on this industry just made by the United States Tariff Commission. Quantities of this acid were imported from Sicily previous to the war, but the United States has placed it upon the restricted import list. The Federal census reported the production of 2,720,943 lbs. of citric acid in 1914, which was but a slight increase over the figures reported in 1904 and 1909. The statistics reported by the Tariff Commission show that in 1915 the United States produced 3,417,795 lbs. of citric acid, in 1916, 4,182,478 lbs., and in 1917, 4,032,897 lbs.

It is reported that a new process has been invented in Japan for manufacturing glycerin directly from tallow. This new process is said to be twice as profitable as the ordinary method of producing glycerin as a by-product of soap and the inventor has made a special contract with the Tokio Gas and Electric Company for the manufacture of the apparatus.

Prior to the war Japan was a large importer of medical instruments from Europe, chiefly from Germany, but conditions brought about by the war have greatly encouraged Japanese industry in this line, much progress having been made in a comparatively short period, especially in the production of clinical instruments, which are now being supplied by Japan to various parts of the world.

By a ruling of Judge Foster in the Federal District Court in New Orleans, the Union Sulphur Co., of Calcasieu Parish, will be compelled to pay to the State of Louisiana a tax of 10 cents per ton on all sulfur extracted from its mines.

At a meeting of the directors of the Chemical Alliance it was decided that a fee of 3 cents per ton be charged by the importers for each ton of Spanish pyrites distributed by them, with the understanding that the funds received from this source would be used in defraying the expense of the Committee on Pyrites. Such charge has been made effective on all cargoes received since March 20, 1918.

It is estimated by a Chilean engineer that upward of 300,000 tons of potash could be recovered yearly from refined nitrate and from nitrate of soda exports from Chile if a proper method of extracting potash from the nitrate were employed. This engineer found after extensive experimentation that the nitrate deposits in the north of Chile contained an average of 1.73 per cent of available potash.

The Aluminum Company of America will build a nitrate plant to cost approximately $2,000,000 near Maryville, Tenn. The factory is to produce nitrate as a by-product of the aluminum works and hydroelectric development. It will cover seven acres, and, it is expected, will be completed September 1. The Government has contracted for this plant's production of nitrate for use in the manufacture of explosives in the $100,000,000 works it is building at Hadley's Bend, near Nashville.

The Brown Instrument Company is opening a branch office at 2086 Railway Exchange Building, St. Louis, Mo. Mr. Paul H. Berggreen will be in charge.

The Lake Charles Naval Stores Co., with a paid-up capital of $900,000, has taken over the Independent Naval Stores Company leases on 60,000 acres of turpentine land in southwestern Louisiana and will continue to operate it. The officers are: W. B. Gillican, *President;* A. Vizard, *Vice President;* B. Chipley, *Vice-President*, all of New Orleans; and W. A. Hood, *Vice President* and *General Manager;* A. Vizard, Jr., *Secretary* and *Treasurer*, both of Lake Charles, La.

Following investigation by the sub-committee on ferro alloys of the American Iron and Steel Institute, it has been recommended that a standard of 70 per cent manganese content and 16 per cent for spiegeleisen be adopted. These recommendations are made because of the necessity of the maximum possible conservation of shipping and the consequent need of utilizing domestic ores to the greatest extent possible.

One of the most important of recent industrial announcements is that the United States Steel Corporation will make cannon for the Government, and especially significant is the fact that the plant to be established for this manufacture is to be located in the interior of the country where it will be as safe as possible from enemy attacks in the event of war being brought to the doors of America, with the possibility of invasion. General plans are being prepared rapidly and will soon be ready for submission to the Federal authorities. It is reported that the plant may be established at either Pittsburgh, Pa., Cleveland, O., or Gary, Ind.

Pittsburgh capitalists have chartered the Shenandoah Valley Manganese Corporation of Stanley, Va., for the purpose of developing Virginia manganese properties. This company is capitalized at $1,500,000, and its officers are George S. Davison, *President*, and Albert P. Meyer, *Secretary*, both of Pittsburgh.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

BUREAU OF STANDARDS

Comparative Tests of Porcelain Laboratory Ware. C. E. Waters. Technologic Paper 105, 8 pp. Paper, 5 cents. Published December 10, 1917. In general there is little choice between the five brands of porcelain tested as far as their resistance to reagents is concerned. One exception is their behavior with caustic-soda solution, in which test the Royal Berlin and Japanese wares were the best, if we except the apparently abnormally high result obtained with one of the Berlin dishes.

"The two American wares and the Bavarian crucibles made a comparatively poor showing when suddenly heated or cooled. In both of these tests the Japanese and the Royal Berlin porcelain and the Bavarian dishes were equally good. No Berlin crucibles were available.

"A serious defect of the American and Bavarian porcelains was the cracking of the glaze when a hot vessel was picked up with tongs."

DEPARTMENT OF AGRICULTURE

Maple Sugar: Composition, Methods of Analysis, Effect of Environment. A. H. Bryan, M. N. Straughn, C. G. Church, A. Given and S. F. Sherwood. Department Bulletin 460, contribution from the Bureau of Chemistry, issued Nov. 3, 1917. 46 pp. Paper, 5 cents.

Standard Forms for Specification, Tests, Reports, and Methods of Sampling for Road Materials. Anonymous. Department Bulletin 555, contribution from the Office of Public Roads and Rural Engineering, issued Nov. 26, 1917. 56 pp. Paper, 10 cents.

Courses in Secondary Agriculture for Southern Schools. (Third and Fourth Years.) H. P. Barrows. Department Bulletin 592, contribution from the States Relations Service, issued November 5, 1917. 40 pp. Price, 5 cents. For use of teachers in southern schools.

Manufacturing Tests of the Official Cotton Standards for Grade. W. S. Dean and F. Taylor. Department Bulletin 591, contribution from the Bureau of Markets, issued December 26, 1917. 27 pp. Paper, 5 cents.

The Relation of Some of the Rarer Elements in Soils and Plants. W. O. Robinson, L. A. Steinkoinig and C. F. Miller. Department Bulletin 600, contribution from the Bureau of Soils, issued December 10, 1917. 27 pp. Price, 5 cents. A description of samples used and analytical results obtained in certain investigations on the subject. Of interest to chemists generally.

The Utilization of Waste Tomato Seeds and Skins. F. Rabak. Department Bulletin 615, contribution from the Bureau of Plant Industry, issued Nov. 30, 1917. 15 pp. Paper, 5 cents.

Articles from the Journal of Agricultural Research

Hydrocyanic-Acid Gas as a Soil Fumigant. E. Ralph de Ong. 11, 421–436 (Nov. 26, 1917).

Enzymes of Milk and Butter. R. W. Thatcher and A. C. Dahlberg. 11, 437–448 (Nov. 26, 1917).

Tests of Large-Sized Reinforced Concrete Slab Subjected to Eccentric Concentrated Loads. A. T. Goldbeck and H. S Fairbank. 11, 505–520 (Dec. 3, 1917).

Movement of Soluble Salts through Soils. M. M. McCool and L. C. Wheeting. 11, 531–548 (Dec. 10, 1917).

Influence of the Age of the Cow on the Composition and Properties of Milk and Milk Fat. C. H. Eckles and L. S. Palmer. 11, 645–658 (Dec. 17, 1917).

Soil Acidity and the Hydrolytic Ratio in Soils. C. H. Spurway. 11, 659–671 (Dec. 17, 1917).

Decomposition of Green and Stable Manures in Soil. R. S. POTTER AND R. S. SNYDER. **11,** 677–698 (Dec. 24, 1917).

Effect of Time of Digestion on the Hydrolysis of Casein in the Presence of Starch. J. S. MCHARGUE. **12,** 1–7 (January 7). Contribution from Kentucky Agricultural Experimental Station.

Studies in Soil Reaction as Indicated by the Hydrogen Electrode. J. K. PLUMMER. **12,** 19–30 (January 7). Contribution from North Carolina Agricultural Experiment Station.

Pure Cultures of Wood-Rotting Fungi on Artificial Media. W. H. LONG AND R. M. HARSCH. **12,** 33–81 (January 14). Contribution from Bureau of Plant Industry.

Gossypol, the Toxic Substance in Cottonseed. W. A. WITHERS AND F. E. CARRUTH. **12,** 83–100 (January 14). Contribution from North Carolina Agricultural Experiment Station.

Relation of Carbon Dioxide to Soil Reaction as Measured by the Hydrogen Electrode. D. R. HOAGLAND AND L. T. SHARP. **12,** 139–147 (January 21). Contribution from California Agricultural Experiment Station.

Influence of Nitrates on Nitrogen-Assimulating Bacteria. T. L. HILLS. **12,** 183–227 (January 28). Contribution from Wisconsin Agricultural Experiment Station.

Water Extractions of Soils as Criteria of Their Crop-Producing Power. J. S. BURD. **12,** 297–309 (February 11). Contribution from California Agricultural Experiment Station.

Effect of Season and Crop Growth in Modifying the Soil Extract. G. R. STEWART. **12,** 311–364 (February 11). Contribution from California Agricultural Experiment Station.

The Freezing-Point Method as an Index of Variations in the Soil Solution Due to Season and Crop Growth. D. R. HOAGLAND. **12,** 369–394 (February 11). Contribution from California Agricultural Experiment Station.

Efficacy of Some Anthelmintics. M. C. HALL AND W. D. FOSTER. **12,** 397–445 (February 18). Contribution from Bureau of Animal Industry.

TARIFF COMMISSION

The Dyestuff Situation in the Textile Industries. 24 pp. This pamphlet is one of a series which the United States Tariff Commission is publishing as an aid to the study and clearer understanding of the tariff and its bearing on various industries. In the present instance a compilation has been made of the dyestuffs consumed by four groups of representative textile manufacturers in order to study the effect the shortage of dyestuffs has had on the textile industry, and to ascertain the extent to which American-made dyestuffs have replaced those of foreign manufacture. Textile manufacturers, who of necessity use dyestuffs, are naturally interested in dyestuff tariffs and their varying opinions are quoted. This pamphlet is divided into five parts, as follows:

First, a summary of the quantity and value of dyestuffs consumed in 1913 and 1916 by 77 important companies engaged in the manufacture of cotton, wool, and silk goods or in the dyeing and finishing of textiles exclusive of that done in the textile mills.

Second, the relation of the dyestuff situation to the manufacture of cotton goods, including a tabulation of the dyestuffs and chemicals consumed by 23 companies in 1913 and 1916 and answers to important questions relating to the scarcity of dyestuffs.

Third, similar information furnished by 25 important manufacturers of woolen and worsted goods.

Fourth, similar information furnished by 8 important manufacturers of silk goods.

Fifth, similar information furnished by 21 important companies engaged in the dyeing and finishing of textiles exclusive of that done in the textile mills.

The present report will be supplemented at a later date with information which is now being collected from the manufacturers of dyestuffs and other coal-tar products, as required by the act of Congress approved September 8, 1916. The section of the law dealing with dyestuffs and coal-tar products and fixing the rates of duty thereon is printed as an appendix to this pamphlet.

BOOK REVIEWS

American Lubricants. From the Standpoint of the Consumer. By L. B. LOCKHART, Consulting and Analytical Chemist. 8vo. Pp. 236. The Chemical Publishing Co., Easton, Pa., 1918. Price, $2.00.

The work comprises a brief résumé of their manufacture, method of testing, and uses. Some of the latter treated are Internal Combustion Engines, Automobiles, Electrical Machinery, Steam Engines, Railway Lubrication, Textile Mills, Air Compressors, etc.

The field covered is a very extensive one and it is not surprising that some parts are open to question. For example, on page 146 one would think that the elaidin test was a specific one for olive oil, whereas it is only one indication. It would seem also that a description of "the Cleveland tester" mentioned in the preface should have been included, it being widely used. Inasmuch as "the Pennsylvania railroad pipette" was never suitable for determining viscosity and has long been out of use, the picture and mention of it might well have been omitted.

The work in general is clear and concise and the chapter on Gasolines and Kerosene particularly good and timely. Mr. Lockhart was for a number of years chemist of the North Carolina Department of Agriculture, and while there made a number of valuable reports upon kerosene, portions of which are here reprinted and made more accessible.

A valuable feature of the book is the inclusion of practically all the latest specifications relative to lubricants, burning oils and gasolines, of the Navy and War Department, and the Pennsylvania Railroad and its allied lines.

The book will no doubt "prove of practical aid" to quote from the preface, and may be heartily and unreservedly recommended to all interested in the subject. A. H. GILL

The Method of Enzyme Action. By JAMES BEATTY, M.A., M.D., D. P. H. P. Blakiston's Son & Co., Philadelphia, 1917. Price, $1 75 net.

This book was written with the view to setting forth a hypothesis of the method of enzyme action. As a preliminary to stating this hypothesis the author has discussed in the early pages the chemistry and physics relating to enzyme action under the headings "Catalysis," "Colloids," "Adsorption," "Chemical Action," etc. The gist of the matter is stated on page 105, in these words "* * * * the whole of enzyme action has been reduced to the action of hydrogen and hydroxyl radicles."

Enzymes, from a chemical point of view, are the substances closest related to organic life with which the scientist has to deal, and they are still surrounded with the same mystery as life itself. Having an appreciation of the complexity and difficulties of his subject, Dr. Beatty urges his hypothesis with the requisite reserve. In the opinion of the reviewer the action of H and OH radicles in explaining enzyme action is the commonsense view to take.

The general review and summary of enzyme action leading up to the statement of the hypothesis is not the least valuable part of the publication. J. F. BREWSTER

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Chemistry: First Stage. F. P. ARMITAGE. 2nd Ed. 80 pp. Price, $0.60. Longmans, Green & Co., New York.

Chemistry: Précis de chimie. R. LESPIEAU. 2 Vol. 16mo. 344 pp. Price, 4 fr. Hachette et Cie, Paris.

Chemistry in the Home. H. T. WEED. New Ed. 12mo. 386 pp. Price, $1.20. American Book Co., New York.

Electrochemistry Applied to Sewage Disposal. F. N. MOERK. 8vo. 77 pp. Price, $1.00. Electrolytic Purification Co., Phila.

Electron Theory of Matter. O. W. RICHARDSON. 2nd Ed. 8vo. 631 pp. Price, $4.75. G. P. Putnam's Sons, New York.

Engineers Guide: Audel's New Marine Engineers' Guide. T. LUCAS AND OTHERS. 16mo. Price, $3.00. Audel & Co., New York.

French Medical Vocabulary and Phrase Book. JOSEPH MARIE. 2nd Ed. P. Blakiston's Son & Co., Phila.

Gas Motor. MAX KUSHLAN. 12mo. 366 pp. Price, $2.50. Branch Pub., Chicago.

Hydraulics: Handbook of Hydraulics. H. W. KING. 16mo. 424 pp. Price, $3.00. McGraw-Hill Co., New York.

Lecithin and Allied Substances. HUGH MACLEAN. 8vo. 206 pp. Price, $2.25. Longmans, Green & Co., New York.

Lubrication: American Lubricants. L. B. LOCKHART. 8vo. 236 pp. Price, $2.00. The Chemical Pub. Co., Easton, Pa.

Machine Design: Elements of Machine Design. H. L. NACHMAN. 8vo. 245 pp. Price, $2.00. John Wiley & Sons, Inc., New York.

Metallurgical Calculations. J. W. RICHARDS. One Vol. Ed. 8vo. 675 pp. Price, $5.00. McGraw-Hill Co., New York.

Oil: Popular Oil Geology. VICTOR ZIEGLER. 12mo. 149 pp. Price, $2.50. C. H. Merrifield, Golden, Colo.

Powdered Coal as Fuel. C. F. HERRINGTON. 8vo. 190 pp. Price, $3.00. D. Van Nostrand Co., New York.

Roads: A Treatise on Roads and Pavements. I. O. BAKER. 3rd Ed. 8vo. 666 pp. Price, $4.50. John Wiley & Sons, Inc., New York.

Sanitary Engineering: Elements of Sanitary Engineering. MANSFIELD MERRIMAN. 8vo. 250 pp. Price, $2.00. John Wiley & Sons., Inc., New York.

Sheet Metal Work. W. NEUBECKER. 8vo. 267 pp. Price, $2.00. American Technical Society, Chicago.

Strength of Materials. E. R. MAURER. 8vo. 126 pp. Price, $1.00. American Technical Society, Chicago.

Van Nostrand's Chemical Annual. J. C. OLSEN. 4th issue. 1918. 12mo. 778 pp. Price, $3.00. D. Van Nostrand Co., New York.

RECENT JOURNAL ARTICLES

Acid Open Hearth Steel Investigation. T. D. MORGANS AND F. ROGERS. *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 5, pp. 216–217.

Acid-Resisting Iron and Its Uses in Chemical Plant. S. J. TUNGAY. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 6, pp. 87t–91t.

Analysis of Aluminum Alloys. B. COLLITT AND W. REGAN. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 6, pp. 91t–95t.

Analysis of Intermediates. THOMAS LECLÉAR. *Color Trade Journal*, Vol. 2 (1918), No. 5, pp. 203–204.

Barium Carbonate: Possible Sources of Barium Carbonate. S. H. DOLBEAR. *Mining and Scientific Press*, Vol. 116 (1918), No. 18, pp. 611–612.

Brownian Movements. W. D. BANCROFT. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 4, pp. 273–299.

Chemical Organization, Value of. C. L. REESE. *Textile World Journal*, Vol. 53 (1918), No. 44, pp. 161–163.

Coal: Efficient Combustion of Bituminous Coal. R. C. HINE. *Industrial Management*, Vol. 55 (1918), No. 5, pp. 388–391.

Coal: Spontaneous Ignition of Bituminous Coal. J. F. SPRINGER. *Power*, Vol. 47 (1918), No. 16, pp. 536–538.

Copper: Bibliography on the Physical Properties of Copper. P. D. MERICA. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 8, pp. 409–415.

Dust Problems in Fertilizer Plants. W. G. CLARK. *The American Fertilizer*, Vol. 48 (1918), No. 8, pp. 30–31.

Dyestuff Testing in the Textile Industry. E. W. PIERCE. *Textile World Journal*, Vol. 53 (1918), No. 43, pp. 69–71.

Electric Furnace: Modern Electric Furnace Practice. J. K. HARRISON. *The Iron Trade Review*, Vol. 62 (1918), No. 15, pp. 913–914.

Electrical Endosmose. T. R. BRIGGS AND OTHERS. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 4, pp. 256–272.

Enzymes: Their Chemical Composition, Mode of Action, Basic Ingredient and Synthetic Preparation. C. B. DAVIS. *The Chemical Engineer*, Vol. 26 (1918), No. 5, pp. 164–170.

Fat: The Determination of Fat in Leather. J. A. WILSON AND E. J. KERN. *Journal of the American Leather Chemists Association*, Vol. 13 (1918) No. 4, pp. 138–141.

Flotation: Cascade Method of Froth-Flotation. H. H. SMITH. *Mining and Scientific Press*, Vol. 116 (1918), No. 15, pp. 505–508.

Flotation in Arizona. RUDOLF GAHL. *Engineering and Mining Journal*, Vol. 105 (1918), No. 16, pp. 717–719.

Flotation in Relation to Gangue Minerals. J. M. MCCLAVE. *Engineering and Mining Journal*, Vol. 105 (1918), No. 16, pp. 738–739.

Flotation of Semi-Oxidized Silver Ore. E. J. ATCKISON. *Mining and Scientific Press*, Vol. 116 (1918), No. 17, pp. 575–577.

Fuel: The Extent of the Use of Pulverized Fuel in the Industries and Its Possibilities in the War. F. P. COFFIN. *General Electric Review*, Vol. 21 (1918), No. 5, pp. 373–380.

Furnace Slag: Classification of Furnace Slags. HERBERT LANG. *Mining and Scientific Press*, Vol. 116 (1918), No. 18, pp. 619–621.

Glass: Crystals of Barium Disilicate in Optical Glass. N. L. BOWEN. *Journal of the Washington Academy of Science*, Vol. 8 (1918), No. 9, pp. 265–268.

Heat Conduction: Theory of Heat Conduction and Transfer. A. D. WILLIAMS. *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 5, pp. 199–201.

Hydroelectric Power in Relation to Industry. J. A. JOHNSON *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 9, pp. 462–466.

Japan's Fertilizer Trade. *The American Fertilizer*, Vol. 48 (1918), No. 8, pp. 21–23.

Liquid Ferromanganese in Open Hearth. E. C. HUMMEL. *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 5, pp. 201–202.

Lubricating and Other Properties of Thin Oily Films. LORD RAYLEIGH. *Chemical News*, Vol. 117 (1918), No. 3045, pp. 160–162.

Manganese Deposits of Clark County, Nevada. F. A. HALE, JR. *Engineering and Mining Journal*, Vol. 105 (1918), No. 17, pp. 775–777.

Microscope to Detect Steel Impurities. JOHN MCCONNELL. *Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 5, pp. 219–221.

Microscopic Study of Welded Tires. S. W. MILLER. *Journal of Acetylene Welding*, Vol. 1 (1918), No. 11, pp. 472–479.

Minerals Used in the Pulp and Paper Industry. L. H. COLE. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 15, pp. 339–341.

Natural Gas: Making Substitutes for Natural Gas. F. DENK. *The American Drop Forger*, Vol. 4 (1918), No. 4, pp. 132–135.

Oil: The Kentucky Oil Fields. W. N. THAYER. *Engineering and Mining Journal*, Vol. 105 (1918), No. 17, pp. 781–785.

Oil-Shale Industry. A. J. HOSKIN. *Mining and Scientific Press*, Vol. 116 (1918), No. 15, pp. 509–516.

Petroleum Industry in Kansas. W. A. WHITAKER AND OTHERS. *Engineering and Mining Journal*, Vol. 105 (1918), No. 18, pp. 817–821.

Power: An Ingenious Solution of a Power Problem. R. J. HORNE. *Paper*, Vol. 22 (1918), No. 5, pp. 15–17.

Radioactivity of Italian Minerals: Sulla radioattività di minerali italiani. L. FRANCESCONI. *Gazzetta chimica italiana*, Vol. 48 (1918), No. 3, pp. 112–113.

Radium: Some Experiments on the Extraction of Radium from American Pitchblende Ores by Chlorination. MRS. RAY CABLE AND H. SCHLUNDT. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 9, pp. 460–462.

Research: Development of Research Work. G. E. HALE *Textile World Journal*, Vol. 53 (1918), No. 44, pp. 163–164.

Research: Efficiency in Industrial Research. C. W. HILL. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 4, pp. 182–184.

Rubber: The Oxidation of Rubber. S. J. PEACHEY AND M. LEON. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 4, pp. 55–60.

Rubber and Jelutong. F. DANNERTH. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 6, pp. 296–298.

Salicylic Acid: The Manufacture of Salicylic Acid. *Color Trade Journal*, Vol. 2 (1918), No. 5, pp. 186–188.

Science and Industry. E. R. WEIDLEIN. *Textile World Journal*, Vol. 53 (1918), No. 44, pp. 186–191.

Shale Oil: Commercial Aspects of the Shale Oil Industry. J. H. G. WOLF. *Mining and Scientific Press*, Vol. 116 (1918), No. 18, pp. 613–614.

Smelting Changes to Conserve Zinc. W. MCA. JOHNSON *Mining and Scientific Press*, Vol. 116 (1918), No. 16, pp. 555–556.

Solubility of Paraffins, Aromatic Naphthenes and Olefins in Liquid Sulfur Dioxide. R. J. MOORE AND OTHERS. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 8, pp. 396–402.

Solvents for Nitrocellulose. J. N. HANS. *DuPont Magazine*, Vol. 8 (1918), No. 3, pp. 13–14.

Spruce Turpentine: Recovery of Spruce Turpentine in the Mill. A. W. NICKERSON. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 18, pp. 345–348.

Steel: Development of Steel from the Early Ages. R. K. GREAVES. *The American Drop Forger*, Vol. 4 (1918), No. 2, pp. 61–66.

MARKET REPORT—MAY, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON MAY 15, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal	
Alum, ammonia, lump	100 Lbs.	4.00 @	4.50
Aluminum Sulfate (iron free)	Lb.	3½ @	4
Ammonium Carbonate, domestic	Lb.	nominal	
Ammonium Chloride, white	Lb.	17¾ @	18
Aqua Ammonia, 26°, drums	Lb	20 @	22
Arsenic, white	Lb.	16½ @	17
Barium Chloride	Ton	65.00 @	85.00
Barium Nitrate	Lb.	12 @	13
Barytes, prime white, foreign	Ton	30.00 @	35.00
Bleaching Powder, 35 per cent	100 Lbs	1.80 @	2.00
Blue Vitriol	Lb.	8.80 @	9.00
Borax, crystals, in bags	Lb.	7¾ @	8¼
Boric Acid, powdered crystals	Lb.	13¼ @	15
Brimstone, crude, domestic	Long Ton	nominal	
Bromine, technical, bulk	Lb.	75 @	85
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00 @	25.00
Caustic Soda, 76 per cent	100 Lbs.	4.25 @	4.35
Chalk, light precipitated	Lb.	4¾ @	5
China Clay, imported	Ton	20.00 @	30.00
Feldspar	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered	Ton	nominal	
Fuller's Earth, domestic	Ton	20.00 @	30.00
Glauber's Salt, in bbls	100 Lbs.	1.50 @	3.00
Green Vitriol, bulk	100 Lbs.	1.15 @	1.25
Hydrochloric Acid, commercial, 20°	Lb.	2¼ @	2½
Iodine, resublimed	Lb.	4.25 @	4.30
Lead Acetate, white crystals	Lb.	17 @	18
Lead Nitrate	Lb.	nominal	
Litharge, American	Lb.	10 @	11
Lithium Carbonate	Lb.	1.50	
Magnesium Carbonate, U. S. P.	Lb.	25 @	30
Magnesite, "Calcined"	Ton	60.00 @	65.00
Nitric Acid, 40°	Lb.	8½ @	9
Nitric Acid, 42°	Lb.	9 @	10
Phosphoric Acid, 48/50%	Lb.	25 @	30
Phosphorus, yellow	Lb.	1.40 @	1.50
Plaster of Paris	Bbl.	2.00 @	2.50
Potassium Bichromate, casks	Lb.	45 @	47
Potassium Bromide, granular	Lb	1.35 @	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	40 @	50
Potassium Chlorate, crystals, spot	Lb.	41 @	42
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%	Lb	83½ @	84
Potassium Iodide, bulk	Lb.	3.75 @	4.00
Potassium Nitrate	Lb.	27 @	30
Potassium Permanganate, bulk	Lb.	3.10 @	3.20
Quicksilver, flask	75 Lbs.	117.00 @	120.00
Red Lead, American, dry	Lb	10 @	10½
Salt Cake, glass makers'	Ton	25.00 @	27.00
Silver Nitrate	Oz.	61½ @	63¼
Soapstone, in bags	Ton	10.00 @	12.50
Soda Ash, 58%, in bags	100 Lbs	2.20 @	2.65
Sodium Acetate	Lb.	23 @	24
Sodium Bicarbonate, domestic	100 Lbs	3.00 @	3.25
Sodium Bichromate	Lb	24 @	24¾
Sodium Chlorate	Lb	25 @	26
Sodium Cyanide	Lb	40 @	43
Sodium Fluoride, commercial	Lb.	17 @	18
Sodium Hyposulfite	100 Lbs	2.50 @	2.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	5.50 @	6.25
Sodium Silicate, liquid, 40° Be.	100 Lbs	2.00 @	2.50
Sodium Sulfide, 60%, fused in bbls	Lb	nominal	
Sodium Bisulfite, powdered	Lb	8 @	10
Strontium Nitrate	Lb.	22 @	28
Sulfur, flowers, sublimed	100 Lbs.	4.05 @	4.50
Sulfur, roll	100 Lbs.	3.70 @	4.10
Sulfuric Acid, chamber 66° Be	Ton	32.50 @	35.00
Sulfuric Acid, oleum (fuming)	Ton	60.00 @	65.00
Talc, American white	Ton	18.00 @	20.00
Terra Alba, American, No. 1	100 Lbs.	1.17½	
Tin Bichloride, 50°	Lb.	27¼ @	28
Tin Oxide	Lb.	1.00 @	1.10
White Lead, American, dry	Lb.	9 @	9½
Zinc Carbonate	Lb.	28 @	30
Zinc Chloride, commercial	Lb.	14 @	15¼
Zinc Oxide, American process XX	Lb.	12½ @	16

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	75 @	79
Acetic Acid, 56 per cent, in bbls		nominal	
Acetic Acid, glacial, 99½%, in carboys	Lb	40 @	65
Acetone, drums	Lb	nominal	
Alcohol, denatured, 180 proof	Gal	68 @	69
Alcohol, sugar cane, 188 proof	Gal	4.85 @	4.90
Alcohol, wood, 95 per cent, refined	Gal	90½ @	91
Amyl Acetate	Gal	5.40 @	5.50
Aniline Oil, drums extra	Lb.	26 @	28
Benzoic Acid, ex-toluol	Lb.	4.00 @	4.10
Benzol, pure	Gal	27 @	30
Camphor, refined in bulk, bbls	Lb.	1.12	
Carbolic Acid, U. S. P., crystals, drums	Lb.	50 @	51
Carbon Bisulfide	Lb.	8½ @	9
Carbon Tetrachloride, drums, 100 gals	Lb.	15½ @	16
Chloroform	Lb.	63 @	65
Citric Acid, domestic, crystals	Lb.	82 @	85
Creosote, beechwood	Lb.	1.90 @	2.00
Cresol, U. S. P.	Lb.	18 @	20
Dextrine, corn (carloads, bags)	Lb.	7¾ @	8¼
Dextrine, imported potato	Lb.	19 @	20
Ether, U. S. P. 1900	Lb.	27 @	30
Formaldehyde, 40 per cent	Lb.	17 @	18
Glycerine, dynamite, drums included	Lb.	61 @	62
Oxalic Acid, in casks	Lb.	43 @	45
Pyrogallic Acid, resublimed, bulk	Lb.	3.10	
Salicylic Acid, U. S. P.	Lb.	90 @	1.00
Starch, cassava	Lb.	—	
Starch, corn carloads, bags pearl	100 Lbs.	6.30 @	6.45
Starch, potato, Japanese	Lb.	15 @	16
Starch, rice	Lb.	8 @	10
Starch, sago flour	Lb.	9¼ @	9½
Starch, wheat	Lb.	5 @	6
Tannic Acid, commercial	Lb.	60 @	75
Tartaric Acid, crystals	Lb.	75 @	78

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	62 @	64
Black Mineral Oil, 29 gravity	Gal.	21 @	22
Castor Oil, No 3	Lb.	33 @	34
Ceresin, yellow	Lb.	17 @	18
Corn Oil, crude	100 Lbs.	17.00 @	17.25
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½ @	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.40 @	20.50
Menhaden Oil, crude (southern)	Gal.	1.00 @	1.02
Neat's-foot Oil, 20°	Gal.	3.15 @	3.20
Paraffin, crude, 118 to 120 m. p.	Lb.	10 @	10¼
Paraffin Oil, high viscosity	Gal.	40 @	41
Rosin, "F" Grade, 280 lbs.	Bbl.	7.50	
Rosin Oil, first run	Gal.	41 @	—
Shellac, T. N.	Lb.	62 @	64
Spermaceti, cake	Lb.	31 @	33
Sperm Oil, bleached winter, 38°	Gal.	2.23 @	2.25
Spindle Oil, No. 200	Gal.	36 @	37
Stearic Acid, double-pressed	Lb.	23 @	25
Tallow, acidless	Gal.	1.58 @	1.60
Tar Oil, distilled	Gal.	32 @	33
Turpentine, spirits of	Gal.	52 @	52½

METALS

Aluminum, No. 1, ingots	Lb.	32 @	33
Antimony, ordinary	Lb.	12¾ @	12½
Bismuth, N. Y.	Lb.	3.50 @	3.65
Copper, electrolytic	Lb.	23.06	
Copper, lake	Lb.	23½ @	—
Lead, N. Y.	Lb.	7 @	7.10
Nickel, electrolytic	Lb.	55 @	56
Platinum, refined, soft	Oz.	nominal	
Silver	Oz.	99½	
Tin, Straits	Lb.	nominal	
Tungsten (WO_3)	Per Unit	20.00 @	23.50
Zinc N. Y.	Lb	7¾ @	8

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.80	
Blood, dried, f. o. b. Chicago	Unit	6.70 @	6.75
Bone, 3 and 50, ground, raw	Ton	42.00 @	—
Calcium Cyanamide	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian	100 Lbs.	—	
Castor Meal	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works	Unit	nominal	
Phosphate, acid, 16 per cent	Ton	18.00 @	—
Phosphate rock, f. o. b. mine:	Ton	nominal	
Florida land pebble 68 per cent	Ton	3.50 @	3.75
Tennessee, 78–80 per cent	Ton	5.50 @	6.00
Potassium "muriate," basis 80 per cent	Ton	nominal	
Pyrites, furnace size, imported	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	6.60	

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X JULY 1, 1918 No. 7

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD *Advertising Manager:* G. W. NOTT

ADVISORY BOARD

H. E. BARNARD, H. K. BENSON, F. K. CAMERON, B. C. HESSE, A. D. LITTLE, A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:

Platinum at White Heat 508
The Modern Miracle 508
An Army without Reserves 508
A French Local Section 510

ORIGINAL PAPERS:

The Manufacture of Amyl Acetate and Similar Solvents from Petroleum Pentane. Benjamin T. Brooks, Dillon F. Smith and Harry Essex 511
The Effect of Annealing on the Electrical Resistance of Hardened Carbon Steels. I. P. Parkhurst 515
Volumetric Determination of Free Sulfur in Soft Rubber Compounds. H. S. Upton 518
Rapid Determination of Carbon in Steel by the Barium Carbonate Titration Method. J. R. Cain and L. C. Maxwell 520
The Preparation and Testing of Pure Arsenious Oxide. Robert M. Chapin 522
The Bisulfate Method of Determining Radium. Howard H. Barker 525
A Rapid Pressure Method for the Determination of Carbon Dioxide in Carbonates. W. H. Chapin 527
A Proximate Analysis of the Seed of the Common Pigweed, *Amaranthus Retroflexus* L. Everhart P. Harding and Walter A. Egge 529
The Detection of Vegetable Gums in Food Products. A. A. Cook and A. G. Woodman 530
Uniform Nitrogen Determination in Cottonseed Meal. J. S. McHargue 533
The Detection and Determination of Coumarin in Factitious Vanilla Extracts. H. J. Wichmann 535
The Determination of Essential Oils in Non-Alcoholic Flavoring Extracts. Frank M. Boyles 537
A Contribution to the Composition of Lime-Sulfur Solutions. O. B. Winter 539

LABORATORY AND PLANT:

A Standard Apparatus for the Determination of Sulfur in Iron and Steel by the Evolution Method. H. B Pulsifer 545
Determination of Acetic Acid by Distillation with Phosphoric Acid. W. Faitoute Munn 550
The Determination of Acetone. Allan J. Field 552
Some Results of Analysis of Airs from a Mine Fire. A. G. Blakeley and H. H. Geist 552
A Differential Refractometer. G. A. Shook 553
A Volumenometer. J. S. Rogers and R. W. Frey 554
An Evaporator for Acid Liquids. Edward Hart 555
Conversion of Formulas. Willis H. Cole 555

ADDRESSES:

Technical Applications of Nephelometry. Philip Adolph Kober 556
Municipal Contribution to Conservation through Garbage Utilization. Edward D. Very 563
American Garbage Disposal Industry and Its Chemical Relation. Raymond Wells 567
The Potteries at Shek Waan, near Canton, China. Clinton N. Laird 568

CURRENT INDUSTRIAL NEWS:

Niter Cake; Petroleum in the British Empire; Potash Lye; Oil Clarifier; Canada's Export Trade; Irrigation Plant; Recovery of Solvent Naphtha; Pure Bismuth; Various Classes of Engines; Register of Overseas Buyers; Industrial Uses of Bismuth; Russian Monazite Sand Deposits; Mineral Output of Great Britain; Effect of Insulation on Steam Drums; Hardening Carbon Steel; Tungsten Filaments; Tar-Still Corrosion by Chlorine; Cotton-Sampling Machine; The Long-Range Gun; British Board of Trade 572

SCIENTIFIC SOCIETIES:

French Section, American Chemical Society; The German Union of Technical and Scientific Societies; American Pharmaceutical Association; Calendar of Meetings 575

NOTES AND CORRESPONDENCE:

Importance of Chemists Recognized by Secretary of War; Cooperation of American Chemical Society with the Chemical Service Section; du Pont Fellowships; Four Hundred Thousand Dollar Gift to the Massachusetts Institute of Technology; Coal-Tar Products for 1917 580

WASHINGTON LETTER 582
PERSONAL NOTES 583
INDUSTRIAL NOTES 585
GOVERNMENT PUBLICATIONS 586
NEW PUBLICATIONS 587
MARKET REPORT 588

EDITORIALS

PLATINUM AT WHITE HEAT

During the past month the subject of platinum has leaped to the forefront in the thoughts of the American people. For the first time, and by one of those quick processes of general understanding which have characterized this war period, the nation has learned the important bearing of this element upon the part we are to play in the war.

The chief factor in arousing this interest and understanding has been the widespread publicity given by the press to the stirring address delivered in the House of Representatives on June 7 by Hon. Henry T. Rainey, Congressman from Illinois. In this address he depicted clearly the important function of platinum in explosives manufacture, the inadequate measures taken for its conservation by those charged with this responsible duty, and the factors which had contributed to such inadequacy.

Since the delivery of that address many things have come to light which would prove interesting reading; editorial discussion of these, however, will be postponed. Only one conviction is expressed here—*the immediate place for the platinum in this country is in the vaults of the Treasury Department.*

THE MODERN MIRACLE

Scarcely two years have elapsed since many lines of our industrial life were threatened with utter demoralization because of the shortage of dyestuffs and medicinals resulting from the blockade of German ports by the British navy. Textile mills faced the imminent possibility of shutting down because of inability to secure dyestuffs for their fabrics. Tanners, lithographers, and wall paper men sought in vain for needed coloring matter, and pharmacists' stocks of many much-used medicinals became depleted. On account of these shortages and the accompanying speculation in the remaining stocks, prices soared to undreamed-of heights.

Yet within this short period of two years, one of which has been devoted to war preparations, a miracle has been wrought. Mills have not closed; all lines of industrial life requiring synthetic colors are operating under normal conditions; the sick have been provided with ample medicinal supples; prices have been largely reduced and are comparable with prices of all other commercial products; in addition, ships have borne from America to other parts of the world large quantities of dyestuffs.

No more fitting tribute could be paid to the skill and energy of the American chemist than has been done through the medium of two government announcements which have been issued during the past month, the one by the U. S. Tariff Commission and the other by the War Industries Board.

In the statement sent out by the Tariff Commission the results of its census of synthetic dyestuffs and medicinals are given (page 582, this issue). According to these figures the importation of dyestuffs in the fiscal year 1914 was 45,840,866 pounds, while in 1917 the domestic production amounted to 45,977,246 pounds. The tonnage has been made good and even exceeded. While it is true that there is a difference "in the relative amounts of the various classes of dyes" in the two periods mentioned, it is interesting to note, as the Commission's statement points out, that the lines which have failed of their full share of development have been exactly those to which were given only the *ad valorem* duty of 30 per cent, while in those classes which were given both the 30 per cent *ad valorem* and the 5 cents per pound special duty "the American manufacturers have shown remarkable progress." The statements of manufacturers and consumers at the hearings on the Hill bill are abundantly confirmed by the announcement of the Tariff Commission. By the enactment of tariff and anti-dumping legislation, capital was attracted to the industry, and the chemist has made good.

As to medicinals, the War Industries Board, in an authorized statement in the *Official Bulletin* of June 6, 1918, says:

"Actual or prospective shortages have come to the notice of the Board in but few instances so far as medicine and medicinal chemicals are concerned.* *"

Congress, capital, and chemists coöperating have accomplished the modern miracle.

AN ARMY WITHOUT RESERVES

General Foch has aroused the enthusiasm of the allied world by the masterly manner in which he has handled the reserves during the recent mammoth drives of the German army. These struggles have fitly been designated as "the battles of reserves." The morale of all the nations joined in the contest against German aggression has been stimulated by the conviction that an endless flow of reserves is proceeding with all possible haste from American to European shores. In the matter of reserves for the armies in the field all goes well.

The army of American chemists is now in rapid process of complete mobilization. At last the matter of efficient utilization of chemists has been grasped with a firm hand by those in authority. The orders issued by the Secretary of War on May 28, 1918 (page 580, this issue) show that the *may* of previous orders has been changed to *must*, and under these new orders the full strength of the chemistry forces will soon be reached. It appears that every possible contingency as to graduate chemists has been provided for. Congratulations to Secretary Baker and to those who have aided him in the preparation of these comprehensive orders!

With the thus mobilized army of chemists all goes well. But what about the reserves for this army? We are preparing for a long war, how long no one knows, but certainly as long as is necessary to insure the triumph of the principles to which we have dedicated our all. Daily grows the expansion of the con-

ception of the vast forces we must put in the field, on the sea and in the air. Increases in personnel necessitate similar expansions in the program of chemical industries, and these in turn must be manned by chemists. It is full time therefore that serious consideration should be given to the matter of reserves for this army of chemists. The source of reserves is in the universities and colleges, and we beg to urge the most broad-minded and far-sighted consideration of this problem by three groups of men: university administrators, War Department officials, and leaders in the chemical industries.

UNIVERSITY CONDITIONS

The universities represent the training camps for the reserves of the chemistry army. These institutions function through their chemistry staffs, their physical equipment, and through the number of undergraduates who present themselves for the chemistry courses.

At the present moment the instructional staffs of most of the universities are in a completely demoralized condition. Many professors and associate professors are on leave of absence in Washington engaged in research on problems vital to the winning of the war and the prevention of needless sacrifice of the lives of our men at the front. No more important work could engage their attention. Others are busy with similar problems in the private laboratories of the universities. The concentrated effort required in such undertakings does not admit of much energy being devoted to effective teaching. On the other hand the university men of lower rank, the instructors and assistants, charged primarily with the instruction of the lower classes, are for the greater part subject to the draft. In certain unusual cases deferred classification has been given such men by Local Boards. These cases, however, are sporadic and form no part of a general policy. Continued low salaries in universities, made necessary by decreased budgets, the high salaries paid in the industries, and the increased cost of living have forced many men from the universities into the industries. The net result is a burning of the candle at both ends, so far as the forces for training reserves are concerned. Bi-terminal combustion is considered a reckless policy in all other matters, why not in this?

In the ranks of the students, present year seniors have already left university campuses and are now either in uniform or in industrial plants. The matter of post-graduate students is evidently a thing of past history until at least the ending of the war. Furthermore, the operation of the draft law (in whose principles we most emphatically believe) and the need of men in the chemical industries have combined to take away from the universities many of the students in the junior classes. Meanwhile preliminary reports for next Fall indicate the largest enrollment of students intending to make chemistry their life work ever known in our educational history. This is only natural in view of the greater recognition given to the importance of chemistry in war work and to its value in every channel of industrial life. These are the men who constitute the chemistry reserves. They will soon be in the training camps of the universities. Will they find sufficient officers present to give them adequate instruction for their development into efficient reserves?

To add to the complexities of the situation there is no question about the crippled finances of the universities and of their helplessness in preventing the present drain upon their corps of instructors.

These are the conditions, as we see them, in this most critical year of our country's history. Certainly such conditions demand the most earnest consideration on the part of all who can in any way contribute to their amelioration. From what sources may help reasonably be expected?

ACADEMIC ASSISTANCE

First, assistance must come from the universities themselves. Such aid cannot be in the nature of increased appropriations, for university finances are already too hard hit. But they can in some instances shake themselves loose from traditions and modify internal organization and the character of courses to meet as far as possible the pressing need of the times. An example of such increased efficiency is shown by the merger of the University and the Sheffield Scientific School departments of chemistry at Yale University, recently announced.

It may be possible in some cases for institutions to combine forces. Many difficulties in such a plan present themselves, though these difficulties may not be as great as at first thought they seem. A certain minimum laboratory space is considered necessary per student. Possibly this space may be more efficiently utilized, at least in the lower classes, by repeated using of the same space by more than one student, in spite of the difficulty which at once suggests itself as to responsibility for equipment. The number of men who can be taught properly by an instructor is limited. This is a real difficulty, and sacrifice may be necessary here. Other courses must be taken besides chemistry and this may present physical difficulties. Hardships may be enforced upon individual students from living conditions under such combined institutions. This is a question of finance for which a remedy might be found. These are but types of the many perplexing academic problems to whose solution the best thought of our university men will be unstintedly given.

AID FROM THE WAR DEPARTMENT

Second, no word of exhortation to the War Department is necessary in the matter of instructors for chemical reserves. The provision of such is only the logical following out of the principles now being applied in the creation of our armies. Reserves are of course essential. These are of no value unless adequately trained. For this training instructors are required. In the training camps to-day are many soldiers who could render effective service on the fighting front, yet they are of greater service to the army in the

work of developing the raw recruit. How then can the War Department aid in the provision of instructors for chemistry students? In one of at least two ways: Either by granting class exemption to instructors in chemistry or by detailing men already in the service to instructional work in the university lecture rooms and laboratories. If exemption as a class should be given, then some distinguishing emblem should accrue to such men, for the time is at hand when peculiar glances are cast at young men of draft age who are not attired in khaki. If on the other hand it is deemed best that they should be enlisted and detailed back to universities, then it is fortunate that under the present orders of the Secretary of War the work of detailment would be in the hands of the Chief of the Chemical Service Section, Lieutenant Colonel Bogert, whose long and distinguished career as a teacher in one of our greatest universities preëminently qualifies him for such a duty. Time is an important factor in the matter, however, for every day that lapses after the opening of the universities next Fall is just so much loss in the work these soldier instructors will be expected to perform.

Of course the time may come when it will be advisable to close university doors and stop many other lines of daily effort, in the hope of putting across the one great blow for victory. That time does not seem to have arrived yet. Our enemies are apparently pursuing that policy now, and judging from the results to date it is proving disastrous for them.

SUPPORT FROM THE CHEMICAL INDUSTRIES

Third, the future of the industries depends upon no factor more than upon the output of chemists from the universities. Wonderful progress has been made in these industries in the past, particularly during the three preceding years. Much more must be accomplished, if we are not to rest content simply with doing as well as some other country has done. Within university walls next year will be young men who some day will have to take up the reins now so ably held by the present leaders. Already the industries have attracted to their staffs many valuable university teachers. We cannot eat our cake and have it too. Furthermore, the industries have already drained the universities of all available students possessing sufficient training to go into works laboratories. We believe that the heads of industrial laboratories will bear out the statement that the standard of qualifications of student accessions to industrial staffs has within the past two years been decidedly lowered. If this condition becomes worse its deleterious effect will be markedly shown in the industries during the next decade. Foresight is called for.

How can the industries aid? By giving generously of their well earned profits of recent years to strengthen and build up the chemistry departments of the universities. It is not a question of charity or philanthropy, but can well be regarded as an investment. With the aid of funds from this source the pay of professors and instructors can be increased, thereby diminishing the necessity for leaving university ranks because of the increased cost of living. So, too, equipment of university laboratories can be fully maintained and improved. The account (page 581, this issue) of the anonymous gift to the Massachusetts Institute of Technology for the purpose of further improvement in its equipment for chemistry and physics shows that someone's mind is moving in this channel. Finally, many of the ablest students are in need of financial assistance if they are to get the best training the universities offer. The creation of scholarships and fellowships will do much to alleviate this situation, aside from the stimulation induced by prospective rewards of good work. An important step in this direction has just been taken by the du Pont Company in setting aside a portion of its earnings for this purpose (page 581, this issue). Many other ways of aiding through funds will suggest themselves if once our industrial leaders are convinced that in this matter they have just as important an interest as in the purchase of raw material or in the efficiency of plant operations.

The chemistry army must have its reserves. Good generalship will provide these.

A FRENCH LOCAL SECTION

Another tie joins France and America; another offspring of the American Chemical Society takes its place in the family of local sections. On page 575 of this issue is printed the application to the Council for permission "to found in Paris a French section of the Society covering the entire territory of France."

As the usual Spring meeting of the Council was not held, this application for charter is now being voted upon by the Directors. It requires no gift of prophecy to predict that the vote will be of such enthusiastic unanimity as never before characterized a vote of the Directors. The first public announcement of the application, made by Secretary Parsons, on the request of President Nichols, at the recent joint outing of the Philadelphia and Delaware Sections, was greeted with tremendous applause.

The signatures on the application are those of distinguished French chemists intermingled with those of American chemists, known to us all, who are now at the front in the service of our Army, a joint brigading of French and American forces similar to that which has been affected recently between units of the respective armies under the leadership of that great soldier, General Foch. The successful result of the military union has already made itself evident on the battlefields of France; with equal confidence we can look forward to increased strength from the closer coöperation of scientific forces through the medium of the French Section.

As we read the application for charter and note the words "the entire territory of France" we know that these words will carry only one meaning to French and American chemists alike, namely a restoration of the eastern boundary of France, changed from that of August 1914 only in that it shall include Alsace and Lorraine, and to that end the entire resources of this country, men and material, are now dedicated.

All hail to the French Section!

ORIGINAL PAPERS

THE MANUFACTURE OF AMYL ACETATE AND SIMILAR SOLVENTS FROM PETROLEUM PENTANE

By Benjamin T. Brooks, Dillon F. Smith and Harry Essex

Received March 12, 1918

In a recent paper[1] we noted the effect of very high pressures on the conversion of chlorpentane to alcohol. In the following paper we describe a method for the conversion of chlorpentane to the corresponding acetates under conditions which we believe are capable of realization on a large scale without great difficulty and without very costly or complicated apparatus.

The present prices of amyl alcohol and acetate are, of course, abnormal. Yet it is very doubtful if the prices during several years before the war will be the rule for some time after the war, unless there is a large production from some source not now known or the synthetic article is brought into the market in large quantities. Before the war this country imported annually approximately 6,000,000 lbs. of fusel oil from Russia. The decrease in the manufacture of distilled liquors and the spread of prohibition generally will cause an increased shortage of amyl alcohol and acetate.

As is well known to all familiar with fusel oil and amyl acetate and their uses, these terms are employed to describe the mixture of amyl alcohols, or their acetates, together with more or less butyl and hexyl derivatives. The composition of the natural fusel oils varies considerably with the material fermented and the character of the fermentation. Fernbach's recently developed fermentation, yielding chiefly isobutyl alcohol, is an extreme case, and isobutyl alcohol alone is too volatile for most of the technical uses of fusel oil or amyl acetate. The following analyses from Worden's "Nitrocellulose Industry" illustrate what is commonly found in commercial fusel oils:

Composition of Natural Fusel Oils

From Potato Spirit	Per cent by wt.	From Corn Spirit	Per cent by wt.
Normal butyl alcohol	6.8	Normal propyl alcohol	3.7
Isobutyl alcohol	24.3	Isobutyl alcohol	15.7
Amyl alcohol	67.8	Amyl alcohol	75.8
Fatty acids, etc.	0.04	Hexyl alcohol	0.2
		Fatty acids, etc.	0.56

The ordinary amyl acetate of commerce contains approximately 70 per cent by weight, distilling within the limits 135 to 140°. The above analyses make clear the fact that it is not necessary to isolate either pure pentane as a raw material for synthetic amyl acetate, or a single monochlorpentane to make an artificial amyl acetate fulfilling all the ordinary requirements of industrial uses.

A fairly large number of patents have been issued which have for their object the manufacture of amyl acetate from light petroleum mixtures, chiefly pentane. The difficulties of most of these processes, so far as we are acquainted with them, appear to be, first, the formation of large proportions of dichlor and trichlor derivatives when the original hydrocarbon mixture is chlorinated, entailing considerable loss of chlorine, decomposition during distillation with evolution of hydrochloric acid, corrosion of the distilling apparatus, etc. The presence of higher chlorinated pentanes also has the very objectionable result that on decomposition, as during distillation, chloramylenes are formed which are relatively stable and make their presence known in the final synthetic amyl acetate by materially decreasing the solubility of many substances in this solvent. One patentee claims that glacial acetic acid need not be used as a solvent in the chlorpentane-sodium acetate reaction, but acetic acid containing as much as 30 per cent of water may successfully be employed. Our experience is that amyl acetate made with acetic acid containing 10 per cent or more of water, contains considerable unchanged chlorpentane, the presence of which markedly decreases its solvent value. The second serious difficulty, common to all the processes known to us, consists in the formation of relatively large amounts of amylene.

The first of the difficulties above mentioned has been overcome almost completely and in a very simple manner.

CHLORINATION OF PENTANE

In the earlier period of our work we lost considerable time by attempting to develop a satisfactory method of chlorination based on the idea that the reaction should take place in the gaseous phase. Accordingly, a large number of chlorinations were made by introducing chlorine into the hydrocarbons at temperatures just sufficient for the complete vaporization of the hydrocarbon. In these experiments we assumed that the chlorine and hydrocarbon gas mixture should be thoroughly mixed before reacting, and this was attempted by introducing the chlorine into the hydrocarbon gases in the dark and then passing this mixture through large illuminated glass tubes. In these experiments it was found that once the chlorinating action had started it would proceed very smoothly in diffused daylight and that ultraviolet light as a catalyzing agent was not necessary; indeed, the reaction often proceeded with considerable violence and the separation of some free carbon. It was difficult to regulate accurately the ratio of hydrocarbon vapors to the chlorine introduced, and the formation of dichlor and trichlor derivatives was unavoidable. The highest yields of monochloride derivatives were obtained when the chlorine-hydrocarbon mixture contained a large excess of hydrocarbons, namely, 2 to 4 times the ratio necessary to form the monochloride derivatives. By employing mixtures containing 3 mols. of hydrocarbon to one of chlorine, a yield of monochloride of 88 per cent of the theoretical was obtained, that is, 88 per cent of the chlorinated material was monochloride. The large volume of hydrogen chloride formed in this reaction carries off large amounts of pentane vapor, this fact necessitating the ab-

[1] *J. Am. Chem. Soc.*, **38** (1916), 1369.

sorption of the hydrogen chloride in cold water in order to recover this pentane. It was easily apparent that the manufacture on a large scale of crude chlorpentane by this method would entail great practical difficulties, and would certainly add a great deal to the cost of this comparatively simple operation.

After a number of preliminary experiments, which need not be recorded here, a method was developed which has proved to be quite satisfactory and which has served for the preparation of large quantities of these chlorinated hydrocarbons. The simplicity of the method makes it entirely adaptable to large scale operations, and a fairly large experience with it over more than one year's time shows that the chlorinated product consists of the monochlorides to the extent of 90 to 94 per cent.

The principle of the method simply consists in maintaining always a very large excess of hydrocarbon as compared with chlorine and also, which is very important, a very large ratio of hydrocarbon to chlorinated products. In brief, the method consists in passing chlorine through a large number of small orifices into a large quantity of cold crude pentane, and stopping the chlorination before the concentration of the chlorine derivatives becomes greater than about 20 per cent of the mixture. In practice, escaping hydrogen chloride is absorbed in cold water and the pentane thus recovered is returned to the reaction vessel. The presence of moisture is not objectionable, in fact it seems to be desirable. Illumination of the reaction mixture is not absolutely necessary, although we have employed a high-power tungsten light bulb in the upper part of the reaction vessel, the light catalyzing the reaction at the start. This reaction exhibits a peculiar phenomenon. At first the pentane appears to dissolve the chlorine unchanged, but after an interval of about ten minutes the color of free chlorine quickly fades and disappears and then chlorine may be passed in very rapidly, reacting as fast as dissolved. The liquid should be kept chilled to at least 10° to prevent too great vaporization of pentane with the hydrochloric acid formed.[1]

The control of the process can readily be accomplished by observing the specific gravity of the mixture, since a specific gravity of 0.820 corresponds to about 20 per cent of monochlorides, when a crude pentane fraction boiling at 25 to 45° is taken for chlorination.

In order to illustrate the per cent of suitable crude pentane contained in a high grade of gasoline, 76 ° Bé., the following table of fractions obtained by slow distillation through suitable column is given:

Boiling Point	Per cent by Volume	
28–30°	2.3	
30–35°	5.0	17.8 per cent suitable for amyl acetate
35–40	5.5	
40–45	5.0	
45–50	6.6	
50–55°	8.5	
55–60	8.5	
60–70°	18.0	

Casing head or natural gas gasoline naturally contains the largest per cent of pentane and when suitable provision is made to avoid losing the butane, as by dissolving in a heavier gasoline, this raw material should prove the most economical.

The fractional distillation of the monochlorides furnishes another opportunity to reject material of unsuitable boiling point. A distillation analysis of the monochlorides employed in most of the work here described, the chlorides having been made from a crude pentane fraction boiling point 25 to 45°, is given below:

Boiling Point	Per cent by Weight
90–100	3.8
100–110°	46.6
110–120	27.4
120–130°	14.4
130–140°	5.3
Above 140	2.4

Several results which are typical of those obtained by chlorinating the cold pentane are given below. The per cent yield is calculated on the per cent of monochlorides in the total chlorinated hydrocarbon, not on the amount of pentane originally taken. Thus if the yield is 90 per cent, the balance of 10 per cent is a higher chlorinated product.

TABLE I CHLORINATION OF CRUDE PENTANE, BOILING POINT 25–45

Wt. Pentane Grams	Time Hours	Lost with HCl Per cent	Wt. Product Grams	Unchanged Grams	Monochlorides 95–140° Grams	Dichlorides Grams
5500	4.5	13.4	5233	3908	1155	170
5500	5.5	35.0	4108	2555	1371	182
5500	4.0	29.0	4206	3312	884	10
2500	4.0	25.0	2698	1775	611	47
2070	5.5	28.0	1492	978	407	110
3700	6.0	25.0	2781	2309	444	28

Concentration of chlorides when chlorination was stopped	Per cent monochlorides in chlorinated part
21	87
24	89
16	99
24	93
34	78
17	95.5

If desired, a pentane fraction of much smaller boiling point range can be employed as the initial raw material, and this will result naturally in a final acetate of smaller range of boiling points. The fractional distillation to obtain most of the crude pentane used in our work was carried out in a small 50-gallon experimental apparatus. More homogeneous fractions would be obtainable from larger stills provided with suitable columns, such as those employed for the rectifying of crude benzols.

A small amount of hydrochloric acid is formed during the distillation of the crude chlorpentane, due to slight decomposition of the chlorides. The amount of decomposition resulting from this cause is so small, however, that no appreciable diminution of the yield of crude chlorpentane results. This fact has to be taken account of, however, in the choice of apparatus for distillation, as will be brought out later.

CONVERSION OF CHLORPENTANE INTO AMYL ACETATE

Although the conversion of chlorpentane into amyl acetate by heating with anhydrous sodium acetate is, at first sight, merely a direct application of a standard method of organic synthesis, we found it necessary to carry out a large number of experiments in order to determine the optimum conditions, particularly as regards temperature and pressure, nature of solvent, effect of agitating the reaction mixture, yield from

[1] Brooks, Essex and Smith, United States Patent No. 1,191,196.

various gasoline fractions, material of construction for apparatus, effect of catalysts, and possible utilization of the by-product amylene.

Early in the course of the work we determined that somewhat better yields of acetate are obtainable with the lower boiling fractions than from hydrocarbons of higher boiling point. Kerosene chlorides are highly unstable, decomposing slowly at room temperature to such a degree that in several cases the pressure of the HCl developed was sufficient to expel the cork from well stoppered containers. The tendency of the alkyl chlorides to decompose with the formation of olefines increases with those of higher molecular weight, as is shown by the following results.

TABLE II—YIELD OF ACETATE FROM CHLORINATED GASOLINE FRACTIONS[1]

Boiling Point Original Hydrocarbon	Yield Acetate Per cent of Theory	Olefines Per cent of Theory	
28–30°	50	35	Calculated for pentane
30–35°	49	34	Calculated for pentane
35–40°	49	34	Calculated for pentane
45–50°	46	42	Calculated for 50 per cent pentane
50–55°	46	42	Calculated for 50 per cent hexane
55–60°	43	43	Calculated for 50 per cent hexane
60–65°	42	43	Calculated for 50 per cent hexane
65–70°	38	47	Calculated for 50 per cent hexane

[1] Heated 11 hours at 190–195° in autoclave, not stirred.

Owing to the large amount of solid material in the reaction mixture, anhydrous sodium acetate at the beginning and sodium chloride toward the end of the operation, we carried out several comparative experiments to determine the effect of continual agitation of the contents of the autoclave. When the reaction mixture is not agitated, a hard, nearly solid salt cake forms, which prevents further reaction.

TABLE III

Method	Reaction Mixture	Time Hours	Pressure Pounds	Acetate Made Grams	Chlorine in Acetate Per cent	Yield Acetate Corrected for Content of Chlorides Per cent of Theory
Autoclave rotated	580 g. Chlorides 750 g. Sodium acetate 375 g. Acetic acid 375 g. Amyl acetate	5	230	394	1.2	51.6
Autoclave stationary	580 g. Chlorides 750 g. Sodium acetate 375 g. Acetic acid 375 g. Amyl acetate	5	250	273	7.1	22.1
Autoclave rotated	730 g. Chlorides 800 g. Sodium acetate 472 g. Acetic acid	12	240	458	0.9	50.1
Autoclave stationary	650 g. Chlorides 650 g. Sodium acetate 750 g. Acetic acid	12	240	300	16.5	26.0

The presence of water in the glacial acetic acid retards the reaction very markedly, acetates made in this way containing relatively large amounts of unchanged chlorides, as illustrated by the following experiments.

TABLE IV.—INFLUENCE OF THE WATER IN REACTION MIXTURE

Solvent	Time Hours	Temp	Yield Acetate Per cent of Theory	Chlorine in Product Per cent
Acetic acid, 99 per cent.....	15	220°	42.3	2.0
Acetic acid, 90 per cent.....	15	220°	38.0	5.3

The presence of a solvent is necessary if a product free from chlorides is desired. The result obtained without a solvent is shown in Experiments 11 and 19, Table V, in which it will be noted that the per cent of unchanged chlorides in the product is very high.

A few substances, $BaCl_2$, $FeCl_3$, and CuCl, were tried for their possible catalytic effect, but no benefit could be noticed in the results.

It is possible that the amylenes resulting in the treatment of the chlorpentane mixture, as herein noted, are derived largely from secondary or even tertiary chlorides or acetates. We tested the stability of commercial amyl acetate, consisting almost entirely of acetates of primary alcohols and found that during 8 hours at 205° and about 300 lbs. pressure in a copper lined autoclave, only 6.5 per cent of amylenes were formed. After cooling, the autoclave showed a pressure of 60 lbs., due to gaseous products of the decomposition, probably CO_2 and ethylene.

We have not had the opportunity to examine the constitution of the amyl acetates made from the petroleum fractions, as the primary object in view was the commercial utility and value of the product. We find that the solvent power of synthetic amyl acetate for cellulose esters and gums is such that by these tests alone the natural and synthetic acetates cannot be differentiated from each other. If, however, the acetate contains two or more per cent of chlorine in the form of unchanged chlorides, its solvent power for gums and resins is markedly diminished.

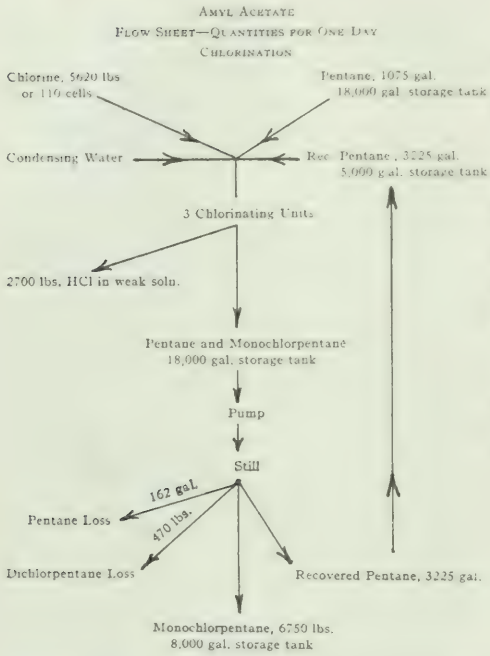
A number of typical results are included in Table V.

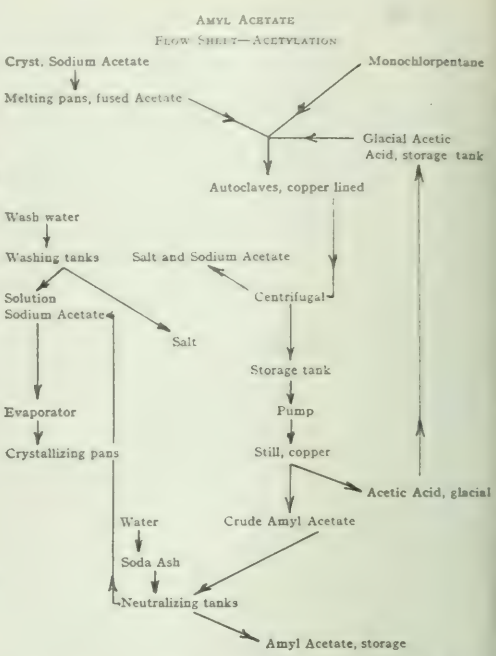
UTILIZATION OF AMYLENES

We believe it is very doubtful if the amylenes, obtained as a by-product in the conversion of the chlorpentanes to acetates, can profitably be converted into alcohols or acetates. So-called hydration of amylenes and other olefines to the corresponding alcohols has been investigated by us and the results

TABLE V

Expt. No.	Chlorides Grams	Sodium Acetate Grams	Solvent Grams	Time Hours	Temp ° C.	Pressure Pounds	Yield Crude Acetate Per cent of Theoretical	Chlorine in Product Per cent	Yield Acetate Corrected Per cent of Theoretical	Remarks
94	50	50	100 g. Acetone	8	180–190	...	60	...	...	
89	400	400	500 g. Absolute alcohol	9	190	...	63.3	3.14	53.2	Product contained free amyl alcohol
31	730	900	470 g. Acetic acid	2	220	...	51.8	0.9	49.7	
18	730	945	470 g. Acetic acid	5	195–200	180	55.0	7.0	43.4	
17	580	750	375 g. Acetic acid 375 g. Amyl acetate	5	195–200	230	55.4	1.2	53.4	
19	1100	1422	None	12	195–200	170	47.0	11.0	31.4	
11	980	1215	None	6	205–210	300	48.3	6.4	36.6	
5	580	750	750 g. Acetic acid	4	195–200	400 430	43.0	1.0	41.2	30 g. $BaCl_2$ in reaction mixture
7	580	750	750 g. Acetic acid	1.5	195–200	200 260	45.0	3.5	31.9	30 g. $FeCl_3$ added
8	580	750	375 g. Acetic acid 375 g. Amyl acetate	5	195–200	...	50.0	0.9	48.8	





embodied in a separate paper.[1] With sulfuric acid the principal results are polymerization to heavier, more viscous oils (not tars), the formation of alcohols and of acid and neutral esters of sulfuric acid. We have not been able to obtain yields of alcohol as high as noted by Wischnegradsky[2] in the case of amylene made from natural fusel oil. The yields obtained by us are given in the following table, and it will be noted that with 50 per cent acid very little change was effected and with 95 per cent acid at 5.0° mostly polymers were formed.

Table VI—Addition of Water to Amylene-Hexene Mixture by Sulfuric Acid of Varying Concentrations

Expt. No.	Conc. Acid Per cent	Reaction Temperature, °C.	Hours Agitated	Alcohol Fraction of Ppt'd Oil	Unchanged Hydrocarbons, Per cent	Loss as Sulfuric Esters and Volatilization	Polymers, Per cent
1	50	— 5	2	1.0	90.0	1.0	8.0
2	75	0	2	18.0	45.0	16.0	21.0
3	75	—10	2	16.0	54.0	17.0	13.0
4	75	0	2	10.0	67.0	9.0	14.0
5	75 + 2 vols.	0	2.5	10.0	57.0	15.0	18.0
6	75	15	2.5	10.0	70.0	12.0	8.0
7	85	—15	2.5	22.0	32.0	14.0	32.0
8	88.6 + 1 vol. acetic acid	10	2.5	13.0	56.0	18.0	13.0
9	95	5	2	4.0	8.0	11.0	75.0

In view of the readiness with which olefines react with many mineral acids, such as H_2SO_4, HCl, HBr, HOCl, and in some cases even HCN and H_2S, we thought it possible that under certain conditions acetic acid might react with the amylenes direct. Accordingly the conditions of the usual acetylation were tried on amylene itself. A quantity of crude amylene, 125 g., boiling point 30 to 60°, was heated in an autoclave at 200° for 5 hrs. with an equal weight of glacial acetic acid. From the reaction product we isolated only 4.5 g. oil boiling at 100 to 135° and 4.0 g. residue above 135°, these fractions consisting of polymers of the original amylenes. In another experiment 90 g. amylene were heated 20 hrs. at 100° with 90 g. acetic acid and 30 g. zinc chloride and the result was 14.5 g. polymers boiling over 100°. A reaction mixture duplicating the last was let stand 30 hrs. at 20 to 24°, obtaining 8 g. polymers.

It is not the purpose of the present paper to go into the details of producing a given output of synthetic amyl acetate. However, a brief discussion of the character of the apparatus required and a conservative estimate of costs should make clear that the commercial manufacture of synthetic amyl acetate is entirely feasible. In view of the amount of amyl acetate annually consumed in the United States alone and the amount of the synthetic acetate which might conservatively be expected to find a ready place in the market we have, for the sake of definiteness, based estimates on a daily production of 600 gal. of synthetic amyl acetate. The figures used are based upon a yield of monochlorides of 90 per cent, a low average for the method described, and a yield on acetylating of 55 per cent of the theory, a result actually attainable and probably exceeded. The minor by-products, amylene, common salt, and hydrochloric acid, have not been given any value in the estimate. It has been assumed that the crude pentane would be

[1] *J. Am. Chem. Soc.* **42** (1918), 822.
[2] *Ann.*, **190** (1877), 328.

furnished in tanks or steel drums, being most advantageously manufactured at the source of production of casing head gasoline. The price of such an article in fairly large quantities bears no relation whatever to the prescription doses of pentane sold for photometric work. It has also been assumed that the most advantageous location for such a plant would be in the neighborhood of a chlorine-caustic soda plant, where the chlorine would be available for use without liquefaction. The diagrams indicate roughly the flow of material.

APPARATUS REQUIRED

1—STORAGE FOR

(*a*) Crude pentane, 18,000 gal. steel tank.
(*b*) Crude chlorinated product, pentane and chlorpentane, 18,000 gal. lead-lined steel tank.
(*c*) Distilled chlorpentane, 8,000 gal. lead-lined tank.
(*d*) Sodium acetate, crystalline, 100 ton covered wooden bins.
(*e*) Glacial acetic acid, 10,000 gal., 5 wooden tanks, 2,000 gal. each.
(*f*) Amyl acetate, finished, 15,000 gal., 3 steel tanks, 5,000 gal. each.

2—CHLORINATION

3 units complete, each consisting of one 500 gal. earthenware vessel[1] fitted with lead coil for cold water or brine, glass Hart condenser of the type used for nitric acid, and earthenware receiver for separating recovered pentane and aqueous HCl.

3—STILLS

2 Steam jacket Duriron stills, 1000 gal. charge capacity for rectifying chlorpentane.
1 Steam jacket copper still for rectifying amyl acetate, acetic acid, and amylene mixture, capacity 900 gal.

4—ACETYLATION

3 Copper-lined steel autoclaves, jacketed, heated by hot oil circulation, provided with agitators of copper or Duriron, capacity 900 gal. each.

5—ACCESSORIES

1 Centrifugal extractor, 30 in. copper mesh basket, for separating salt from reaction mixture.
1 Agitator, copper, for washing amyl acetate with soda ash solution, capacity 900 gal.
1 Wooden tank with chain type agitator for washing excess sodium acetate from salt, capacity 500 gal.
2 Crystallizing pans, iron, in brick setting, slow direct fire for recovering sodium acetate, 300 gal. each.
3 Melting pans, steel in brick setting, slow direct fire for fusing sodium acetate, capacity 200 lbs. sodium acetate each.
1 Motor for agitating autoclave, 8 h. p. steam, 200 boiler h. p. for distillation, heating building, pumping, etc.
4 Dump cars and track for conveying salt, sodium acetate, etc.
1 Motor, 8 h. p., for operating pumps.
3 Low-pressure rotary pumps for pumping pentane, amyl acetate, etc.

BUILDINGS

1 Shed for storing acetate of soda.
1 Building for chlorinating pentane and distillation of chlorpentane, fireproof asbestos board.
1 Building for acetylating and distillation of amyl acetate.
1 Building for boilers and fusing sodium acetate.

[1] Suitable vessels of this size are regularly manufactured.

ESTIMATED COST OF SYNTHETIC AMYL ACETATE ON THE BASIS OF 600 GALLONS DAILY PRODUCTION

DAILY COSTS

Gasoline, 990 gal. at 40 cts	$ 396.00
Chlorine, 5200 lbs. at 2.5 cts.	130.00
Acetate of soda, 4880 lbs. cryst. acetate at 15 cts.	732.00
Soda ash, 1450 lbs. at 3 cts.	43.50
Interest on $35,000 at 6 per cent, and depreciation at 20 per cent per annum	30.30
Labor, one chemist at $8.00, 10 laborers at $4.00	48.00
Fuel and Power	40.00
TOTAL DAILY COSTS	$1419.80

VALUE OF PRODUCTS

Amyl acetate, 600 gal. at $4.50 per gal.	$2700.00
Total daily costs	1419.80
DAILY PROFIT	$1280.20

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
PITTSBURGH

THE EFFECT OF ANNEALING ON THE ELECTRICAL RESISTANCE OF HARDENED CARBON STEELS[1]

By I. P. Parkhurst

Received November 24, 1917

The electrical resistance of steels as affected by impurities or by different heat treatments applied over wide ranges of temperature, has attracted the attention of several investigators. A résumé of previous work is here given.

RÉSUMÉ OF PREVIOUS WORK

W. H. Johnson[2] made a study of the electrical resistance of steels in order to determine the effect of impurities. The resistance of seven samples of different analyses was measured. The impurities were found to increase the resistance, but the data obtained were not sufficient to allow of specific conclusions.

A. Campbell[3] determined the effect of stress on the resistance of iron and iron-nickel wires. Practically no change was observed up to the breaking point.

H. Le Chatelier[4] investigated the effect of high temperatures on the resistance of iron, steel, hard steel, iron-nickel, platinum, etc. His measurements were made in an atmosphere of hydrogen. In a 0.6 per cent carbon steel he observed breaks in the temperature-resistance curves at 710 and 820° C.

H. Le Chatelier[5] studied the effect of hardening and tempering on the resistance of steels. His results showed that the resistance was increased by hardening and decreased by tempering.

L. Compredon[6] made a study similar to that of W. H. Johnson, referred to above, and obtained similar results.

J. De War and J. A. Fleming[7] determined the resistance of iron and nickel at temperatures down to the boiling point of oxygen. They found that the resistance decreased rapidly with the decrease in temperature.

[1] Read in abstract at the Metallurgical Symposium, Boston Meeting, American Chemical Society, September 1917.

[2] "Chemical Composition and Electrical Resistance of Steel Wire," *J. Iron and Steel Inst.*, **19** (1881), No. 2, 605.

[3] "Electrical Properties," *Engineering*, **63** (1887), 468.

[4] "Electrical Resistance of Iron and Its Alloys at High Temperatures," *Compt. rend.*, **110** (1890), 283.

[5] "Effect of Tempering on the Electric Resistance of Steel," *Compt. rend.*, **112** (1891), 40.

[6] "Electro-conductivity of Steel," *Le Genie Civil*, **19** (1891), 309.

[7] "Electrical Resistance of Iron," *Phil. Mag.*, **34** (1892), 326.

F. Osmond[1] investigated the effects of carbon, silicon, nickel and manganese on the resistance of steels. He found that the resistance was increased by all these elements, and especially by silicon, nickel and manganese. The temperature coefficient fell in a parabolic curve with increase in resistance.

H. Le Chatelier[2] studied in detail the effects of carbon, silicon, and manganese on the resistance of steels. Carbon was found to increase the resistance of 7 microhms for 1 per cent, silicon 14 microhms for 1 per cent, and manganese 3 microhms for 1 per cent.

C. Benedicks[3] investigated the effect of impurities on the resistance of iron and steel. He used commercial iron and steel varying from 0.08 to 1.7 per cent. C. and varying in amounts of silicon, manganese, phosphorus, and sulfur. Calculating the percentages of silicon and manganese to equivalent carbon, he proposed the following formula

$$\rho = 7.6 + 26.8 \Sigma C,$$

in which ρ is the resistance of the steel, 7.6 the resistance of pure iron, and ΣC the sum of the percentages, in terms of carbon, of the impurities in the iron.

M. Portevin[4] determined the resistance of ternary steels, including alloys with nickel, chromium, tungsten, aluminum, molybdenum, vanadium, titanium, boron and thallium. He discussed also the influence of titanium on the arrest points.

A. P. Schleicher and W. Guertler[5] studied the resistance of alloys containing 35.25, 30.6 and 25.2 per cent nickel. It was observed that there was a pronounced discontinuity in the resistance at about 420° C. for the steel containing 35.25 per cent nickel, and at 700° C. for the one containing 30.6 per cent nickel. The alloy containing 25.2 per cent nickel gave, in the original condition, abnormally low values, but the resistance increased with each heating until it became stabilized with a discontinuity at 900° C.

A. Portevin[6] heated steel bars in a salt bath at 750 and 900° C. for varying lengths of time and after quenching, measured the increase in resistance.

K. Honda[7] investigated the influence of high temperatures on the electrical resistance and magnetic properties of iron, steel, and nickel. He concluded that the magnetic transformation was not an allotropic change, but a gradual change of the property of a phase, due to a change in temperature.

G. K. Burgess and I. N. Kellburg[8] measured the electrical resistance of pure iron from 0 to 900° C. The resistance increased with a gradually rising rate to A_2. There was an inflection at A_2 and an abrupt fall in resistance at 894° C. The reverse change took place at approximately the same temperature. The interval was 25° C. The change at A_3 was progressive and thermoelectrically nonreversible. The change at A_2 was reversible.

P. Mahler[1] studied the influence of carbon and manganese on the resistance of steel. The specific resistance increased 7 microhms for 1 per cent of carbon, and 5 microhms for 1 per cent of manganese. Mahler believes that occluded gases increase the resistance, and points out that hydrogen is known to do so.

Edward D. Campbell[2,3] investigated the effect of annealing on the resistance of quenched steels. He measured the resistance of the quenched steels and subjected them in turn to temperatures of 100, 200, 300° C., etc. The annealing at 100° C. was prolonged for 48 hrs. The time of annealing at the other temperatures was from 1 to 2 hrs. He plotted curves showing the resistance against the temperature of annealing.

OBJECT OF THE PRESENT INVESTIGATION

The object of the investigation here presented was to determine the rate of softening of quenched steels, under conditions in which the temperature of annealing is kept constant. Changes in the electrical resistance were used as a measure of the changes in hardness.

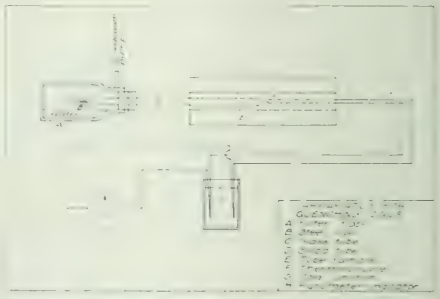


FIG. 1—APPARATUS FOR QUENCHING COILS

The work was carried out by first quenching the steel and measuring the resistance. This was followed by annealing the steel for a definite time at a definite temperature, and again measuring the resistance. This procedure was repeated at the same temperature but with an increasing interval of time, followed by another measurement of the resistance. The total period of annealing for the different specimens varied from 90 to 190 hrs. The results were then plotted as time against resistance.

EXPERIMENTAL

The steels were treated in the form of a wire coil. The specimens were prepared by forging steel bars

[1] "The Electrical Resistance of Iron and Steel," *La Lumière Electrique*, **46** (1893), 93.

[2] "The Electric Resistance of Steel," *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, **3**, p. 743.

[3] "Electric Resistance of Iron and Steel," *Z. phys. Chem.*, **40** (5), 1903).

[4] "Electric Resistance of Steel," *Revue de Métallurgie, Memoirs*, **6** (1909), 1304.

[5] "Electric Resistance of Iron-Nickel Alloys," *Z. Elektrochem.*, **20** (1914), 253.

[6] "Influence of High Temperatures on Magnetic Properties," *Compt. rend.*, **158** (1914), 51.

[7] "Influence of High Temperatures on Magnetic Properties," *Revue de Metallurgie, Memoirs*, **11** (1914), 483.

[8] "Electric Resistance of Iron at Varying Temperatures," *J. Wash. Acad. Sci.*, **4** (1914), 436.

[1] "Electric Resistance of Steel," *Revue de Métallurgie* **12** (1915), 345.

[2] "The Influence of Heat Treatment on the Thermoelectric Properties and Specific Resistance of Carbon Steels," *J. Iron and Steel Inst.* (2), **94** (1916), 286.

[3] "Do Equatomic Solutions of Iron Possess Equal Resistances?" *Trans. Faraday Soc.*, **12** (1917), 1.

down to $^1/_8$ in. round. The pieces of this size, about 4 in. long, were drawn down to wires varying from 0.014 to 0.019 in. in diameter (0.355 to 0.482 mm.). From 20 to 50 cm. of this wire were used as a specimen. The specimens were heated and quenched in a vacuum, being contained in a silica tube which was heated in an electric combustion furnace. Temperatures were measured with a platinum–platinum-rhodium thermocouple.

The arrangement for heating and quenching is shown in Fig. I. The specimen was placed in the glass extension of the silica tube. The tube was then placed in the tube furnace and kept there for 5 min. At the end of this time it was evacuated, withdrawn from the furnace, inverted, and replaced in the furnace. After about 1 min. it was again withdrawn and the specimen quenched. The object of this procedure was to bring the coil to the desired temperature as quickly as possible, in order to prevent oxidation. It was necessary to guard carefully against oxidation, since the coils were long and slender. It will be shown later that the effect of oxidation was small.

After measuring the resistance, the method of which will be explained later, the coil was annealed at a definite temperature. The temperatures chosen were 125, 150, 175 and 250° C. For the first three temperatures the specimens were annealed in a constant temperature paraffin bath, which was heated on an electric hot plate to a temperature which was a few degrees below that desired. The temperature was then further raised and adjusted by means of a resistance coil in the bath. The current in the coil was regulated through a thermostat regulator and a relay. The temperature was constant to about one degree.

For the first 5 min. the specimen was immersed directly in the paraffin. For longer annealing the specimen was placed in a tube immersed in the paraffin. The reason for putting the coil directly in the paraffin was to allow a closer determination of the time of annealing. The specimen would take up the temperature of the liquid much more quickly than that of air, hence the time of annealing could be more accurately measured in the paraffin than in air. For longer annealing, a small difference in time would make much less difference in the results, hence the tube was used. This was desirable whenever possible in order to prevent any chance of carbonization.

For annealing at 250° C. a constant temperature oven was used, in which the temperature varied about 5° C.

For measuring the resistance of the specimens, they were immersed in a tube of alcohol, which was placed in a thermostat regulated to 30° C. The maximum variation of the temperature was 0.05° C.

The resistance was measured with a Kohlrausch bridge used as shown in the diagram in Fig. II. The unknown resistance X and a known resistance, R, are connected in series, and in parallel with them is the slide wire of the bridge. The bridge is balanced with each end of each resistance, thus making four readings. If the readings for the known resistance are a and b, and those for the unknown resistance c and d, then

$$\frac{X}{R} = \frac{d - c}{b - a}$$

This method was used in order to eliminate the effect of contact resistance. The double-throw switch was used in order to eliminate the effects of all thermo-electromotive forces and generated electromotive forces.

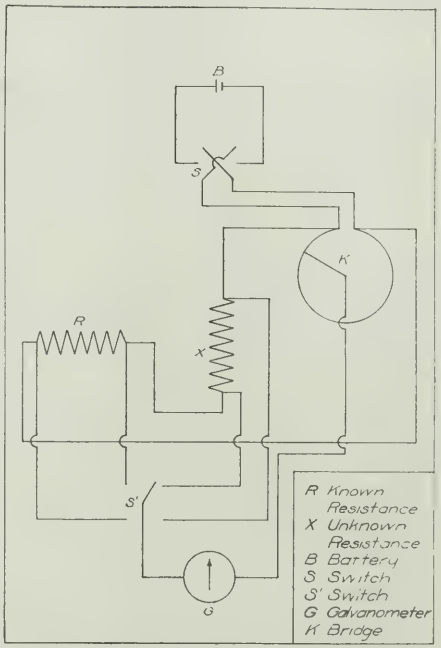


FIG. II—APPARATUS FOR MEASURING RESISTANCE

The resistance measurements themselves were accurate to one part in one thousand. However, the impossibility of placing the contacts at exactly the same point each time increased the error. This added error depended on the length of the coil. For both contacts it was not more than 0.5 mm. This would give a possible error of 0.25 per cent for coil No. 5, which was the shortest, and 0.1 per cent for the longer coils. This makes a total probable error of from 0.2 to 0.35 per cent.

The analyses of the specimens and the dimensions of the coils are given in the following tables:

TABLE I

No	Analyses of Specimens C Per cent	Si Per cent	P Per cent	Mn Per cent	S Per cent	Dimensions of Coils Diameter Mm	Length Mm.
1	0.05	0.006	0.021	0.055	0.025	0.355	514
2	0.09	0.059	0.013	0.044	0.019	0.368	500
3	0.18	0.025	0.090	0.068	0.092	0.482	486
4	0.25	0.058	0.109	0.075	0.036	0.431	503
5	0.45	0.122	0.112	0.092	0.106	0.431	196

The results of the resistance measurements are plotted in the following curves, which show the effect of the duration of annealing on the resistance of the steels.

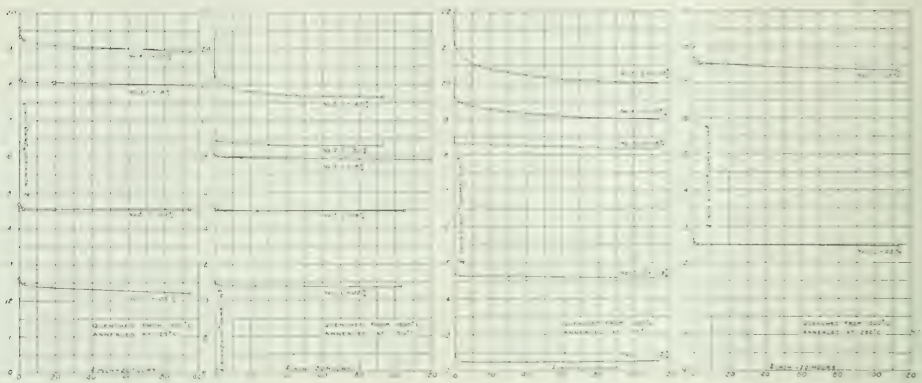


FIG. III

CONCLUSIONS

The total change in resistance increases with the carbon content of the steel. The change is very rapid at the beginning of the annealing and becomes slower as the resistance decreases. However, there was no indication in any case that the change was complete at the end of the test.

Since the resistance of a steel changes with the hardness, the curves are a fair indication of the varying rates at which hardened steels are softened by annealing at a constant temperature. The larger part of the change is completed within a few minutes, but the change is not entirely complete in 113 hrs.

DIVISION OF METALLURGY AND APPLIED CHEMISTRY
UNIVERSITY OF KANSAS, LAWRENCE

VOLUMETRIC DETERMINATION OF FREE SULFUR IN SOFT RUBBER COMPOUNDS

By H. S. UPTON

Received October 5, 1917

The published and accepted methods of determining free sulfur in a rubber compound are more or less tedious, and, where manufacturing operations are dependent upon them, are the cause many times of serious delays. These delays, the cost of materials required, and the time consumed by the determining process, make these methods expensive. It was with this in mind that the following method was evolved and results obtained both in conservation of time and materials and also in accuracy lead us to believe it may be of interest to others who are using the present day accepted methods.

METHOD

The proposed method depends on the fact that sulfur when heated with an alcoholic potash solution is converted into a mixture of potassium sulfide and potassium thiosulfate, both of which may be titrated with standard iodine by usual methods as given in this article. The free sulfur is determined in the acetone extract from the rubber compound. The resinous extract of certain commercial rubbers and the extract of other compounding materials are acted upon by the alcoholic potash solution and by various standard solutions used in analysis, thereby rendering necessary the application of corrections. The amount of correction or blank used in titrating is determined by the nature and amount of the various ingredients in the extract from the rubber compound. This limits the use of the method with confidence to a sample of rubber, the composition of which is known to the analyst. The proposed method can be used successfully where a large number of tests are being run on a compound made up to a certain formula, for example, insulated wire compounds, boot and shoe compounds, etc.

The equation generally given for the oxidation of sulfur by a water solution of potassium hydroxide is:

$$4S + 6KOH = 3H_2O + K_2S_2O_3 + 2K_2S$$

This varies with change of conditions. When using an alcoholic potash solution instead of potash in water more thiosulfate is formed than is indicated in the equation and in some cases the conversion to this product is complete. Using this principle, a method has been worked out which is as follows:

PROCEDURE

Extract a 2-g. sample of rubber compound with acetone into a 300 cc. Erlenmeyer flask until the free sulfur has been removed. A similar compound, which is known to be free of free sulfur, is tested at the same time. This is used to determine the blanks in the subsequent titrations.

Evaporate the acetone gently until little remains, completing the drying in an oven at 100° C. This operation need not take longer than a half hour. The sulfur in the dried extract is oxidized to thiosulfate and sulfide with 25 to 50 cc. of 5 per cent alcoholic potash solution by boiling gently for one hour, using a small glass funnel placed in the neck of the flask for a condenser. Remove from heat. Wash and remove funnel from flask. Add 25 to 50 cc. of ammoniacal zinc chloride solution and just bring to boiling.

This solution is made as follows: 10 g. of zinc oxide are dissolved in dilute hydrochloric acid. The solution is made alkaline with ammonia (sp. gr. 0.90), adding 50 cc. in excess. The solution is now made up to a liter.

This precipitates the sulfide as its zinc salt, leaving the thiosulfate in solution.

Cool to room temperature in water. Acidify with glacial acetic acid, adding 3 cc. in excess. Dilute to 200 cc. Titrate with $N/25$ iodine and starch. This gives the sulfur present as thiosulfate. The precipitate of zinc sulfide is not acted upon by the acetic acid.

Add ammonium hydroxide to destroy the acidity and a trace of iodine. Add hydrochloric acid to acidity, having 5 cc. in excess. This dissolves the zinc sulfide and liberates hydrogen sulfide. Titrate the liberated sulfide with iodine and calculate to sulfur. The titration in each case is carried to a permanent blue, lasting half a minute. The end-point is generally very distinct.

The determination of thiosulfate is called (*a*) titration, and that of the sulfide, (*b*) titration. The sum of (*a*) and (*b*) titrations gives the total free sulfur. The sulfur-free sample is tested at the same time as the sample containing free sulfur and blanks for (*a*) and (*b*) titrations found. In a straight rubber compound blank (*a*) is about 1 cc. and blank (*b*) is 0.5 cc. of iodine. Often all the sulfur in a pure rubber compound is converted completely to thiosulfate and (*b*) titration may be omitted. When this is the case make the solution acid with hydrochloric, adding 5 cc. in excess, and carry out the determination as for thiosulfate, instead of making acid with acetic.

It is important that the solution should be kept cool during the determination. The different reagents should be measured as their quantity tends to vary the results. Solutions should be kept to approximately the same volume, as this affects the iodine blank. Two hundred cubic centimeters of solution are a convenient volume to work with. In the process of treating sulfur with alcoholic potash a white crystalline precipitate of potassium thiosulfate is sometimes found. This is almost insoluble in 95 per cent alcohol but dissolves readily in the more dilute solution. Potassium sulfhydrate (KSH) may be formed by the action of alcoholic potash, but it is oxidized to potassium sulfide when the potash is present in excess. The strength of the standard iodine solution is determined at least twice a week, as it becomes weaker on standing, due to the volatilization of the iodine.

FACTORS AND CALCULATIONS

It is very convenient to use factors in calculating the results. The factor for (*a*) titration of sulfur is 0.50536 times the value of 1 cc. of standard iodine solution. This is found from the following equation:

$$2K_2S_2O_3 + 2I = 2KI + K_2S_4O_6$$

Factor for (*b*) titration for sulfur is 0.12630 times the value of 1 cc. of standard iodine solution and is found from the following equation:

$$H_2S + 2I = 2HI + S$$

An example of calculation where 0.0328 g. of sulfur or 1.64 per cent on a 2-g. sample was known to be present is as follows:

1 cc. Standard Iodine = 0.005139 g. of Iodine

(*a*) Titration: 1 cc. Standard Iodine = $0.005139 \times 0.50536 = 0.002597$ g. of Sulfur

(*b*) Titration: 1 cc. Standard Iodine = $0.005139 \times 0.12630 = 0.000649$ g. of Sulfur

Blank (*a*) = 1.00 cc. Blank (*b*) = 0.50 cc

(*a*) Titration required 12.00 cc. — 1.00 cc. (Blank) = 11.00 cc. of Iodine

11.00 cc. $\times$ 0.002597 ÷ 2 (2 g. sample) = 0.0143 g. of Sulfur

(*b*) Titration required 5.80 cc. − 0.50 cc. (Blank) = 5.30 cc Iodine

5.30 cc. $\times$ 0.000649 ÷ 2 (2 g. sample) = 0.0017 g. of Sulfur

(*a*) Titration + (*b*) Titration = 0.0160 g. or 1.60 per cent of Sulfur

By this method 0.1 g. of sulfur may be titrated with good results. There has not been time to experiment with larger amounts of sulfur.

Some actual determinations by this method are given below. They are average results from a large number of determinations of many different compounds.

The most active types of various substances liable to react with the reagents were tested to see if they would interfere with the determination. Linseed oil, while not used extensively in rubber compounding, is chosen for this purpose, for it has high saponification, iodine absorption and oxidation values. These determinations were carried out according to the procedure for free sulfur in rubber compounds.

A much larger quantity of material in each case was tested than would be present in an analysis. Only starch seemed to have any effect which would interfere with the determination. It is well known that correct results are impossible in an iodine titration with much starch present. Starch would not be liable to occur in a rubber mixture and at least would not appear in the acetone extract.

Sample No.	Weight of Sample Grams	Per cent of Acetone Extract Tested	Sulfur Equivalent G. per Cc. (*a*)	Sulfur Equivalent G. per Cc. (*b*)	(*a*) Titration Standard I Used Cc.	(*a*) Blank Standard I Used Cc.	(*b*) Titration Standard I Used Cc.	(*b*) Blank Standard I Used Cc.	Free S by New Method Per cent	Free S by Fuming Nitric Method Per cent
1	2.0000	4.00	0.002598	0.000647	2.20	1.00	0.40	0.50	0.16	0.21
2	2.0000	4.00	0.002598	0.000647	1.20	1.00	0.40	0.50	0.03	0.15
3	2.0000	4.00	0.002598	0.000647	4.00	1.00	0.40	0.50	0.39	0.37
4	2.0000	4.00	0.002598	0.000647	3.80	1.00	0.85	0.50	0.38	0.30
5	2.0000	4.00	0.002598	0.000647	3.70	1.00	0.35	0.50	0.35	0.39
6	2.0000	4.00	0.002598	0.000647	2.65	1.00	0.25	0.50	0.22	0.22
7	2.0000	4.00	0.002598	0.000647	2.50	1.00	0.25	0.50	0.20	0.21
8	2.0000	4.00	0.002598	0.000647	2.05	1.00	0.25	0.50	0.14	0.16
9	2.0000	4.00	0.002598	0.000637	1.55	1.00	0.25	0.50	0.07	0.12
10	2.0000	25.00	0.002598	0.000647	12.95	1.00	6.70	0.50	1.75	1.65
11	2.0000	25.00	0.002598	0.000647	12.45	1.00	4.75	0.50	1.61	1.58
12	2.0000	28.50	0.002598	0.000647	12.00	1.00	5.80	0.50	1.60	1.64
13	2.0000	22.85	0.002598	0.000647	14.40	1.00	2.50	0.50	1.81	2.08
14	2.0000	22.85	0.002598	0.000647	15.70	1.00	2.70	0.50	1.98	2.13
15	2.0000	24.50	0.002598	0.000647	10.10	1.00	2.40	0.50	1.29	1.40
16	2.0000	25.00	0.002598	0.000647	9.30	1.00	4.70	0.50	1.21	1.33
17[1]	1.0000	8.00	0.002586	0.000646	187.0	1.00	0.90	0.50	4.62	4.53
18[1]	1.0000	8.00	0.002586	0.000646	17.70	1.00	2.80	0.50	4.48	4.48
19[1]	1.0000	8.00	0.002586	0.000646	18.70	1.00	0.60	0.50	4.60	4.62
20[1]	1.0000	8.00	0.002586	0.000646	17.00	1.00	0.30	0.50	4.14	4.44

[1] Smoked sheet cured with 5 per cent sulfur

Material Tested	Weight of Sample Gram	Per cent of Extract Tested	Standard I Value G. per Cc.	(a) Titration Standard I Used Cc.	(a) Blank Standard I Used Cc.	(b) Titration Standard I Used Cc.	(b) Blank Standard I Used Cc.	Free S by New Method Gram	Free S Present Gram
Blank of Reagents			0.005121		0.60		0.30	None	None
Blank of Reagents			0.005121		0.80		0.55	None	None
Sulfur	0.0700		0.004798	8.10	0.60	5.40	0.40	0.0200	0.0200
Sulfur	0.0700		0.004798	8.60	0.60	5.85	0.40	0.0200	0.0200
Sulfur	0.0700		0.005121	8.55	0.60	5.80	0.40	0.0211	0.0200
Sulfur	0.1000		0.005141	12.60	0.60	8.40	0.40	0.1007	0.1000
Potato Starch	0.5000		0.004727	14.55	0.60	9.85	0.40	0.0526	0.0200
Potato Starch	0.5000		0.004727	13.65	0.60	9.05	0.40	0.0364	0.0200
Potato Starch	0.5000		0.004727	13.60	0.60	9.00	0.40	0.0300	0.0200
Potato Starch	0.5000		0.004727	13.55	0.60	8.95	0.40	0.0286	0.0200
Potato Starch	0.5000		0.004727	13.50	0.60	0.40	0.40	0.0300	0.0200
Potato Starch	0.5000		0.004727	14.25	0.60	0.40	0.40	0.0536	0.0200
Potato Starch	0.5000		0.004727	14.20	0.60	0.40	0.40	0.0536	0.0200
Potato Starch	0.5000		0.004727	13.40	0.60	0.40	0.40	0.0286	0.0200
Rosin	0.0500		0.005121	8.60	0.60	5.60	0.40	0.0201	0.0200
Rosin	0.0500		0.005121	8.00	0.60	5.05	0.40	0.0203	0.0200
Linseed Oil	0.0500		0.005121	8.20	0.60	5.60	0.40	0.0219	0.0200
Linseed Oil	0.0500		0.005121	8.00	0.60	5.40	0.40	0.0207	0.0200
Linseed Oil	0.0500		0.005121	8.50	0.60	4.70	0.40	0.0219	0.0200
	1.0000	4.18	0.004768		0.80		0.55	None	None
	1.0000	4.00	0.004768		0.80		0.30	None	None
	1.0000	3.90	0.004768		1.00		0.30	None	None
Acetone Extract of Smoked Sheet Rubber to Determine Blank with Reagents	1.0000	4.16	0.004768		1.00		0.30	None	None
	1.0000	3.50	0.005121		0.85		1.55	None	None
	1.0000	3.80	0.005121		0.80		0.30	None	None
	1.0000	4.00	0.005121		0.70		0.50	None	None
	1.0000	4.00	0.005121		0.70		0.40	None	None
Cane Sugar	1.0000		0.004727						
Cane Sugar	1.0000		0.004727	8.95	0.60	5.50	0.40	0.0221	0.0200
M. R.	1.0000		0.004727	8.60	0.60	5.60	0.40	0.0222	0.0200
M. R.	1.0000		0.004727	10.00	0.60	6.80	0.40	0.0230	0.0200
Ceresine	1.0000		0.004727	10.00	0.60	6.70	0.40	0.0229	0.0200
Ceresine	1.0000		0.004727	10.70	0.60	3.10	0.40	0.0249	0.0200
Ceresine	1.0000		0.004727	9.15	0.60	3.55	0.40	0.0210	0.0200

The above is a tabulation of results:

The advantages of this method are its accuracy, ease of manipulation, rapidity, and cheapness.

When the dried acetone extract from a rubber compound is obtained, eighteen samples may easily be determined in $2^1/_2$ hrs. The operator need not spend more than an hour's time in actual manipulation. This method may be used to determine sulfur, and mixtures of soluble sulfides and thiosulfates.

ATLANTIC INSULATED WIRE AND CABLE COMPANY
STAMFORD, CONNECTICUT

RAPID DETERMINATION OF CARBON IN STEEL BY THE BARIUM CARBONATE TITRATION METHOD[1]

By J. R. CAIN AND L. C. MAXWELL

Received May 3, 1918

INTRODUCTION

Because of the increased demands now made on the testing and steel works laboratories which analyze steel delivered on government contracts, and because of the reduced number of chemists available for such work, it becomes desirable to increase the efficiency of laboratories in all possible ways. Short-cuts or simplifications which will reduce the time required for determination by standard methods, or reliable new methods which require less time than those now in use are of value in contributing towards increased output of work. With this idea the following modification of the barium carbonate titration method originally described by Cain[2] has been developed. The work was carried on recently at the Bureau of Standards in connection with a military problem where speed was considered important.

The barium carbonate method is much used, especially by testing laboratories which usually have to analyze steels of unknown composition from many sources. It has been recognized that this method as heretofore used is not as rapid as the soda-lime method, but it is also felt by many that it is less subject to disturbing influences and is in most respects simpler than the latter method. It is believed that the modifications herein recommended put the barium carbonate titration method more nearly on the same basis with the soda-lime method as to time requirement, with but little loss in accuracy, and with added simplicity in manipulation. The time required per determination has been reduced 50 per cent and it is now possible for a chemist during an 8-hr. day to make 50 determinations by the barium carbonate titration method.

The procedure recommended in the cited paper was briefly as follows:

The combustion of the steel was carried out by admitting oxygen at a moderate rate to the combustion tube. No details were given in that paper as to furnace temperatures at the time the boat was inserted in the furnace, nor as to whether the boat was allowed to preheat before admitting oxygen. Actually, the results given in the paper were obtained by placing the cold boat in a furnace kept at 1000 to 1050° and admitting the oxygen immediately; the passage of the oxygen at the moderate rate specified was continued for 20 to 25 min. The oxides thus obtained were frequently not well fused. If an incomplete combustion was suspected, the oxides were crushed and reburned. This method of burning corresponded to practice here and elsewhere at that time. The barium carbonate was filtered under an atmosphere free from carbon dioxide, using a special apparatus illustrated and described in the cited publication. The filter consisted of a carbon tube fitted with a perforated porcelain plate; on this was placed a bed of coarse quartz particles, and on this a layer of asbestos. When filtration was finished the porcelain plate and superimposed layers of quartz and asbestos were transferred to a wide-mouth flask, treated with excess of the standard hydrochloric acid, and the solution titrated against sodium hydroxide, using methyl orange as indicator.

Various precautions in manipulation and filtration were described. These precautions, the necessity for preparing a filter of this type each time, and the slow-

[1] Published by permission of the Director of the Bureau of Standards.

[2] Bureau of Standards, *Technologic Paper* No. 33

ness of the combustion all contributed toward making the barium carbonate method as described longer than others in use. This was compensated by the high degree of accuracy attainable and the insurance against numerous sources of error, as detailed in the paper.

The present method saves time in the following ways:

1—Admission of oxygen at a very rapid rate to the burning sample with automatic provision against too rapid passage at the exit end of the combustion tube. (This would cause loss of carbon.) This rapid admission of oxygen, coupled with the use of a preheated boat and the practice of allowing the sample to preheat in the furnace a minute before admitting oxygen, gives complete combustion of a 2-g. sample in $1^1/_2$ to 2 min. If combustion is allowed to take place gradually, instead of rapidly, as specified, the rapid method herein described cannot be used. The criteria of a successful combustion by this method are:

(*a*) Well-fused oxides in which no trace of the original grains of steel is apparent.

(*b*) Much accelerated oxygen inflow during the actual combustion of the sample.

(*c*) Vivid incandescence while the sample is burning, visible if a quartz combustion tube is used.

Should these signs of a good combustion be lacking, determinations should be rejected.

2—Use of glass plungers to take up dead space in the forward end of the combustion tube so as to decrease the amount of gas that has to be flushed out at each determination.

3—Rapid filtration as described in Section 6.

4—The delivery of all the reagents from reservoirs by air pressure.

The main prerequisite for the use of the modified method is a laboratory atmosphere not contaminated with excessive amounts of carbon dioxide, so that the barium carbonate may be filtered in a simple apparatus not requiring exclusion of the carbon dioxide contained in the laboratory air. This requirement is met by any modern laboratory with even fairly good ventilation and without an excessive number of gas burners operating at one time in a confined space. Practically this point may be tested by comparing blanks run with the filtering apparatus described in the original paper[1] and that herein recommended. If the difference in the blanks is such as would cause an error exceeding 0.005 per cent carbon when a 2-g. sample is used, *i. e.*, 0.0001 g. carbon, either the longer method must be used or steps taken to reduce the carbon dioxide content of the laboratory atmosphere.

METHOD

1 FURNACES AND TEMPERATURE

An electric furnace operating at not less than 1063° C. (the melting point of pure gold) is used.[2] Such a furnace may be obtained upon specification or as a standard article from manufacturers or may be constructed by the operator. The furnace should be equipped with a rheostat so designed with respect to the line voltage that initially the furnace gives the proper temperature with nearly all the rheostat resistance inserted. As the furnace is used its winding deteriorates and increases in resistance, and this should be compensated by removing resistance on the rheostat so as to maintain the furnace temperature as specified. If the temperature is too low when all the rheostat resistance is removed, the furnace must be supplied with a new winding. Temperatures are checked by the melting point of pure gold. A piece of this metal is flattened out, placed on a clean porcelain or alundum boat and left in the furnace (previously brought to full heat) for 10 min. If the gold is not then melted the temperature is too low.[1] The same piece of gold may be used repeatedly provided care is taken always to place it on a clean surface of either alundum or porcelain.

2—BOATS AND LINING MATERIALS

Boats may be of alundum, porcelain, platinum or nickel. Nickel boats may be made very cheaply by cutting a sheet of nickel of proper size at the corners and bending these up. Such boats should be ignited in the furnace in a current of oxygen until free from carbon. To protect the combustion tube from the effects of spattering oxides it is provided with a sleeve of nickel sheet (also ignited until free from carbon). Boats are lined with alundum sand, free from materials causing a blank. The special grade supplied by the Norton Company is quite satisfactory.

3—COMBUSTION TUBES AND CATALYZER

Combustion tubes may be standard forms of porcelain or well-glazed quartz, or in fact, any material which has been carefully tested for freedom from porosity. To facilitate fitting of stoppers the cross-section at the end should be circular. In the forward end of the tube a roll of copper gauze 3 in. long and of a diameter sufficient to fill the tube is inserted so that it is heated by thermal conduction from the heated zone of the furnace to a temperature of 200 to 300° C. The copper should not, however, be placed so far in the furnace that there is danger of its melting. The copper is then oxidized by bringing the furnace to a proper temperature while passing oxygen. This copper oxide serves to oxidize any carbon monoxide that might be formed, also any sulfur dioxide, which is oxidized and fixed as copper sulfate. Should too great an accumulation of copper sulfate take place the catalyzer should be renewed.

4—RATE OF FLOW OF OXYGEN

The rate at which oxygen is admitted to the forward end of the tube should be not less than 10 to 15 l. per min. At the exit end of the tube the rate should not exceed 225 cc. per min. This latter rate of flow is attained most simply by constricting a glass capillary tube inserted in the forward stopper of the combustion tube so that the desired rate of outflow is obtained with the specified rate of inflow. A plug of glass wool precedes the capillary. The rate of outflow is especially important, for if this is much ex-

[1] *Loc. cit.*

[2] Lower temperatures may be used with very fine chips, the temperature recommended will burn successfully chips that will just pass a 10-mesh sieve.

[1] The melting point of pure silver (960.5° C.), determined in the same way, is a convenient check on the lower temperature limit.

cooled, carbon dioxide will be carried past the absorption tube containing the barium hydroxide. The dead space in the combustion tube in front of the copper oxide catalyzer is taken up with a glass tube closed at both ends. This decreases the amount of gas to be flushed out of the tube at each combustion, and materially shortens the time required for a determination.

5—MEYER ABSORPTION TUBES AND BARIUM HYDROXIDE SOLUTIONS

The form of Meyer tube shown in the cited paper has many advantages and may be obtained from dealers on specification. It should be filled with sufficient barium hydroxide solution (25 g. $Ba(OH)_2.2H_2O$ per liter) so that when gas is passing for a determination the liquid fills all the small bulbs and one-half the large bulb at the exit end. The barium hydroxide solution is held in a 10-l. bottle and is delivered by pressure of air free from carbon dioxide.

6—FILTERING AND WASHING

A Büchner funnel fitted to a suction flask and supplied with two superimposed, open-grain, 7-cm. filter papers is used for filtrations. Much time is saved by not having to fold and fit the papers. The large surface exposed insures rapid filtration. The Meyer tube is washed three times, using care to reach all points. The precipitate on the filter is then washed four times, washing the top of the funnel carefully. The wash water is free from carbon dioxide and is delivered from a large glass reservoir by air pressure.

7—STANDARD ACID AND ALKALI

Tenth-normal hydrochloric acid is used. This may be conveniently standardized against weighed portions of chemically pure sodium carbonate which has been fused in a platinum crucible and cooled in a current of pure, dry carbon dioxide. The carbon dioxide is conveniently obtained by heating acid sodium carbonate in a hard glass test tube and passing the liberated gas through a calcium chloride tower. The alkali is standardized sodium hydroxide solution adjusted to be equivalent to the acid. Methyl orange is used as an indicator. Both acid and alkali are delivered from the respective stock bottles to the burettes by air pressure.

8—PROCEDURE

The furnace being at the proper temperature and the filled Meyer tube connected, 2 g. of steel are weighed and transferred to the boat filled with alundum sand. This should have been placed in the hot furnace previous to weighing the sample and then removed so that at the time of placing the sample on it its temperature is just below a visible red. (This will not cause loss of carbon unless the particles of the sample are extremely small—less than 60 mesh.) The boat is then immediately placed in the furnace and allowed to heat for one minute with no oxygen passing. During this time a second sample is being weighed (the balance should be placed in the same room with the furnace for convenience). Oxygen is now admitted at the rate prescribed in Section 4, and at the end of 5 min., if the combustion has been successful (see Introduction), the Meyer tube may be disconnected and the boat removed from the furnace to cool sufficiently for introducing the second sample. The filtration and washing of the barium carbonate is then carried out as described. By this time the boat is ready for the second sample, which has already been weighed out. The combustion of this sample is then started, using another Meyer tube. The absorption tube used for the previous determination is now washed out by adding to it from the burette the necessary amount of standard acid (this being usually about 5 cc. more than is actually needed to dissolve the carbonate). The acid is transferred from the Meyer tube to a wide-mouth flask, as is also the filter paper carrying the precipitate. The Meyer tube, after washing twice with water, is filled with barium hydroxide solution for the next determination. The flask containing the precipitate is placed on the hot plate until the carbonate is dissolved.[1] Titrations are conveniently made when several flasks are ready. During filtration, washing, etc., of the first determination, the combustion of the second proceeds, but there is still time before its completion for the operator to adjust the acid burette for the second determination, to fit papers to the Büchner funnel, and to weigh out the third sample.

TABLE I—RESULTS OBTAINED BY MODIFIED BARIUM CARBONATE TITRATION METHOD ON BUREAU OF STANDARDS ANALYZED STANDARD SAMPLES

Sample No.	Certificate Value by Direct Combustion Per cent	Carbon Found by Method Herein Described Per cent	Number of Determinations	Mean Variation from Certificate Value
35	1.03	1.016 to 1.027	3	—0.01
23	0.805	0.81	3	+0.005(a)
10b	0.373	0.380	2	+0.007(a)
21a	0.617	0.605 to 0.620	12	—0.005

(a) The corresponding differences in the determinations of carbon in Sample 23 given in the cited paper were: 0.000 per cent, 0.000 per cent, 0.000 per cent, and —0.005 per cent; in 10b they were: 0.001 per cent and —0.001 per cent.

BUREAU OF STANDARDS
WASHINGTON, D. C.

THE PREPARATION AND TESTING OF PURE ARSENIOUS OXIDE[2]

By ROBERT M. CHAPIN

Received March 12, 1918

INTRODUCTION

A supply of assuredly pure arsenious oxide is an important matter to the modern analytical chemist. Analytical methods that involve titration with standard iodine, by virtue of their accuracy and convenience, are constantly finding new applications in addition to the already considerable list, and for standardizing such iodine solutions pure arsenious oxide is generally useful and frequently used. Moreover, employment of the substance as an alkalimetric standard has been advocated by Menzies and McCarthy.[3]

From textbooks and various papers dealing with the applications mentioned above, it appears that pure arsenious oxide is very easily obtained. Typical are the statements of Menzies and McCarthy[4]

[1] Avoid long continued heating which apparently causes some action on the filter paper involving a slight error in the determination.

[2] Published by permission of the Secretary of Agriculture.

[3] *J. Am. Chem. Soc.*, **37** (1915), 2021.

[4] *Loc. cit.*

that it "may be purchased commercially at a low price already in a high state of purity," and that "it may readily be purified further both by recrystallization, if necessary, and by sublimation." The experience of the writer points to the contrary. Commercial specimens, even of "guaranteed analysis," may be far from pure. Sublimation alone is not a dependable method of purification, and, unless proper conditions prevail, preliminary recrystallization may not be an adequate supplementary measure. In fact it is entirely possible, after recrystallization and sublimation, to end with a "purified" arsenious oxide more impure than the original material. Finally, extant methods for testing are inadequate for detecting the presence of important amounts of certain impurities. Particularly is this true of antimonous oxide, certainly an important impurity and one not unlikely to be present, but for the detection of which, aside from the dubious test of the Pharmacopoeia, there seems to be no practical method extant.

As impurities commonly present in commercial white arsenic, Scott[1] gives "SiO_2, Sb_2O_3, Fe_2O_3, NiO, CoO, CaO, SO_3, Cu, Pb, and Zn." The *United States Pharmacopoeia* IX prescribes tests for As_2S_3, Sb, Sn, Cd. Thorpe[2] mentions the presence of bismuth, sulfur and carbonaceous matter from the fuel.

TESTS FOR PURITY

1. INSOLUBLE—To 1 g. of the powdered sample in a wet[3] test tube add 10 cc. of a mixture of 1 vol. concentrated ammonia (sp. gr. 0.90) with 2 vols. water. Heat with shaking to very gentle boiling. The solution should be perfectly clear and colorless with no trace of insoluble residue.

2. HEAVY METALS—To the solution obtained under (1) add 10 cc. clear and fresh saturated hydrogen sulfide water, mix, and heat just to boiling. No precipitate, turbidity, or color other than a faint yellow should appear.

3. ANTIMONOUS OXIDE—If necessary, filter the hot solution obtained under (2) into another test tube, otherwise cool at once in water and finally place in ice water for 15 min. No turbidity should appear (less than 0.15 per cent Sb_2O_3).

4. SULFUR, SULFIDES—Dissolve in a test tube, with heat, 1 g. of the sample in 10 cc. normal caustic soda solution, add 1 drop of lead acetate solution, and mix. No coloration should appear (less than 0.005 per cent sulfur).

5. NONVOLATILE—Under a hood cautiously heat 1 g. of the sample in a weighed crucible, raising the heat at the end to barely perceptible redness. The material during sublimation should show no darkening (carbonaceous matter) and should leave a nonvolatile residue of less than 0.05 per cent.

Tests 1, 4 and 5 are essentially those of Krauch[4] merely modified in details as experience indicated desirable. Tests 2 and 3, however, are new. Test 2 hardly needs further remark. Test 3 depends on the fact that antimonous sulfide is somewhat soluble in hot ammonia,[1] but separates on cooling, excess of arsenious oxide precluding the presence of ammonium sulfide.

The strength of the ammonia may vary considerably without injury, but the delicacy of the test cannot be increased by using relatively more substance. In fact it is sensibly diminished thereby, probably as the effect of mass action exerted by the arsenious oxide. Merely cooling to about 20° C. will eventually bring out even small amounts of antimony. At this temperature a little over 0.20 per cent is soon plain, but smaller amounts require so much time that the use of ice water is desirable. The first indication of a positive test is an opalescence much like decomposing hydrogen sulfide water. This slowly increases to a yellow turbidity which would tempt the inexperienced to assert positively that the test was a failure and that arsenious sulfide was coming out. Soon, however, examination by transmitted light will reveal a distinct orange tint, and coagulation to characteristic red flocks will ensue after a sufficient time. Pure arsenious oxide with pure reagents will show no trace of turbidity, even on long standing.

The ultimate sensibility of the test is distinctly greater than above indicated, for by letting the tube stand in ice water for 2 hrs. it apparently becomes possible to detect down to 0.10 per cent Sb_2O_3. But in this connection it must be remembered that, iodimetrically at any rate, small quantities of antimonous oxide will act exactly like arsenious oxide except for the difference in molecular weights. Therefore, the presence of 0.15 per cent of antimonous oxide is equivalent to less than 0.05 per cent of inert matter, a limit sufficient for all purposes except those of such a high degree of accuracy that special purification of commercial material would be imperative in any event.

For experiments on the antimony test, crystallized arsenious oxide was prepared from a mother liquor assuredly freed from antimonous oxide by the removal of an extra and liberal crop of crystals after the regular test on the preceding crop was negative as later described. Antimonous oxide was introduced in the form of a 0.23 per cent solution of tartar emetic, equivalent to a 0.1 per cent solution of the oxide, the desired amount being added to the test tube already containing both the arsenious oxide and the ammonia, but before boiling.

The sulfur test was checked by means of pure arsenious sulfide, dissolved in freshly boiled normal caustic soda.

The matter of tests for pharmaceutical purity being outside the writer's present field of work will be only briefly discussed. Careful sublimation of one gram in a hard glass test tube appears to yield considerable information regarding nonvolatile residue, arsenious sulfide, metallic arsenic, and organic matter. But a test for antimony is certainly desirable. The test in

[1] "Standard Methods of Chemical Analysis," Wilfred W. Scott. D. Van Nostrand Co., 1917.

[2] *Dictionary of Applied Chemistry*, 1 (1912).

[3] To prevent the substance caking on the glass.

[4] "Chemical Reagents; Their Purity and Tests," E. Merck; *Translation* by Schenck. D. Van Nostrand Co., 1907.

[1] "Qualitative Chemical Analysis," Prescott & Johnson, 7th Edition, 1916.

the form specified for determining chemical purity is probably too delicate, though it may be made less so by changes of concentration or by cooling at a higher temperature. Apparently the best way of reducing its delicacy is to employ caustic soda solution of definite strength in place of ammonia as a solvent. For example, using 10 cc. of normal caustic soda on a one-gram sample, and cooling in tap water, one per cent of Sb_2O_3 in the sample quickly gives a heavy precipitate, while with 0.6 per cent Sb_2O_3 the test remains negative for a period much longer than 15 min. Caustic soda might also serve for the detection of insoluble matter in pharmaceutical testing.

The present assay method of the *Pharmacopoeia* must necessarily be inaccurate if antimonous oxide is present, and the only recourse seems to be distillation with hydrochloric acid.[1]

PREPARATION OF PURE ARSENIOUS OXIDE

The production of pure arsenious oxide on a manufacturing scale is not here considered; merely its preparation in the laboratory. Under such conditions sublimation cannot be depended on to separate volatile impurities. Among these must be included antimonous oxide, as may be easily demonstrated by the specific test for that substance now available. It evidently possesses a sufficient vapor tension at temperatures ordinarily employed, even in careful work, for subliming arsenious oxide to produce appreciable contamination. Since volatile impurities—including carbonaceous matter which will produce elementary arsenic—are apparently quite as important as the nonvolatile, measures to eliminate them ought to precede final sublimation if a reasonably pure product is to be assured.

The classic step preliminary to sublimation is crystallization. The writer has been unable to discover any more practical means for attaining the desired end. But the process of crystallization to be employed is usually very sketchily outlined. Either water or hydrochloric acid of varying strength is specified as the solvent and few details are given. It seems to have escaped notice that arsenious oxide during crystallization strongly adsorbs many impurities—particularly antimonous oxide—present with it in solution. Consequently a "recrystallized" product may be more impure than the original material. Fractional crystallization is the obvious recourse, and properly carried out is very effective and not especially tedious. The absence of antimonous oxide is a rational and convenient index of the success of the operation.

As solvents for arsenious oxide, ammoniacal solutions and strong hydrochloric acid solutions are temptingly effective, but unfortunately both are also effective solvents for accompanying impurities. Water usually dissolves far less of the impurities, so that its disadvantages as a solvent are outweighed by the simplicity of the ensuing fractional crystallization. The final crystals, however, are best deposited from a slightly acid solution.

To 2 liters of boiling distilled[1] water in a 3-liter "boiling flask" are slowly added 150 g. powdered, white arsenic made into a cream with a little water. The mixture is boiled briskly for about $1^1/_4$ hrs. or until the volume is reduced to about 1600 cc., then is removed from the heat and allowed to settle for a few minutes. If the liquid tends to settle fairly clear it may be filtered at once through a fluted paper, but if it remains pronouncedly milky it will filter badly and must be clarified. To this end it is decanted from the sediment into another flask, brought to boiling, treated with milk of lime prepared from 2 g.[2] pure CaO, boiled 10 min.. then filtered.

The filtrate is boiled down in a stout beaker until 4 or 5 g. of solid have separated. Bumping will not be serious if the flame is lowered sufficiently. It is then decanted, boiling-hot, through a rapid fluted paper into another stout beaker kept hot during filtration, either on the steam bath or over a flame, and the filtrate kept close to the boiling point while the test for antimony is made on the deposited arsenious oxide in the first beaker. For the purpose in view a comparatively coarse and rapid test is adequate. A quantity of the moist substance which is judged to be equivalent to about one gram dry is brought into a test tube and the test made as usual except that cooling for 5 min. under running tap water is sufficient. Unless antimony is very plainly present in the deposit, the mother liquor is cert ainly antimony-free. Sometimes no antimony will be found even when much was present in the original substance for it appears to be practically wholly adsorbed by solid arsenious oxide if a sufficient quantity of the latter remains undissolved. Conversely, if solid arsenious oxide is absent, antimonous oxide may pass into the filtrate in large amount, evidently being much more soluble in a solution of arsenious oxide than in pure water.

If the test for antimony is positive it will be necessary to take off successive crops of crystals in the same way until a negative test finally results. Fractional crystallization by cooling is not advised for the reason that at temperatures below 85° the formation of crystalline from amorphous arsenious oxide progresses with such rapidity that the process is likely to get out of control.

The antimony-free mother liquor is treated with approximately either one or one and one-half per cent of its volume of concentrated hydrochloric acid, depending on whether lime was employed for clarification, and boiled down in a beaker to evident saturation. After a final filtration, it is cooled rapidly with frequent stirring to prevent the formation of crusts, then let stand over night. After being well stirred up, the crystals are filtered with suction and washed chloride-free. The yield naturally varies much, but will commonly be around 75 g. The crystals will probably be very nearly pure, but the writer has never been able to secure any which did not show slight darkening during sublimation.

For sublimation the apparatus of Menzies and

[1] Most recently studied by Roark and McDonnell, THIS JOURNAL, 8 1916), 327.

[1] Tap water may introduce undesirable organic impurities

[2] This quantity has so far proved sufficient.

McCarthy[1] is convenient but of small capacity. On a larger scale excellent results may be obtained with a stout-walled 250 cc. Erlenmeyer flask of rather hard glass, charged with 75 g. arsenious oxide evenly spread over the bottom. The flask is set in a flat sand bath, and the sand brought about one-half inch above the level of the material within. The mouth of the flask is covered with a porcelain crucible cover, and the bath is heated under a hood with a sufficiently powerful burner of the ring or stove type. The sublimation may require 7 hrs. and should not be intermittent for the flask, once cooled, is likely to crack when reheated. It is finished when a line of clear glass appears all around the flask above the sand. When completely cool, the flask is removed from the bath and with cautious handling the bottom is cut off with a hot point just below the line of the sublimate. The latter may then be easily removed with a knife blade. It is best to reject the portion in the neck of the flask, for volatile impurities will tend to concentrate there. The writer prefers to reject also the glassy ring of sublimate just above the sand level. With proper management the yield is excellent, very little being lost by volatilization.

CONCLUSION

It must be admitted that arsenious oxide lacks some of the qualities desirable in a standard substance for volumetric analysis. Nevertheless it is capable of affording extremely accurate results and for the purpose of directly standardizing iodine solutions there seems to be no other substance[2] which can fully take its place. Since it must be used, the chemist must possess practical and reliable methods for determining whether commercial samples are sufficiently pure for ordinary analytical work, while in case of deficiency, or when the material must be of the highest purity, dependable methods of preparation must be available. It is believed that these needs are met by the methods of preparation and testing here presented. Especially are methods given for detecting and eliminating an impurity to which far too little attention has been given in the past, *viz.*, antimonous oxide.

BIOCHEMIC DIVISION, BUREAU OF ANIMAL INDUSTRY
DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

THE BISULFATE METHOD OF DETERMINING RADIUM

By HOWARD H. BARKER

Received December 5, 1917

The quantitative determination of the small amounts of radium in radioactive ores and various products obtained in their treatment for the recovery of radium is generally conducted by the emanation method. It is based upon the fact that the gaseous disintegration product of radium—the emanation—can be completely separated from radioactive materials and that the equilibrium quantity is proportional to the radium content. Very small quantities of radium emanation are capable of exact measurement by electrical methods, for which carefully standardized electroscopes have come into general use.

The care and accuracy with which the emanation is separated from the specimen under examination are very essential in quantitative work and demand skilful manipulation, especially in the case of solids. Since heat alone rarely affects a complete separation of the emanation from the radioactive solids, the recognized methods of determining radium involve chemical treatment that will result in a solution or in decomposition of the material by fusion. Our experiments test the applicability of fusion with bisulfate, for the separation of radium emanation, and afford a comparison of this method with other methods recognized as more or less standard.

Our work deals with substances which are not susceptible of direct solution in water or acids. The emanation is separated by direct fusion with sodium or potassium bisulfate or mixtures of the two. Since solids generally emit, at ordinary temperatures, variable proportions of the emanation continually produced by the radium present, the customary procedure is to first expel the emanation, that is, reduce it to zero, and then seal up the sample, allow it to stand for a definite time—a day or longer—and finally separate the accumulated emanation by fusing again. The equilibrium amount is then conveniently obtained by reference to a table of growth of radium emanation.[1]

Plum[2] made use of potassium bisulfate for radium determination in his study of methods of separating the radioactive constituents from carnotite ores. Schlundt[3] employed potassium bisulfate in a few of his experiments on the quantitative determination of radium mainly by fusion with mixed alkali carbonates. The experiments that follow I hope will serve to establish the reliability of the bisulfate method and also its range of applicability.

PLAN OF EXPERIMENTS

Representative carnotite ores and the radium-bearing products obtained therefrom were selected for the determinations of radium which were conducted by at least two other methods for comparison with the bisulfate method. The samples include (1) two carnotite-bearing sandstones from different localities and differing considerably in composition and radium content, (2) a siliceous concentrate obtained from an ore by chemical treatment in which the radium has been concentrated about fifteen-fold, (3) a sample of first sulfate containing about 600 parts of radium per billion of total weight, one-fourth of which is barium sulfate, (4) one sample of tailings, the sandy residue left after the extraction of radium from the ore, (5) a by-product very rich in gypsum, but containing also vanadium, iron and uranium compounds.

The radium was determined in case of these samples by at least three methods.

[1] *Loc. cit.*

[2] Antimony potassium tartrate, advocated by Metzl (*Z. anorg. Chem.*, **48** (1906), 156), is well known to be efflorescent when crystallized. The present writer has been unable to dry it to strictly constant weight in agreement with the theoretical composition of the anhydrous salt.

[1] Kolowrat, *Le Radium*, **6**, 195; also Curie, "Traité de Radioactivité," I, p. 419; *Chem. Kalender*, **2** (1914), 361; Rutherford, "Radioactive Substances and Their Radiations," **1913**, 665.

[2] *J. Am. Chem. Soc.*, **37** (1915), 1811.

[3] *Trans. Am. Electrochem. Soc.*, **26** (1914), 163.

METHODS OF SEPARATING THE EMANATION

1—Preparation of a refined radium barium sulfate by fusing a weighed sample, to which a small quantity of barium compound has been added, with 3 to 5 times its weight of a mixture of sodium and potassium carbonates. After leaching the melt with water, the insoluble carbonates are dissolved in dilute hydrochloric acid and pure radium-barium sulfate is precipitated by the addition of a few drops of sulfuric acid. The

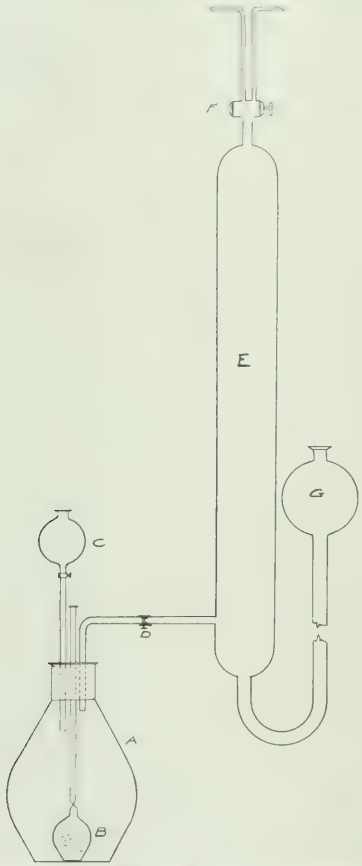


FIG. I TYPE OF APPARATUS FOR BOILING OFF EMANATION FROM MIXED CARBONATE FUSION

refined sulfate thus obtained is fused in a platinum boat with a mixture of sodium and potassium carbonates and is then sealed and stored for a certain period after which the accumulated emanation is again separated, collected and transferred to a standardized electroscope.[1]

2—Direct separation of the emanation from the melt is obtained by fusion of the sample in a platinum crucible with mixed carbonates of sodium and potassium. The melt is poured into a clean iron mortar. The crucible may be rinsed out by fusing a little more of the carbonates in it. The melt is powdered and sealed up in a thin-walled glass bulb, B, shown in Fig. I. After standing for a day or longer the emanation that has accumulated during the period of storage is separated by dissolving the carbonate in nitric or hydrochloric acid. The gas burette E of the apparatus used for this operation (Fig. I) is filled with a boiling hot solution of caustic soda through the levelling reservoir G by closing cock D and having F open. Then, after closing F, the levelling bulb G is lowered to a position below the outlet tube D in order that subsequent boiling will be conducted under slightly diminished pressure. This precaution also enables one to detect small air leaks in the apparatus. The bulb B containing the powdered carbonate is so adjusted in the 3-hole rubber stopper of the wide-mouth flask A, the boiler, that it is cracked by forcing down the stopper. The cock D is then opened and moderately strong acid is admitted gradually from the drop funnel C. When the sample is siliceous and the carbonate fusion exceeds 5 g., the capacity of the boiler should be at least 250 cc., and it is sometimes advantageous to have a little water in it to distribute the carbonate when the bulb is broken and in this way prevent the formation of a coating of silicic acid over the dry powder when acid is admitted. If the volume of air remaining in the boiler still exceeds the capacity of the burette, the air may be partly displaced by carbon dioxide before connecting up with the burette. As the decomposition of the carbonate proceeds the solution is heated and finally boiled until the liquid in the gas burette is forced down by water vapor to the level of D. The gas is then transferred quantitatively to an air-tight electroscope.

3—The bisulfate method consists in making a fusion of the material whose radium content is to be determined with either sodium or potassium bisulfate alone, or better, a mixture of the two in a hard glass pyrex tube of suitable dimensions. Hard glass pyrex tubes 25 cm. by 2.5 cm. were used in most of the determinations. The material and the bisulfate are thoroughly mixed before introducing into the tube, after which they are fused and boiling continued long enough to expel the last traces of emanation. The sides of the tube are washed down by introducing a little fresh bisulfate into the tube, allowing it to fuse and run down into the melt. The test tube is sealed with a stopper carrying two outlet tubes, one extending to within an inch or two of the melt, and the other just reaching through the stopper. After the emanation has been allowed to accumulate for a given definite period, the tube is connected up with the evacuated ionization chamber of an electroscope as shown in Fig. II. The micro drying bulb next to the ionization chamber contains concentrated sulfuric acid, whose function is to remove moisture from the air and emanation before entering the electroscope. The other drying bulb connected to the test tube on the ionization chamber side of the apparatus contains a fairly strong solution of caustic soda to remove any traces of sulfuric acid distilled over in the operation. The drying bulb hitched

[1] Further details are given by Lind, THIS JOURNAL, 7 (1915), 1024, and in U. S. Bureau of Mines, *Bull.* 104, 94.

to the other side of the test tube contains concentrated sulfuric acid or water, and is there primarily for noting the inflow of air into the system. It also serves for detecting any leaks in the line of connection. All rubber connections are wired, and the tips of the glass tubes are not broken until all connections have been made. Before breaking the capillary tips, the intermediate system is placed under a slight vacuum. The tips are then broken and by adjusting the stopcocks of the evacuated ionization chamber the flow of air through the chain is regulated. Heat is now gently applied until the mass is molten, after which it is boiled for about 5 min. Sometimes it is a little difficult to get good boiling at this stage, but I find where an equal mixture of the fused bisulfate and crystals is used, that this difficulty seldom appears. The emanation is swept into the chamber by a slow, steady current of air which is maintained during heating until atmospheric pressure is nearly attained in the chamber.

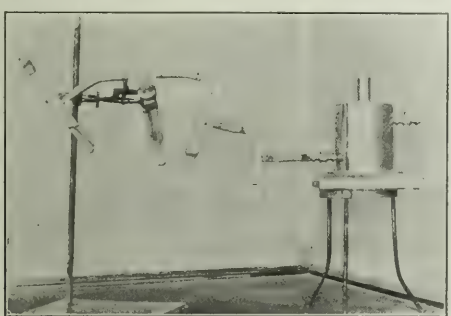


FIG. II

Readings of the rate of discharge are made 3 hrs. after the introduction of the gas, the same as in the other methods.

RESULTS AND DISCUSSION

The results obtained are summarized in the following table. The values represent duplicate determinations for the most part, but some of them are triplicate. The values in the table represent grams of radium per gram of material $\times 10^{-9}$.

TABLE I

Material	Wt. of Sample	Refined Sulfate	Mixed Carbonate	Mixed Bisulfate
Carnotite No. 1	1.00	5.15	5.18	5.22
Carnotite No. 2	1.00	10.60	10.00	10.40
Concentrate	0.50	29.90	30.00	29.40
Tailings	3.00	0.90	0.94	1.00
First Sulfate	0.05	676.00	680.00	678.00
By-products	2.00	1.26	1.24	1.27

The good agreement in the values shows that from the standpoint of accuracy in radium determination, no one method has any advantage for the classes of materials examined. The bisulfate method, however, presents some advantages which deserve recognition.

I—It has been established that the bisulfate method may be used in liberating the emanation from samples of pitchblende, whose radium content is known, used in the standardization of electroscopes. There are two advantages worthy of mention which the bisulfate method has in this operation over the solution method: (*a*) It is not necessary to take into consideration the "emanating power" of the pitchblende in the case of the bisulfate method, while it is in the case of the solution method; (*b*) The same carefully weighed samples of pitchblende may be used for several standardizations by resealing the bisulfate melt after the emanation has been driven off and collected for standardization.

II—Besides simplicity of operation, the bisulfate method is by far the most rapid procedure. Not only is the actual time required for the final separation of the emanation shorter than in the other procedure, but the time in work expended in preparing a sample and getting it sealed up is reduced to a few minutes.

III—The chances for loss due to manipulation are reduced to one operation, when the material is transferred to the test tube. In both of the other methods great care must be exercised in avoiding losses when fusions are in progress. Instead of one, two to three transfers of materials occur in the other methods.

IV—The cost of the operation is reduced. If one is careful the test tubes may be used for several determinations. In the refined sulfate method the small platinum boats, costing at least a dollar each are not good for more than 5 to 6 determinations. The use of larger platinum vessels is essential in the other methods, while in the bisulfate method all fusions are made in hard glass test tubes.

V—After the final separation of emanation by the bisulfate method, the material remains and is ready for another determination in case an accident occurs.

When the material under examination contains thorium, then the gas cannot be transferred directly to the electroscope during fusion, but must be collected in a gas burette to allow the decay of thorium emanation.

I wish to thank Mr. J. C. Simpkins, who assisted me at the outset in this work, and Dr. H. Schlundt for his helpful suggestions.

CHEMICAL PRODUCTS COMPANY
DENVER, COLORADO

A RAPID PRESSURE METHOD FOR THE DETERMINATION OF CARBON DIOXIDE IN CARBONATES

By W. H. Chapin

Received October 3, 1917

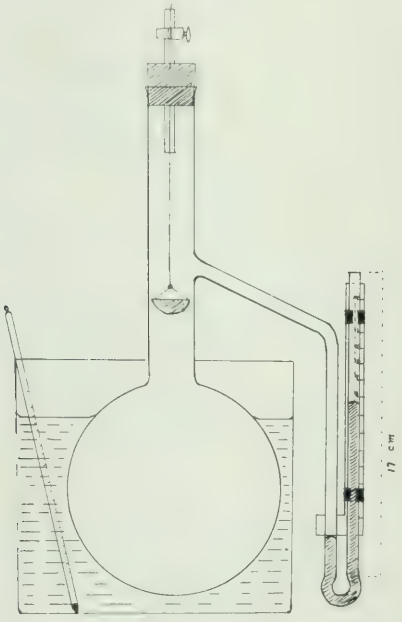
By use of the apparatus sketched below carbon dioxide may be very quickly determined in any carbonate which is soluble in cold hydrochloric acid. The accuracy of the method is equal to that attainable with the absorption method, except possibly when the latter is in the hands of a very skilled manipulator who has had long practice with the method.

The principle is very simple: The carbonate is allowed to dissolve in dilute HCl contained in a flask of known volume to which is attached a small mercury manometer. The change in pressure is read off, and by a simple calculation the weight and percentage of CO_2 are obtained. The necessary details are given in the procedure.

APPARATUS

The flask is made from a 600 cc. distilling flask by cutting off the side tube and sealing on the manometer tube in its place. The latter should have a bore of 5 mm. If too small, the capillary effect will interfere with accurate reading, and if too large the movement of the mercury changes the volume of the apparatus too much.

Attached to the manometer tube is a sliding scale of celluloid 15 cm. long and graduated in millimeters. This scale is made from a 15 cm. (6 in.) ruler by cutting out one side as seen in the sketch. It is held in place by means of small metal clips which may be slipped out of the way when reading. By use of a small lens it is possible to read the position of the mercury to $^1/_5$ mm. The inside of the manometer tube and the mercury used in it must be clean and dry or no accurate readings can be expected.



The capsule used for weighing out the sample is suspended by a thread as seen, the latter being caught and held in the stopcock until it is desired to drop the sample into the acid. This capsule may be made of copper or any metal not displacing hydrogen from the acid

The stopper should be of rubber, smooth and close fitting. Its tightness may always be insured by wetting slightly at the moment of inserting. It should be adjusted to a mark on the neck of the flask.

To keep the temperature of the apparatus constant and to make it easy to determine, the bulb of the flask is kept immersed in water at room temperature. The thermometer used in reading the temperature is kept standing in this water.

Before using the apparatus, its capacity is determined by filling with water from the bottom of the near arm of the manometer to the stopcock, and weighing. To prevent the water going too far in the manometer tube a rubber connector is placed over the open end and then closed by means of a pinchcock. If this is opened slightly after the flask is filled the water may be adjusted to any position.

PROCEDURE

First set up the apparatus as seen in the sketch, surrounding the bulb with water at room temperature. Fill the flask with carbon dioxide from a generator or pressure cylinder, and then run in by means of a pipette 10 cc. of 3 *N* HCl which has also been saturated with carbon dioxide.[1] Weigh out a sample of the powdered carbonate into the capsule (0.7 g. where the CO_2 content is about 20 per cent, and 0.4 g. where it is as high as 40 per cent). Suspend the loaded capsule as seen in the sketch, taking care to moisten the stopper well and to press it down to the mark. This may cause a slight compression of the gas in the flask and a consequent rise in the mercury, but the effect may be corrected by holding the end of the thread and opening the stopcock for a moment while gently tapping the manometer tube. When all is ready place a finger over the end of the stopcock tube, taking care not to catch the thread, and then open the cock so as to let the capsule drop. After this immediately close the cock again. The carbonate usually dissolves within a minute, but it is always best to watch the manometer for about 5 min. for further rise, tapping gently in the meantime. Finally, when the reaction is complete, adjust the scale so that the lower end corresponds with the meniscus in the near arm of the tube and then read off the height of the column in the other arm. Great care must be taken to get exact adjustment and to avoid parallax. Read to centimeters and tenths and estimate to hundredths. Also take the temperature accurately.

We now have the volume of the CO_2 at room temperature, V_t (vol. of flask minus 10 cc. occupied by acid). We also have the pressure P of the CO_2 (as read on the manometer). Finally, we have the temperature t. We can get the weight of the CO_2 by calculating down to standard conditions and multiplying into the weight of 1 cc. of CO_2 under standard conditions (0.001965 g.). We then have:

$$\text{Wt. of } CO_2 = \frac{V_t \times P \times 273 \times 0.001965}{760 \times (273 + t)}$$

Since the factors Vt, 273, 0.001965 and 760 are always the same, we may work out the value of the fraction

[1] If the acid is not first saturated with CO_2 a part of the gas evolved during the reaction will remain in solution. If the flask is not first filled with CO_2 a part of the gas dissolved in the HCl will at first be given off, and later during the determination, when the pressure of the CO_2 rises, gas will again go into solution. Where the pressure of the CO_2 in the flask is one whole atmosphere at the start, no gas will be given off from the acid, and since the change in pressure during the determination will be comparatively slight, very little will then go into solution. It is best to keep the stock of HCl in a gas wash bottle connected with a Kipp generator, where CO_2 may at any time be forced through it. The tube through which the CO_2 is led into the apparatus when filling with this gas is attached to the wash bottle. Thus every time the apparatus is filled just that much CO_2 passes through the acid.

$$\frac{V_t \times 273 \times 0.001065}{760}$$

and call this the constant for the apparatus, K. We then have:

$$\text{Wt. of } CO_2 = \frac{KP}{273 + t}$$

The percentage of CO_2 in the carbonate then follows, thus

$$\text{Percentage of } CO_2 = \frac{100\ KP}{(273 + t) \times \text{Wt. of sample}}$$

By use of logarithms the necessary calculation may be made in less than 2 min. The total time consumed in making a determination, including the weighing and calculation, need not be over 15 min.

After completing a determination the capsule may be lifted out of the apparatus by means of a wire hook, and the spent acid may be drawn out with a pipette. The apparatus is then ready for the next determination without even refilling with CO_2.

RESULTS

Calcite Per cent CO_2	Argillaceous Limestone Per cent CO_2	Na_2CO_3 aq. Per cent CO_2
43.53	24.71	34.74
43.67	24.34	34.40
43.40	24.67	By absorption method
43.52	24.36	34.59
	24.59	34.30
Av., 43.51		
By ignition 43.59	Av. 24.53, By absorption method 24.47(a)	

(a) Average of 100 determinations varying from 24.1 per cent to 24.8 per cent.

SEVERANCE CHEMICAL LABORATORY
OBERLIN COLLEGE, OBERLIN, OHIO

A PROXIMATE ANALYSIS OF THE SEED OF THE COMMON PIGWEED, AMARANTHUS RETROFLEXUS L

By EVERHART P. HARDING AND WALTER A. EGGE

Received August 3, 1917

It was thought by the authors of this paper that the partially carbonized bracts of the seeds of this common plant might make a good filtering medium for decolorizing sugar and other colored solutions. This suggested other possible uses of the seeds which led to their proximate analysis.

DESCRIPTION OF PLANT[1]

This variety of pigweed is commonly called "red root," "rough pigweed," "green amaranthus" and "Chinaman's greens." It is an annual weed which grows from a well-formed and fairly deep-rooted tap root. The root is generally red. The plant grows from 1 to 3 ft. high and is branched, the branches coming obliquely from the stem. The stem and leaves are rough. The plant flowers from July to September. These flowers are very inconspicuous, appearing in the angle formed by the stem and leaf stalk. The seeds are oval, black and shiny, and ripen during August, or before. The weed occurs in all parts of the State of Minnesota and thrives in all kinds of soil, but prefers a rich loam. It is common in gardens and waste places and does most injury by crowding out crop plants.

[1] Minnesota Agricultural Experiment Station, *Bull.* **129**, March 1913, p. 37

PREPARATION OF SAMPLE

The seeds were stripped from plants growing in Waseca County in the southern part of Minnesota. They were cleaned by removing foreign matter and chaff (bracts). The separation and removal of the bracts was difficult and tedious. Approximately 75 per cent of the seeds were black and fully matured, the rest were red, showing varying degrees of maturity. The sample was rapidly ground to 20-mesh size and the moisture determined on a portion of this size to represent total moisture in the seeds. The rest was air-dried for 7 days and then ground to a 72-mesh size. Moisture and all other determinations were made on this size sample.

ANALYSIS

MOISTURE IN 20- AND 72-MESH SAMPLES—One-gram samples were dried in an electric drying oven at exactly 100° C. Preliminary tests showed that 14 and 4 hrs., respectively, were required to bring the 20- and 72-mesh samples to constant weight.

	—20-Mesh—		—72-Mesh—		
	I	II	I	II	III
Moisture content, grams	0.1127	0.1129	0.0860	0.0860	0.0860
Average percentage of moisture	11.28			8.60	

ASH—Ash was determined on one-gram samples in an electric muffle at a temperature of 620° C.

	I	II	III
Ash content in grams	0.0445	0.0448	0.0446
Average percentage of ash		4.46	

It was very difficult to burn the substance completely to an ash over a Bunsen burner.

DETERMINATION OF OIL (ETHER EXTRACT)—About one-gram portions of the material, dried respectively to constant weight in an air oven and in a vacuum sulfuric acid desiccator, were extracted in Soxhlet extractors with anhydrous, alcohol-free ethyl ether to completion, which required 16 hrs.

	I	II	III	IV
Oven dried, grams oil	0.0798	0.0793	0.0788	0.0791
Desiccator dried, grams oil	0.0814	0.0788	0.0801	. . .
Oven dried, average percentage of oil		7.92		
Desiccator dried, average percentage of oil		8.46		

The dried oil dissolved in cold sulfuric ether, but not in cold petroleum ether.

PROTEIN—Protein was determined by Gunning's modification of Kjeldahl's method, using one-gram samples and the nitrogen conversion factor 6.25.

	I	II	III	IV
Protein content, grams	0.1880	0.1873	0.1867	0.1880
Average percentage of protein		19.13		

STARCH DETERMINATION (ACID CONVERSION METHOD)—Three-gram samples were used. The usual acid conversion[1] of starch into dextrose was made and the amount of dextrose determined by the Munson-Walker method.[2] The seeds occupied a volume of 2.10 cc., for which allowance was made. Aliquot parts of the solution equivalent to 0.30 g. of substance were used in the reductions and the starch conversion factor of 0.90 was used.

The following amounts of reduced cuprous oxide and the corresponding weights of dextrose and starch were found.

[1] Sachse, *Chem. Zentr.*, **1877**, 732, Bureau of Chemistry, U. S. Dept. of Agriculture, *Bull.* **107**.

[2] Browne, *J. Am. Chem. Soc.*, **1906**, 439

	I		II		III	
	1	2	1	2	1	2
Cu_2O, mg	299.6	298.0	297.5	298.4	300.1	299.4
Dextrose, mg.	137.0	136.2	135.95	136.40	137.25	136.90
Starch, mg.	123.3	122.6	122.4	122.7	123.5	123.2
Percentage of starch	41.09		40.91		40.98	

Average percentage of starch 40.99

STARCH DETERMINATION (DIASTASE METHOD)—Three-gram samples were used and the diastase conversion carried out as outlined in Leach's "Food Inspection and Analysis," p. 284. The Munson-Walker method was used for determining the amount of dextrose. The reductions were determined on an aliquot part of a definite volume equivalent to 0.240 g. of material. For the conversion 0.60 g. of commercial diastase with a reduction equivalent of 33.1 mg. of cuprous oxide was used.

	I		II		III	
	1	2	1	2	1	2
Cu_2O, mg.	233.9	234.1	232.8	233.3	232.8	232.0
Dextrose, mg.	89.40	89.50	88.85	89.10	88.85	88.46
Starch, mg.	80.46	80.55	79.96	80.19	79.96	79.61
Percentage of starch	33.53	33.56	33.32	33.41	33.32	33.17

Average percentage of starch 33.39

DETERMINATION OF SUGAR (REDUCING SUGARS)—The determination of sugar was difficult on account of the colloidal condition of the sugar extract. This difficulty was finally overcome by keeping the solution just slightly alkaline, which seemed to settle the colloids. Filtering was avoided as far as possible by increasing the volume of the solution and pipetting an aliquot volume.

Five-gram samples were boiled in 150 cc. of 50 per cent neutral alcohol for an hour on a steam bath with reflux condenser. The solution was cooled to room temperature and the volume made up to 500 cc. with 95 per cent alcohol made just alkaline. After thoroughly mixing and settling over night, 400 cc. were pipetted off with continuous suction and evaporated on a water bath to 20 cc. This volume was made up to 250 cc., using 2 cc. of lead acetate to clarify. After clarifying, 200 cc. were pipetted with continuous suction into a beaker and the excess of lead precipitated with anhydrous sodium carbonate. The solution was filtered and 50 cc. of the filtrate used for determining the sugar by the Munson-Walker method. From an aliquot part of the solution equivalent to 0.80 g. of material only a mere trace of Cu_2O was formed.

DETERMINATION OF SUGAR (AFTER INVERSION)—Fifty cubic centimeters of the solution in the preceding determination from which the excess lead was precipitated were pipetted into a 100-cc. graduated flask, 5 cc. of concentrated hydrochloric acid added, the volume made up to 100 cc. with distilled water, and allowed to remain over night at about 20° C.

	I		II	
	1	2	1	2
Cu_2O, mg.	21.00	21.40	21.90	21.10
Dextrose, mg.	9.40	9.56	9.76	9.44
Percentage of dextrose	2.35	2.39	2.44	2.36
Average percentage of dextrose		2.39		
Percentage calculated as cane sugar		2.15		

The acid was nearly neutralized and the sugar determined in an aliquot part of the solution, equivalent to 0.40 g. of material, by the Munson-Walker method.

DETERMINATION OF CRUDE FIBER—This determination was made on 2-g. samples containing 8.57 per cent of moisture. Kennedy's modification[1] of Sweeney's method was used and modified by filtering and igniting in alundum crucibles.

	I	II	III	IV
Crude fiber and ash, grams	0.2585	0.2650	0.2590	0.2580
Ash, grams	0.0358	0.0380	0.0398	0.0382
Crude fiber, grams	0.2127	0.2220	0.2192	0.2198
Percentage crude fiber	10.63	11.1100	10.96	10.99
Average per cent crude fiber		10.92		

TANNIN—Qualitative tests showed tannin.

SUMMARY

	Percentages on			
Constituents	20-Mesh as Received	72-Mesh Air-Dried	Oven-Dried	Desiccator-Dried
Moisture	11.28	8.60	0.00	....
Ash	4.33	4.46	4.88	....
Oil (ether extract)	7.03	7.24	7.92	8.46
Protein	18.57	19.13	20.93	....
Starch (diastase)	32.40	33.39	36.52	....
Starch (acid conversion)	39.77	40.98	44.83	....

	Percentages on		
Constituents	20-Mesh as Received	72-Mesh Air-Dried	Oven-Dried
Hemicellulose (starch by acid conversion minus starch of diastase)	7.37	7.59	8.31
Sugar reducing	trace	trace	trace
Sugar (after inversion)	2.32	2.39	2.31
Sugar (after inversion computed to cane sugar)	2.08	2.15	2.35
Crude fiber	10.59	10.92	11.92
Tannin and other undetermined substance by difference	6.35	6.52	7.17

The proximate analysis shows that the seeds would make a good component part of a stock food and as seeds of related species have been found to contain considerable amounts of potassium nitrate, the rather high protein content would suggest that they might be valuable as a chicken or bird food.

CHEMICAL LABORATORY
UNIVERSITY OF MINNESOTA
MINNEAPOLIS

THE DETECTION OF VEGETABLE GUMS IN FOOD PRODUCTS

By A. A. Cook and A. G. Woodman

Received May 2, 1918

The use of gums in food products is dependent mainly on their physical properties, the most noteworthy of which is their colloidal nature. This property enables the gum substance to hold within itself relatively large quantities of water and still impart a decided "body" to the mixture. Their use is specifically, then, as thickeners and binders in such food products as marshmallow preparations, ice cream, custards, pie fillings, egg substitutes, and flavoring emulsions. The gums ordinarily employed are gum arabic, gum tragacanth, Indian gum, agar-agar, and commercial dextrin. Gelatin, egg albumin, and commercial glucose, as well as starch, are also used for the same purpose.

EXISTING METHODS

The methods which have been proposed for the detection of this class of materials are based for the most part on isolated reactions for a particular gum, depending on some color or solubility test of the crude gum itself, and having no reference to the detection of small amounts of the gum in a complex food mixture. Of the few that are more general perhaps the best

[1] This Journal, 4 (1912), 600

known are those proposed by Patrick,[1] and Howard,[2] and the group scheme devised by Congdon.[3] The first two of these were suggested only for ice cream and, while quite simple and easily performed, are unsatisfactory for complicated food mixtures and entirely useless so far as identification of the gum is concerned. The more pretentious scheme of Congdon appeared quite promising and was given a thorough trial on food products and on known mixtures with gums. The results obtained were, however, very disappointing.

Congdon's procedure is evidently based on qualitative tests made on the crude gums, no provision being made for separating the gum from the other components of the complex food mixture, no matter how seriously these interfere with precipitation or color tests. Further, some of the tests included in the scheme were found to be neither specific nor conclusive even with the gum itself.

SEPARATION OF THE GUM

As the basis for a workable scheme it was decided at the outset that on account of the complex food mixtures to which gums are added, all tests for the identification of the thickener should be limited to tests made on the relatively pure gum substance, previously separated from the food product. This, of necessity, eliminates many of the tests described in the literature for the individual gums, most of which are dependent on impurities naturally occurring in the raw gums, and limits the available reactions for an orderly scheme largely to the precipitation tests. All such tests that could be found in the literature, and the action of all available solvents were carefully studied on solutions of gum arabic, agar, gum tragacanth, Indian gum, dextrin, gelatin, and egg albumin. Since Indian gum is not so specific a term as "arabic" or "tragacanth" and includes at least two different species, two samples of this gum, of entirely different appearance and obtained from different sources, were used.

After much experimentation, which need not be detailed here, the following systematic procedure was finally adopted for the separation of the gum in a comparatively pure condition from the food product. This procedure consists, in brief, in precipitating the protein of the food mixture by heating with acetic acid and tannin, and then precipitating the gums from the filtrate by acetone. In this way the sugars and other acetone-soluble materials are left in the filtrate. Since milk is a common ingredient of the class of foods in question, soluble phosphates have also to be removed by an extra precipitation with ammonia. Finally, the redissolved gums are precipitated relatively pure by alcohol. The procedure is summarized in Table I.

TABLE I—THE SEPARATION OF GUMS

A—ELIMINATION OF PROTEINS

1—Dilute sample to suitable concentration with water, add 5 cc. dilute acetic acid and 25 cc. of 10 per cent tannin solution, and heat mixture for 20 to 30 min. Centrifuge and filter. Discard precipitate.

Note—Casein, coagulable proteins, and some of the gelatin precipitated. Fats and other insoluble substances included in precipitate.

2—Add 40 to 50 cc. more tannin solution to filtrate from A1 and heat for short time. Centrifuge and filter. Discard precipitate.

Note—Remainder of gelatin and soluble proteins precipitated.

B—SEPARATION OF GUMS AND DEXTRIN FROM SUGARS

1—Treat clear filtrate from A2 with twice its volume of acetone. Centrifuge and filter. Discard filtrate. Wash precipitate twice with acetone.

Note—Precipitate includes gums and dextrin. No precipitate shows absence of gums, dextrin, and milk solids.

2—Dissolve precipitate from B1 in 50 cc. of warm water slightly acidified with acetic acid and add 10 cc. of ammonia (sp. gr. 0.90). Centrifuge and filter. Discard precipitate.

Note—Calcium phosphate from milk solids precipitated.

C—ISOLATION OF PURE GUM SUBSTANCE

Add acetic acid to filtrate from B2 until slightly acid. Add alcohol, one volume at a time, until a well defined precipitate appears.

Note—Gums and dextrin precipitated in fairly pure condition. No precipitate with five volumes of alcohol indicates absence of gums and dextrin.

Within certain limitations, which will be discussed later, this procedure is capable of separating gums and dextrin from complex food mixtures. In the numerous experiments on which it was based the amount of gum present varied from 0.1 to over 1.0 g. and the weight of sample from 50 to 200 g. It is certain that amounts of gum as small as 0.1 g. can be separated by the procedure from ordinary food mixtures. It should be remembered in this connection, however, that some gums are more readily detected than others when present in equivalent amounts. Tragacanth, for example, is much easier to detect in small quantities than either arabic or agar. The relation of the amounts of other precipitable matter, especially protein, is also of some importance since the gums tend to be carried down mechanically in the precipitation of protein, hence the ratio of protein to gum may be so great that the procedure will fail to detect the gum through mechanical loss.

TABLE II

	Approximate Volumes of Alcohol Necessary for Precipitation		Characteristic Appearance of Gum Precipitate	Characteristics of Gum Precipitate After Standing for Some Time in Air
	Vols. Alcohol	Vol. Gum Solution		
Agar	3–4	1	Finely divided white precipitate; settles very slowly	Usually remains soft and non-coherent
Arabic	2	1	White flocculent precipitate, settles quickly; neither sticky nor coherent	Becomes dry and powdery
Indian	2–3	1	Stringy precipitate; becomes very coherent after settling	Becomes dark colored; tough coherent layer
Tragacanth	2	1	Coherent, jelly-like mass; floats in clots in upper part of solution	Flattens down, becoming a semi-transparent coherent layer
Dextrin	3	1	White, fine precipitate; settles slowly; very sticky	Tends to become hard on long standing

IDENTIFICATION OF THE GUM

Certain of the precipitation tests for the gums, which have been used as the basis for the foregoing method of separation, serve also fairly well for the

[1] U. S. Dept. of Agr., Bur. of Chem., *Bull.* **116**, 24.
[2] *J. Am. Chem. Soc.*, **29** (1907), 1622.
[3] THIS JOURNAL, **7** (1915), 606.

identification of the gums. It suffices in general to note the approximate volume of alcohol required for the final precipitation and the nature and appearance of the alcohol precipitate. It is advantageous in this connection to pour off most of the alcohol after the precipitate has settled and allow the moist gum precipitate to stand exposed to the air for a short time, noting its behavior when drying. Table II presents in concise form the characteristic differences which are shown by the common gums.

CONFIRMATORY TESTS

While the characteristic differences described in the preceding table have been the chief reliance in identifying the gums, a number of the tests described in the literature have been examined to determine their value as confirmatory tests. Most of these, as previously stated, depend on impurities present in the crude gum and hence, as would be expected, proved of little value when applied to the separated gum precipitate. Several procedures, however, were found even under these conditions to be distinctly helpful. Chief of these was the presence of characteristic diatoms in the agar. The test is a well-known one and consists in identifying under the microscope the peculiar diatoms which are associated with agar, chiefly *Arachnoidiscus Ehrenbergii* and various species of *Cocconeis*, after destroying the organic matter by digestion with acid. The characteristic appearance of these diatoms will be found figured in most standard texts on food analysis.

The procedure consisted in destroying the organic matter of the sample by heating with nitric and sulfuric acids until the solution became colorless, diluting the concentrated acid solution with water, centrifuging to collect the siliceous residue, and examining this under the microscope. The test may be applied to the original material, but much time will be saved by using the tannin precipitate obtained in A1 of Table I. Since this precipitate is separated by the centrifuge it will obviously contain all the relatively heavy particles, including the diatoms, and its use will eliminate the interference due to soluble carbohydrates, as cane sugar, commercial glucose, etc., which use up time and acid in the digestion. This procedure was tried repeatedly on many samples of agar including the purest bacteriological material, and on food mixtures containing agar, and the presence of the characteristic diatoms noted in every case. Although this test actually depends on the presence of "impurities" in the gum, it was found that the diatoms are so widely distributed in commercial samples and remain so consistently in the tannin precipitate that the test was most useful.

The volatile acidity of Indian gum was also found of value as a confirmatory test. It has been noted by several authors that the species of gum coming under the classification of Indian gum have the characteristic property of developing an acetic odor when exposed to the air, and Emery[1] has made this characteristic the basis of a method for the detection of Indian gum as an adulterant of gum tragacanth. The method consists, in brief, of accelerating the hydrolysis of the gum by heating with acid, distilling, and titrating the acetic acid produced. Emery gives the following typical figures, expressed as cc. of $N/10$ acid per gram of gum:

Tragacanth	3 – 4
Indian gum	25 – 28

Emery's method was applied to the dried gum precipitates obtained in the systematic procedure of Table I and the following results were obtained:

TABLE III

Gum	Volatile Acidity
Indian gum, No. 1	20.3
Indian gum, No. 3	16.4
Indian gum, No. 3, dried for 3 mos. after precipitating	19.1
Indian gum, No. 4	9.5
Indian gum, No. 5	4.8
Tragacanth, No. 1	3.5
Tragacanth, No. 2	2.3
Tragacanth, No. 3	2.9
Gum arabic	0.25
Dextrin	1.0

These figures show that the differences found by Emery hold for the precipitated gums, although to a less marked degree. The method, although rather long and tedious, has distinct value as a confirmatory test on gum precipitates when Indian gum is suspected and the characteristics described in Table II are not conclusive.

LIMITATIONS OF THE METHOD

The delicacy of the method under favorable conditions has been pointed out in a previous paragraph. There are, however, certain limitations to its usefulness which should be definitely noted.

First, the successful use of the procedure for the identification of the gums depends primarily upon the ability to recognize the different visible characteristics of the gum precipitates. It is, therefore, highly desirable that before using the procedure for analytical purposes the analyst should know the various gum precipitates "by sight." This can be readily accomplished with the aid of a few prepared solutions of the gums concerned.

The identification of the gums where more than one is present in the food mixture is a more difficult matter. With some combinations of gums a partial separation can be accomplished by the fractional precipitation of the procedure, but with such a combination as dextrin and agar-agar, or Indian gum and tragacanth, this would be practically impossible, although there might be indications as to the presence of both gums.

A more serious matter is the possible presence of two substances which interfere distinctly with the separation and identification of the true gums. These are pectin and commercial glucose. The first of these is perhaps less important since, although it is somewhat similar to the gums and would to a certain extent be precipitated with them in the procedure, few of the commercial food products in which gums are used ordinarily would be likely to contain fruit pectins. The most likely combinations would be fruit pie fillings and jellies and jams made from apple stock, food products in which the presence of gums has been noted.

[1] THIS JOURNAL, 4 (1912), 374.

In the few cases where from the source of the sample the presence of pectin might be expected, its removal prior to the alcoholic separation of the gums may be aided by observing the following precautions:

(1) In adding the acetic acid to the ammoniacal solution (C of Table I), it should be added slowly, the mixture stirred, and allowed to stand for some time with occasional shaking. The removal of pectin at this point may be accelerated by adding a few drops of a tannin-iron solution before the ammonia and acetic acid treatment.

(2) Small amounts of alcohol, one-quarter to one-half of a volume, are added with stirring to the ammoniacal solution.

(3) When the amount of iron present is slight, judging from the color of the solution, as well as the precipitates, a few drops of a ferric chloride solution are added to the aqueous solution of the acetone precipitate (B1 of Table I).

Of greater practical importance is the presence of commercial glucose in products which also contain gum, a combination which is common in commercial products like marshmallow creams. The interfering factor here is of course dextrin and this is precipitated with the final gum precipitate by alcohol, although the scheme of fractional precipitation outlined in Table I should give some indication of its presence.

Numerous tests have shown that in the case of Indian gum and gum tragacanth commercial glucose interferes but little with their detection and identification, even when the ratio between the quantities of glucose and gum is as high as 40 to 1 for Indian gum and 120 to 1 for gum tragacanth. In the case of gum arabic the interference of commercial glucose is distinctly noticeable when the ratio of glucose to gum is 20 to 1, a portion of the dextrin precipitating with 2 volumes of alcohol along with the gum arabic, and by its sticky character masking the flocculent, noncoherent characteristic of the gum arabic. With agar, although no experiments were carried out, the interference would be still greater. Since the amount of commercial glucose present in a marshmallow paste, for example, is likely to exceed the ratio given for gum arabic, in such cases an additional step in the procedure may be needed.

This additional step is based on the fact that dextrin is more readily hydrolyzed by boiling with dilute acid than are the gums. It is carried out on the precipitate obtained with two volumes of alcohol, which will contain the greater part of the gum arabic and a portion of the dextrin. 0.5 g. of the dried gum precipitate is heated for 5 min. with 50 cc. of water and 2.5 cc. of concentrated hydrochloric acid (sp. gr. 1.20). The hydrolysis is conveniently carried out in a large test tube immersed in boiling water.

Experiments on known mixtures have shown that in this way one part of gum arabic may be detected in a mixture with 4 parts of dextrin, a delicacy which allows the detection of the gum in the presence of a considerable proportion of commercial glucose. Further, it must be remembered that the precipitate obtained with 2 volumes of alcohol would not contain the whole of the dextrin involved, for the larger part of this, as has been shown, would come down only with the third volume of alcohol. The precipitate to be hydrolyzed would, therefore, contain the gum with a small amount only of the dextrin present in the original mixture. Without question, then, the procedure is quite delicate and is capable of detecting relatively small quantities of gum arabic in the presence of commercial glucose.

SUMMARY

A method is described for the separation of the more common gums from food products based upon elimination of proteins by acetic acid and tannin and precipitation of the gums by acetone and finally alcohol.

The separated gums are identified mainly by their fractional precipitation with alcohol and the characteristic appearance of the precipitated pure gum.

The necessary modification of the method in the presence of such interfering substances as milk solids, pectin, and commercial glucose is described.

The method described is capable of detecting with ordinary commercial products 0.1 g. of gum in 100 g. of a complex food mixture.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

UNIFORM NITROGEN DETERMINATION IN COTTONSEED MEAL

By J. S. McHARGUE

Received April 13, 1918

Chemists often have trouble in obtaining uniform results in duplicating nitrogen determinations on cottonseed meal. Since cottonseed meal is so extensively used as a source of protein in feeds, it is a matter of considerable importance whether or not all serious errors have been eliminated in a nitrogen determination on this material.

The object of this paper is to call attention to procedures common among chemists which are often the cause of considerable error in the determination of nitrogen in cottonseed meal.

During the past year the writer has been called upon to check a number of cottonseed meal samples in which the amount of nitrogen was in question. On a few of these samples duplicate determinations of nitrogen showed variations ranging from as much as 0.50 to 1.50 per cent of protein, while other samples of cottonseed meal gave almost identical results upon duplication. The samples upon which varying results were obtained naturally suggested further investigation in regard to the cause of the variations.

Self[1] has shown that nitrogen can be lost by volatilization during the digestion if a large excess of potassium sulfate has been added. He attributes this loss to the formation of $KHSO_4$ when an excess of H_2SO_4 has been boiled off.

The following experiments were made to determine whether or not nitrogen was lost in a cottonseed meal

[1] *Pharm. J.*, **88**, 384-5, *Chem. Abs.* (Amer.), **6** (1912), 2048.

digestion when there was considerable variation in the amount of Na_2SO_4 added.

Six 0.7005 g. portions of cottonseed meal were weighed and transferred into 800 cc. Kjeldahl digestion flasks. 25 cc. of H_2SO_4 and the amount of the reagents indicated in the table were added to each flask and the digestion carried on at a brisk boil for 2 hrs. After cooling, the contents of the flasks were diluted, made alkaline, the mercury or copper precipitated with sodium polysulfide[1] and the ammonia distilled in the usual way. The results were as follows:

TABLE I

	Reagents Added		Results	
	Anhyd Na_2SO_4 G.	Mercury G.	N Obtained Per cent	Protein Per cent
A	2	0.7	6.32	39.50
B	4	0.7	6.30	39.37
C	12	0.7	6.29	39.31
	$CuSO_4.5H_2O$			
A	2	0.5	6.16	38.50
B	4	0.5	6.32	39.50
C	12	0.5	6.38	39.87

From the foregoing results it is to be observed that there is a gradual diminution in the nitrogen determinations receiving mercury as the amount of Na_2SO_4 is increased, whereas in those digested with copper sulfate there is a gradual increase in the nitrogen as the Na_2SO_4 increases. The results obtained with mercury agree with the findings of Self.

Robertson[2] has also noted slightly higher results where copper sulfate replaced mercury in the digestion. The loss in nitrogen in the presence of mercury can be assumed to be due either to volatilization of a nitrogen compound during the digestion or to the formation of a mercurammonium compound which is not decomposed during distillation. While the losses of nitrogen in the experiments digested with mercury are noteworthy they are not sufficiently great to account for the variations often experienced in nitrogen determinations on cottonseed meal. Hence it was necessary to continue the search for other sources of error.

Further experiments were made on a sample of cottonseed meal which had baffled the wits of another chemist in regard to its nitrogen content. Six nitrogen determinations were made on this sample for the purpose of showing the variations between determinations and to test the efficiency of Na_2SO_4 *versus* K_2SO_4 in cottonseed meal digestions. In three of the determinations 7 g. of K_2SO_4 were used in each digestion and 6 g. of Na_2SO_4 in each of the remaining determinations. Mercury was used as the catalyst and the amount of acid and time of digestion were the same as in previous experiments. The results obtained were as follows:

TABLE II

	Potassium Sulfate Per cent Nitrogen	Sodium Sulfate Per cent Nitrogen
A	6.90	6.71
B	6.92	6.75
C	6.74	6.64
Average	6.85	6.70
	Per cent Protein	Per cent Protein
Average	42.81	41.87
Maximum	43.25	42.19
Minimum	42.13	41.50
Difference	1.12	0.69

[1] Sodium polysulfide can now be obtained from Messrs Charles Cooper & Co., 194 Worth Street, New York.

[2] Brackett and Haskins, "Nitrogen," *J. A. O. A. C.*, 1, No. 3, 395

In the averages of the above experiments there is a difference of 0.15 per cent nitrogen or 0.94 per cent protein in favor of the K_2SO_4 digestions. The difference between the maximum and minimum results in the K_2SO_4 digestions is 0.18 per cent nitrogen or 1.12 per cent protein. In the Na_2SO_4 digestions these differences are 0.11 per cent nitrogen or 0.69 per cent protein, a little more than one-half the difference in the K_2SO_4 digestions. It is also to be noted that the results for "C" in each digestion are decidedly off in comparison with the results for "A" and "B."

In order to locate the cause of the "off" results in the foregoing determinations the following series of experiments was carried out:

One hundred grams of cottonseed meal were transferred onto a series of sieves of 20, 40, and 60 mesh, and after placing a few coins on each sieve the whole was shaken for about 25 min. That portion of the sample remaining on the 20 mesh sieve was 13.58 per cent, on the 40 mesh 30.82 per cent, on the 60 mesh 16.71 per cent, and the portion that passed through the 60 mesh was 38.89 per cent. The parts into which the sample was divided by sieving were bottled separately and six nitrogen determinations made on each sample. The amount of the reagents and the time of digestion were the same as in the previous experiment.

Table III shows the results obtained for nitrogen on each of the samples with K_2SO_4 and Na_2SO_4.

TABLE III

	Greater than 20 mesh Per cent N	Between 20 and 40 mesh Per cent N	Between 40 and 60 mesh Per cent N	Less than 60 mesh Per cent N
With K_2SO_4	A 4.84	4.76	7.01	7.69
	B 4.72	4.66	7.00	7.65
	C 4.65	4.66	6.85	7.64
Average	4.74	4.69	6.95	7.66
Equivalent to protein	29.62	29.31	43.44	47.88
Range of N	0.19	0.10	0.16	0.05
Equivalent to protein	1.19	0.62	1.00	0.31
	Per cent N	Per cent N	Per cent N	Per cent N
With Na_2SO_4	A 4.72	4.72	6.98	7.65
	B 4.54	4.67	6.96	7.65
	C 4.52	4.63	6.93	7.62
Average	4.59	4.67	6.96	7.64
Equivalent to protein	28.69	29.19	43.50	47.75
Range of N	0.20	0.09	0.05	0.03
Equivalent to protein	1.25	0.56	0.31	0.18
N by K_2SO_4 > N by Na_2SO_4	0.15	0.02	—0.01	0.02

From the results presented in the foregoing table on the nitrogen determinations of the different sized particles that were contained in the sample of cottonseed meal, it is to be observed that there is a gradual diminution in the variations of the different nitrogen determinations as we approach the fine ground material. On the 20 mesh sample there is a difference of 0.20 per cent nitrogen, which is equivalent to 1.25 per cent of protein, in the averages of the two different digestions, while on the 40 mesh sample there is a difference in the averages of the two different digestions of 0.02 per cent nitrogen, which is equivalent to a difference of 0.12 per cent of protein. There is also a striking diminution in the difference between the averages of the two methods of digestion on the 60 mesh sample as compared with the difference on the 40 mesh sample. It is also to be noted that there is less variation in the results obtained in the sodium sulfate digestions than in the potassium sulfate digestions.

From the results in Table III it is to be concluded that another and perhaps the greater cause of irregularities in nitrogen determinations in cottonseed meal is due to the lack of regrinding the larger particles to a sufficient degree of fineness to obtain a homogeneous mixture in weighing out portions for digestion.

In order to confirm this conclusion more definitely, about 300 g. of cottonseed meal were sifted with coins on a 40 mesh sieve for about 25 min. The greater part of the coarse particles that remained on the sieve were hulls and were ground to pass through the 40 mesh sieve. The two portions were again thoroughly mixed and quartered down to a 100 g. sample. Upon this sample the following experiments were made for the purpose of testing, first, the uniformity of the results obtained on the material treated in the above manner, and second, the time necessary to complete a digestion on cottonseed meal.

Four series of experiments of twelve nitrogen determinations each were made. The digestions in these series of experiments were carried on for 1, 2, 3 and 4 hrs., respectively. In each series all the digestions were heated gently at first and then to a brisk boil, and after about 45 min. all the solutions were clear. Upon distillation the following results were obtained:

TABLE IV—SHOWING THE EFFECT OF DIFFERENT PERIODS OF DIGESTION WITH MERCURY, COPPER SULFATE, POTASSIUM SULFATE, AND SODIUM SULFATE ON A SAMPLE OF COTTONSEED MEAL

	1 hour Per cent N	2 hours Per cent N	3 hours Per cent N	4 hours Per cent N
	7 g. K_2SO_4 + 0.7 g. Hg + 25 cc. H_2SO_4			
A	6.10	6.26	6.22	6.12
B	6.16	6.23	6.24	6.18
C	6.15	6.26	6.27	6.21
Average	6.14	6.25	6.24	6.17
Protein	38.38	39.06	39.0	38.56
	6 g. Na_2SO_4 + 0.7 g. Hg + 25 cc. H_2SO_4			
A	6.13	6.26	6.20	6.24
B	6.14	6.28	6.22	6.22
C	6.18	6.25	6.26	6.12
Average	6.15	6.27	6.23	6.19
Protein	38.44	39.19	38.94	38.69
	7 g. K_2SO_4 + 0.5 g. $CuSO_4.5H_2O$ + 25 cc. H_2SO_4			
A	6.16	6.24	6.33	6.36
B	6.18	6.22	6.25	6.34
C	6.19	6.20	6.32	6.26
Average	6.18	6.22	6.30	6.32
Protein	38.63	38.88	39.38	39.50
	6 g. Na_2SO_4 + 0.5 g. $CuSO_4.5H_2O$ + 25 cc. H_2SO_4			
A	6.18	6.21	6.26	6.36
B	6.17	6.29	6.34	6.34
C	6.16	6.24	6.28	6.33
Average	6.17	6.25	6.29	6.34
Protein	38.56	39.06	39.31	39.63

TABLE V—SHOWING THE AVERAGE PERCENTAGE OF PROTEIN FOR EACH DIGESTION PERIOD WITH MERCURY AND WITH COPPER SULFATE

With mercury	38.41	39.13	38.97	38.62
With copper	38.60	38.97	39.35	39.57

In comparing the results obtained under the different conditions of digestion, as shown in the foregoing table, the following points are of most interest.

In all of the one-hour digestions the results for nitrogen are low; therefore, a longer period than 1 hr. is necessary for a complete digestion of cottonseed meal. In the experiments in which mercury was used as the catalyst, the 2-hr. digestions gave the maximum results. Longer periods of digestion apparently caused a slight loss of nitrogen, negligible after 3 hrs., but appreciable at the end of 4 hrs.' digestion.

In the experiments in which copper sulfate and 6 g. of sodium sulfate were used, the maximum results were only obtained after 4 hrs. of digestion. However, the addition of larger amounts of sodium sulfate will reduce the time of digestion, 12 g. being sufficient to bring about complete digestion in 2 hrs.

It was observed that in determinations in which copper was used as the catalyst, the precipitation of the copper as sulfide greatly facilitates the boiling and reduces the time of distillation as compared with determinations in which the copper was not precipitated previously to starting the distillation.

Approximately 300 cc. of liquid should remain in the flask after distillation, since alkali will distil over if the solutions are concentrated to a much less volume. A large excess of alkali should always be avoided. Blanks were run on all of the reagents and deducted from each determination.

CONCLUSIONS

From the data presented in this paper the following conclusions may be drawn in regard to obtaining uniform nitrogen determinations on cottonseed meal.

1—The chief source of irregularity in nitrogen determinations on cottonseed meal may be due to a lack of grinding the sample to a sufficient degree of fineness (40 mesh) to obtain a homogeneous mixture of hulls and meal for weighing out a charge.

2—When mercury is used as the catalyst a digestion period of more than 2 hrs. of brisk boiling in an excess of sulfuric acid apparently causes a loss of nitrogen.

3—When copper sulfate is used as the catalyst the digestion period will depend upon the amount of sodium sulfate added, 12 g. being sufficient to bring about a complete digestion in 2 hrs.

4—The precipitation of the copper as sulfide facilitates the boiling and shortens the time of distillation.

5—Sodium sulfate is just as efficient as potassium sulfate in cottonseed meal digestions.

6—The writer suggests the use of the following charge: 0.7005 g. of cottonseed meal, 0.3 g. $CuSO_4$ or 0.5 g. $CuSO_4.5H_2O$, 12 g. Na_2SO_4 + 25 cc. H_2SO_4, and brisk boiling for 2 hrs.

KENTUCKY AGRICULTURAL EXPERIMENT STATION
LEXINGTON, KENTUCKY

THE DETECTION AND DETERMINATION OF COUMARIN IN FACTITIOUS VANILLA EXTRACTS

By H. J. Wichmann

Received March 18, 1918

A quick qualitative test for coumarin is very desirable for separating those extracts that contain it from those that do not. The number of extracts that contain coumarin without a declaration of its presence on the label is so small that the extra work of making the double extraction, as in the modified Hess-Prescott method, seems entirely superfluous and unnecessary. The method of testing for coumarin described in U. S. Department of Agriculture, Bureau of Chemistry, *Circular* 95 has, in the hands of the writer, been very efficient for this purpose. The method there outlined requires the distilling of the extract to a low volume, evaporating the distillate containing vanillin and coumarin, if the latter is present, with 1 cc. of

50 per cent potassium hydroxide, followed by fusion. The salicylic and protocatechuic acids formed from the coumarin and vanillin by the fusion are separated by distilling the acidified solutions of these acids or separating them with benzene, the former being volatile with steam and soluble in benzene, properties not possessed by the latter. The writer prefers the benzene method of separation because of its simplicity. The method, however, requires some preliminary experience before very small quantities of coumarin can with certainty be detected. One precaution necessary is not to carry on the distillation so far that yellow decomposition products result, but to stop just short of that point; otherwise it will be difficult to make a clean-cut fusion.

T. R. Dean[1] modified the original method. It was recognized in the original article that certain volatile salicylate-forming compounds like saccharin should not be present. If they are present a qualitative test will indicate coumarin, but a subsequent quantitative determination would give no weighable quantity, because both salicylic acid and saccharin would be removed with the vanillin thus leaving no coumarin where it would be expected. This disagreement between qualitative and quantitative results would indicate salicylate-forming compounds, the identity of which would have to be determined by further work. Dean's modification simplifies the original method in that the fusion is not complicated by the presence of vanillin and other organic matter. Such matter may cause a destruction of the salicylates if sufficient alkali has not been added.

When a vanilla extract is extracted with ether a certain amount of coloring matter always accompanies the vanillin. In the case of an alcoholic extract this is always more than if it had been dealcoholized. However, the amount of coloring matter is greatly reduced in either case if the solution is alkaline. Dean recommends using a dealcoholized extract, preferably the residue from an alcohol distillation. Experiments by the writer have shown, however, that it is not necessary to dealcoholize before testing for coumarin. Certain further simplifications have been introduced and attention is called to the peculiar color changes that coumarin undergoes when heated with concentrated potassium hydroxide. These are interesting and characteristic and furnish the first indication of the presence of coumarin. The method is as follows:

Ten cc. of extract are made alkaline with 10 per cent sodium hydroxide, then diluted with 15 cc. of water to reduce the alcoholic strength and extracted with 20 cc. of ether in a separatory funnel. The ether solution will be slightly colored when the brown lower layer has been drawn off. A few cc. of strong alcoholic potassium hydroxide solution are added, the mixture shaken and then washed with 10 cc. of water. The ether layer will then be found to be white. This procedure removes all organic acids, vanillin, coloring matter or saccharin that might be present. One cc. of 50 per cent potassium hydroxide solution is placed in a test tube and the ether solution of coumarin poured over it. After thoroughly shaking, the ether is hastily evaporated. The tube is then placed over a free flame, the water evaporated and the potassium hydroxide fused. If coumarin is present in any amount a change of color will be noticed as the evaporation of the water proceeds and fusion begins. Even very small quantities of coumarin in strong, hot potassium hydroxide solution will show a greenish yellow color that suddenly disappears as the heating is continued. The disappearance of the color shows that the coumarin has been converted into the salicylate and heating should be discontinued. The melt is taken up with a few cc. of water, the solution acidified with sulfuric acid and extracted in a small separatory funnel with 5 to 10 cc. of benzene. Benzene is preferred to any other solvent because of its low density, low solvent power for mineral acids, and because it will not dissolve any protocatechuic acid formed from vanillin that might possibly have been carried over with the ether. The acid solution is removed from the separatory funnel and the benzene washed with a few cc. of water. After washing, the benzene is filtered into a test tube and tested for salicylic acid with a cc. or two of water containing a few drops of ferric chloride solution. If no color develops on shaking, one or two drops of $N/10$ sodium hydroxide should be added to neutralize any trace of mineral acid that may be present and which prevents the development of the purple color.

This test can be conducted easily in 15 min., takes only 10 cc. of extract, and does not require dealcoholization or any complicated apparatus. The only evaporation necessary, that of the ether, can be done on a steam bath without appreciable loss of coumarin. The change of color on fusion indicates its own end-point and gives, together with the purple salicylate color, a double test for coumarin. Coumarin is changed to salts of coumaric acid by hot concentrated potassium hydroxide. The development of the yellow color shows this phase and the sudden disappearance of the color indicates the conversion into a colorless salicylate. The delicacy is unquestionably great since the writer has obtained a very decided purple color with 10 cc. of extract containing only 0.005 per cent of coumarin. This modified method is considered simpler than the original and can be conducted in a shorter time.

This qualitative test has not been made quantitative. The results obtained so far by fusing pure coumarin with potassium hydroxide in test tubes, extracting the salicylic acid and matching the color developed against standard solutions, have been from 2 to 15 per cent too low. This is probably due to a slight volatilization of coumarin before the alkali can attack and hold it. However, results by a gravimetric method, to be described later, have been so satisfactory as to accuracy, speed and ability to determine small quantities that a colorimetric method is hardly necessary.

The Hess-Prescott method directs that the extract be dealcoholized before the vanillin and coumarin are extracted. The vanillin is then removed from the ether by a number of extractions with 2 per cent ammonia, the coumarin remaining in the ether. Unpublished results of the writer indicate that it is possible to titrate vanillin in non-aqueous solutions with alcoholic sodium ethylate or potash. The sodium-vanillin salt can then be removed from the solvent by washing with water. Coumarin is not affected by the vanillin titration. Therefore, it remains in the solvent and, after the vanillin salt has been washed out, can be determined by evaporation,

[1] THIS JOURNAL, 7 (1915), 519.

drying and weighing. Excess alcoholic alkali can be used without affecting the coumarin results if it is not desired to determine the vanillin volumetrically.

It has been found that benzene, chloroform and ether are the best solvents for extracting vanillin and coumarin from either aqueous or alcoholic solutions. Forty cc. of chloroform, 100 cc. of benzene and 60 cc. of ether in four or five extractions will extract quantitatively large amounts of vanillin from water and alcohol solutions up to 25 per cent strength. Since a half aliquot is usually taken for analysis this corresponds to 50 per cent alcohol in the extract which is probably more than the average commercial extract contains. Benzene, chloroform and ether all extract acids and coloring matter from vanillin extracts treated with lead acetate, ether extracting by far the most. Hence ether cannot be used if the vanillin is to be determined by titration, because the acetic acid it extracts at the same time cannot be removed by washing. Benzene or chloroform can be used for such purposes. There is, therefore, a possibility of combining a volumetric vanillin with a gravimetric coumarin determination in such cases where the qualitative test shows the presence of the latter. The details of a volumetric vanillin determination will be published later. However, if results for coumarin only are desired, it is recommended that ether be used as the extracting solvent as it has decided advantages in such cases. It evaporates more quickly and the extractions and washings are speedier because ether and water can be separated faster than water and chloroform or water and benzene. While ether extracts considerably more coloring matter and acid than benzene or chloroform from vanilla solutions, these impurities are neutralized by the alkali and removed with the vanillin in the subsequent washing with water. A water-white solution of coumarin in ether remains. The ether can be evaporated and the coumarin dried and weighed. No dealcoholization is necessary and the results can be obtained speedily. It is not recommended in quantitative work to extract the coumarin from alkaline vanilla solutions as in the qualitative method, because emulsions are liable to form, and coloring matter must be removed anyhow. In many cases where speed is desirable it would be advantageous to determine coumarin in one portion and the vanillin by colorimetric or other methods in another.

To show the results that can be obtained by the above method the following data are submitted:

To 50 cc. of vanilla extract various quantities of coumarin were added, the vanilla solutions then treated with lead acetate without dealcoholization, made up to 100 cc., filtered, and the excess lead precipitated with dry potassium oxalate. The removal of the lead facilitates extraction because it reduces emulsion formation. Fifty cc. of the solutions thus prepared were extracted with ether, benzene or chloroform, as indicated in the table, a few drops of phenolphthalein solution and excess alcoholic alkali added and the vanillin salt removed by washing with several 10 cc. portions of water. The disappearance of the red phenolphthalein color in the wash water is an indication of sufficient washing. The washed solutions containing the coumarin were evaporated and the coumarin dried and weighed. The results are given in Table I.

TABLE I

Coumarin added Mg.	Extracting solvent	Quantity of extracting solvent Cc.	Number of extractions	Coumarin recovered Mg.	Coumarin recovered Per cent
25.0	Benzene	100	5	24.5	98.0
24.5	Benzene	100	5	24.0	97.9
24.5	Chloroform	40	4	24.0	97.9
25.0	Chloroform	40	4	25.2	100.4
25.0	Ether	80	4	25.2	100.4
25.0	Ether	80	4	24.8	99.2
5.0	Ether	80	4	4.8	96.0
10.0	Ether	80	4	10.2	102.0
15.0	Ether	80	4	15.0	100.0
25.0	Ether	80	4	24.5	98.0
50.0	Ether	80	4	49.3	98.6

The results shown in the table indicate that an accurate quantitative determination of coumarin can be made by the method outlined above. Quicker methods for lead number and vanillin, to correspond with the coumarin method, are in preparation.

SUMMARY

A simple and quick modification of the original method for the detection of coumarin in factitious vanilla extracts has been developed. While quantitative results based on the qualitative method are too low, another method has been given which is shown to be both quick and accurate for the determination of coumarin.

U. S. DEPARTMENT OF AGRICULTURE
FOOD AND DRUG INSPECTION LABORATORY
DENVER, COLORADO

THE DETERMINATION OF ESSENTIAL OILS IN NON-ALCOHOLIC FLAVORING EXTRACTS

By FRANK M. BOYLES

Received March 28, 1918

There has been appearing for some years on the American market, in increasing numbers, a variety of so-called non-alcoholic flavoring extracts which consist essentially of an emulsion of the respective essential oils in mucilage of acacia, tragacanth, karaya, or other gums. Glycerin is quite often present.

In making a survey of these products, the writer tried first the method suggested by Redfern[1] which was found to be quite unsatisfactory; first, because the procedure of precipitating the gum from 25 cc. of the sample with 25 cc. of 95 per cent alcohol and filtering through a Gooch into a 100 cc. flask and making up to the mark was too tedious and time-consuming; and second, because the writer did not in this case, and never has been able to obtain concordant results by the method of Howard[2] to which Redfern refers. Indeed this method is even less adaptable to the non-alcoholic extracts than to the ordinary alcoholic extracts, for the reason that the former contain, in a number of cases, as much as four times more oil than the strictly standard alcoholic extracts and there is always danger, if not certainty, of losing oil through volatilization when from 10 to 20 per cent is present.

Taking advantage of the fact that many gums are precipitated by lead subacetate, the following procedure was tried: 5 cc. of the emulsion were diluted with 20 cc. water and transferred to a Babcock milk

[1] THIS JOURNAL, **8** (1916), 421.
[2] *J. Am. Chem. Soc.*, **30** (1908), 608.

bottle and the gum precipitated by lead subacetate and centrifuged. The precipitated gum came to the top and the volume of oil could not be read. This was then modified by adding chloroform to absorb the oil after precipitation of the gum. On centrifuging this mixture the gum precipitate settled to the bottom of the bottle with the chloroform, and upon decanting the supernatant liquid, adding ether, and heating to expel the chloroform as recommended by Howard and then diluting with water and centrifuging, the gum precipitate came to the top with the oil and again interfered with the reading of the volume of the oil.

Finally the following method which consists simply of making an alcoholic extract from the emulsion and proceeding according to the official method[1] was found to give satisfactory and concordant results for the lemon and orange extracts.

METHOD

Measure 10 cc. of the emulsion into a graduated cylinder, transfer as much as possible to a 50 cc. flask, rinse the cylinder with 10 cc. portions of 95 per cent alcohol, and with the aid of a glass rod transfer all of the emulsion and precipitated gum to the flask, fill to the mark, shake thoroughly, let stand about 30 min. Filter through a folded filter and determine the oil in a 20 cc. portion of the filtrate by the official method.[1] The per cent of oil found in the filtrate is multiplied by 5 to give the per cent of oil in the original emulsion.

The gum is completely precipitated and it is more expeditious to throw down the gum in the volumetric flask and to make up to volume and use an aliquot of the filtrate than to precipitate the gum and attempt to wash the oil from it into the flask. It is possible to pipette the aliquot directly from the flask, but as the precipitated gum gathers at the shoulder of the flask and frequently stops the outlet of the pipette this procedure offers little advantage over filtering, as it is not necessary to avoid transferring the gum to the filter.

In the case of extracts containing less than 5 per cent oil it is necessary to use more sample than specified in the directions given.

Non-alcoholic extracts of lemon and orange containing 10 per cent of the respective oils were prepared according to the formula

Essential oil	20 cc.
Tragacanth	3 g
Glycerin	40 cc
Water, q. s.	200 cc

The results obtained on these extracts are given in Table I. Results obtained on commercial non-alcoholic extracts are also given.

TABLE I

	Prepared Extracts Strength Per cent	Prepared Extracts Oil Found Per cent	Commercial Extracts Oil Found Per cent
Orange	10	10	7.0
Orange	10	10	17.0
Orange	10	9.7	15.0
Lemon	10	10	6.2
Lemon	10	10	14.0
Lemon	10	9.8	6.8
Lemon	10	10	7.5
Lemon			19.0
Lemon			17.0
Lemon			19.8
Lemon			20.0

Contrary to Redfern's statement it was found that quite accurate results could be obtained by ordinary steam distillation.

It is necessary first to run blank experiments on pure oils to determine just what percentage of recovery can be accomplished with the particular apparatus at hand.

Using a 200 cc. side-neck distilling flask with outlet tube midway of the neck and a cassia flask as receiver, the writer has consistently recovered 95 per cent of lemon and orange oils when proceeding as follows:

Measure 10 cc. of the extract into a graduated cylinder and transfer it by means of about 35 cc. water to a side-neck distilling flask and distil with steam into a 100 cc. cassia flask. In the case of lemon and orange oils 95 per cent of the oil is recovered so that the amount found must be multiplied by 100 and divided by 95.

Table II gives the results obtained by steam distillation on the 10 per cent extracts described above.

TABLE II

	Strength Per cent	Oil Found Per cent
Lemon	10	10.0
Lemon	10	9.5
Lemon	10	9.7
Orange	10	10.0
Orange	10	10.0
Orange	10	9.5

For cassia, cinnamon, and clove extracts, the following modification of the official method[1] is successful.

Dilute 10 cc. of the sample with 95 per cent alcohol to 50 cc. as in the case of lemon and orange. Filter. Place 10 cc. of the filtrate in a separatory funnel containing 50 cc. water, add 1 cc. HCl (1 : 1), and shake out 4 times with 25 cc. portions of ether. Wash the combined ether extracts twice with water and then shake for a few minutes with about 5 g. granular calcium chloride

Place a small piece of cotton in the outlet of the separatory funnel and draw the ether into a tared beaker. Evaporate the ether on a boiling water bath, place in desiccator for 3 min. and weigh; divide the weight by the specific gravity of the oil to find the per cent of oil by volume.

Table III gives the results on cassia, cinnamon and clove extracts containing 10 per cent of the respective oils and prepared according to the formula given under lemon and orange. Results on commercial extracts are also given.

TABLE III

	Prepared Extracts Strength Per cent	Prepared Extracts Found Per cent	Commercial Extracts Found Per cent
Cassia	10	9.83	13.5
Cassia	10	9.90	12.4
Cassia	10	9.94	
Cinnamon	10	9.90	17.5
Cinnamon	10	9.96	
Cinnamon	10	9.90	
Clove	10	10.0	
Clove	10	9.89	
Clove	10	9.95	

Almond, anise, and nutmeg extracts of the non-alcoholic type are converted into alcoholic extracts as in the case of lemon and orange and an aliquot portion analyzed by the official methods.[2]

PEPPERMINT EXTRACT

A standard extract was made up containing 10 per cent peppermint oil by the formula given under lemon and orange. 10 cc. of this were made up to

[1] "Report of Com. on Methods of Analysis," *J. A. O. A. C.* p. 267

[2] *Ibid.* pp. 266 and 269

50 cc. with 95 per cent alcohol, filtered, and an attempt made to assay the filtrate by the official method[1] with the following results. These results are calculated to the original extract.

1—Following the method as given, 2 per cent of oils found.

2—Heating was carried on for only 1 min. (shaking at 15 sec. intervals), 8 per cent oil found.

3—Heating was continued for only 45 sec., 8 per cent oil found.

4—Heating was continued for only 20 sec., 11 per cent oil found.

5—Heating was continued for 25 sec., 8 per cent oil found.

6—Heating was continued for 20 sec. and then the suction was continued for an additional 15 sec. without heat, 9 per cent oil found.

7—Heating was continued for 20 sec. and the suction for an additional 10 sec. without heat, 9 per cent oil found.

The writer's experience with this method has been most unsatisfactory, even moderate agreement in duplicate determinations has never been attained. The method leaves too much to chance. If the flask is not disconnected from the suction the instant the last of the solvent is drawn off, there is a loss of oil, and we have not been able to discover any means whereby we can be assured when this instant is at hand.

Steam distillation gives very good results for peppermint if one determines beforehand what per cent of oil can be recovered with the apparatus in blank experiments using known quantities of pure oil. The writer has found this recovery to be 90 per cent, so that the quantity of oil found is multiplied by 100 and divided by 90 to find the amount present in the extract.

Proceeding according to the directions given for lemon and orange extracts for steam distillation the following results were obtained on a 10 per cent non-alcoholic extract and on commercial extracts.

TABLE IV

	Prepared Extracts Strength Per cent	Found Per cent	Commercial Extracts Found Per cent
Peppermint	10	10	11.0
Peppermint	10	9.8	12.8
Peppermint	10	10	7.2

CHEMICAL LABORATORIES
MCCORMICK AND COMPANY
BALTIMORE, MARYLAND

A CONTRIBUTION TO THE COMPOSITION OF LIME-SULFUR SOLUTIONS[2]

By O. B. WINTER

Received April 19, 1918

The principal constituents of lime-sulfur solutions are calcium polysulfides and calcium thiosulfate. Small amounts of calcium sulfate and possibly of calcium sulfite are also present, and the claim has been made that the solutions may contain other compounds such as hydrogen sulfide, calcium hydrosulfide, calcium hydroxyhydrosulfide, different calcium oxysulfides, free lime, and free sulfur. How much of each of these compounds is liable to be present? It is the purpose of this paper to discuss some of the work done in this laboratory which pertains to the above question.

HYDROGEN SULFIDE, H_2S. CALCIUM HYDROSULFIDE, $Ca(SH)_2$. CALCIUM HYDROXYHYDROSULFIDE, CaSHOH

In reviewing the literature on the composition of lime-sulfur spray, it is interesting to note the discussions on the theoretical composition of the solution, together with the absence (except in a few articles) of even an attempt to prove the existence of certain of the compounds discussed. Divers and Shimidzu[1] give detailed methods for preparing some of the above-mentioned compounds and state some of their properties, but their work has nothing whatever to do with an ordinary lime-sulfur solution. Roark[2] discusses the possible existence of these compounds in a lime-sulfur solution, but does not give experimental proof of their presence. Tartar and Bradley[3] conclude that they are not present in appreciable amounts. Thompson and Whittier[4] claim the presence of hydrosulfide sulfur and give experimental data which they believe justifies their claim. Green[5] says, "We have, however, never been able to detect definitely the presence of hydrosulfide or free sulfuretted hydrogen in lime-sulfur solutions."

It may be possible to prepare a lime-sulfur solution which contains hydrogen sulfide, calcium hydrosulfide, or calcium hydroxyhydrosulfide, but it has yet to be shown conclusively that any of these compounds are present in appreciable quantities in a "straight"[6] lime-sulfur solution either as a result of the preparation of the solution, or of hydrolysis or other action taking place during storage under normal conditions.

It is also interesting to note that writers seem to have different opinions regarding the chemical actions which take place in lime-sulfur solutions, and for this reason literature is quite confusing in regard to the formation of any of the above-mentioned compounds. For example, the action of water on a polysulfide is represented as follows by different chemists:

Divers and Shimidzu:[7]

$$CaS_5 + 2H_2O = Ca(SH)(OH) + 3S + H_2S + O$$
$$Ca(SH)(OH) + 2O_2 + H_2S = CaS_2O_3 + 2H_2O$$

Auld:[8]

$$CaS_x + 2H_2O = Ca(OH)_2 + H_2S_x$$
$$H_2S_x = H_2S + (x - 1)S$$

Roark:[7]

$$2CaS_x + 2H_2O = Ca(SH)_2 + Ca(OH)_2 + 2S_x$$

[1] "Report of Com. on Methods of Analysis," *J. A. O. A. C.*, p. 268.

[2] This work was done in the chemical laboratory of the Michigan Agricultural College Experiment Station and the results are published with the permission of the Director.

[1] *J. Chem. Soc.*, **45** (1884), 270–91.

[2] *J. A. O. A C.*, [1] **1** (1915), 81.

[3] THIS JOURNAL, **2** (1910), 271–7.

[4] Delaware Agricultural College Experiment Station, *Bull.* **105** (1914), 8.

[5] Union of S. Africa Dept. of Agr., 3rd and 4th Report of the Director of Vet. Research, **1915**, p. 179.

[6] By a "straight" lime-sulfur solution is meant a solution prepared from ordinary commercial lime and sulfur to which no foreign substance has been added, and which has stood for several days.

[7] *Loc. cit.*

[8] *J. Chem. Soc.*, [1] **107** (1915), 482.

$$Ca(SH)_2 + H_2O = Ca(SH)(OH) + H_2S$$
$$\text{also } CaS_x + 2H_2O = Ca(OH)_2 + H_2S + 4S$$

Averitt[1] Up to a certain dilution no decomposition takes place when freshly boiled distilled water is added to a lime-sulfur solution.

A similar disagreement might be given for many of the other reactions which are supposed to take place in boiling, storing, or diluting a lime-sulfur solution.

Experiments in this laboratory show that any one of the compounds mentioned above (containing the SH radical) may be detected by titrating an aliquot of the solution with standard iodine, determining the end-point by the disappearance of the yellow color, and by titrating an equal aliquot with the same solution determining the end-point with nitroprusside[2] of sodium. When the polysulfide has been entirely decomposed the solution loses the yellow color, while the blue color of the nitroprusside of sodium remains as long as there is any sulfur present either in the form of a sulfide or in the form of any compound containing the (SH) radical. If the two above titrations agree, none of the above-mentioned compounds are present. The following two equations represent the reactions which undoubtedly take place:

$$CaS_x + Ca(SH)_2 + H_2S + I_2 = CaI_2 + Ca(SH)_2 + H_2S + S_x \text{ (Titrated to disappearance of yellow color)}$$

$$CaS_x + Ca(SH)_2 + H_2S + 4I_2 = {}_2CaI_2 + S_{(x+3)} + 4HI \text{ (Titrated with nitroprusside of sodium as indicator)}$$

One might anticipate that the difference between the two titrations would be a measure of the amount of sulfur present other than sulfides, but we have not been able to prove this since the color end-point in the presence of a considerable quantity of a compound containing the (SH) radical does not appear sharp. However, the method is sufficiently accurate to show the presence or absence of any of these compounds.

It might be well to state here that other experiments have shown that when compounds containing the (SH) radical are present in a solution, an aliquot titrated with standard zinc chloride, using nickel sulfate as indicator, is higher than one titrated with standard hydrochloric acid, using methyl orange as indicator. This may be explained by the following equations:

$$CaS_x + Ca(SH)_2 + 3ZnCl_2 = 2CaCl_2 + ZnS_x + 2ZnS + 2HCl$$
$$CaS_x + Ca(SH)_2 + 4HCl = 2CaCl_2 + 3H_2S + S_{x-1}$$

If any of the compounds referred to above are formed in an ordinary lime-sulfur solution, they must be unstable in the presence of other existing compounds, since the two iodine titrations mentioned in a preceding paragraph agree in every "straight" lime-sulfur solution that has been tested in this laboratory, whether prepared with an excess of lime or sulfur, whether freshly boiled or of long standing, and whether concentrated or dilute. Therefore we believe that none of the above-mentioned compounds exist in appreciable quantities in a "straight" lime-sulfur solution; and *vice versa*, if the spray contains any of these compounds, which can easily be detected, it is not a "straight" lime-sulfur solution.

FREE LIME

Roark[1] makes the statement that "While not more than a trace of calcium hydroxide [$Ca(OH)_2$] may be present in a freshly prepared lime-sulfur solution, it is formed in appreciable amounts upon dilution, according to the reaction

$$CaS_x + 2H_2O = Ca(OH)_2 + H_2S + 4S$$

and would be present, therefore, in lime-sulfur solutions which had stood for some time and become partially decomposed." He gives no proof of its actual existence. Thompson and Whittier[2] claim that, "Free calcium hydroxide may occur either from simple solution, where an excess of lime has been used, or it may result from hydrolysis of the polysulfide." They found "free lime present when the ratio of lime to sulfur exceeded a certain definite figure, increasing in amount as this ratio increased until the limit of the solubility of calcium hydroxide was reached." They say nothing about how long the solutions in which they found free lime had stood before making the analyses, and show no data to prove the statement that "free lime may result from the hydrolysis of the polysulfide." Tartar and Bradley[3] reported that no free lime or only a trace was found by them in lime-sulfur solutions. They say, "It appears that if there is hydroxide in the freshly prepared solution it either unites with some of the sulfur already in combination to form more polysulfide, or it unites directly with the polysulfide to form oxysulfides which crystallize out of the more concentrated solutions." Chapin[4] says, "If originally made with an excess of lime or if not boiled long enough, excess of lime is at first present in solution, but if such a preparation be allowed to stand quietly and cool off in the cooking vat, the indications are that the undissolved lime soon settles down, while the small amount of dissolved lime rapidly reacts with polysulfide according to equation

$$10CaS_x + 3Ca(OH)_2 = 12CaS_{x-1} + CaS_2O_3 + 3H_2O$$

so that in this case also, unless the cooled solution is again stirred up with the sediment, a plus reaction figure can never be present in the end" In other words, no free lime can be present. Green[5] claims

[1] J. Ind. Eng. Chem., 1 (1909), 760.

[2] In titrating with nitroprusside of sodium as an indicator for sulfur compounds it is essential that the indicator should not be added until the end point is practically reached, since if the blue color is well developed it is almost impossible to change back to a colorless solution. If necessary, a few extra samples should be titrated, and those with the persisting color discarded.

[1] Delaware Agricultural College Expt. Sta. *Bul.* **105** (1914), 11.

[2] This Journal, **2** (1910), 273.

[3] U. S. Dept. of Agr. *Bur.* **451** (1916), 13.

[4] Union of S. Africa Dept. of Agr., 3rd and 4th Report of the Director of Vet. Research, **1915**, p. 180.

that a trace of free lime is usually present but that the amount is very small.

In view of the above apparent differences of opinion, an attempt was made to prove either the presence or absence of free lime in an ordinary lime-sulfur solution.

Two different methods have been used by analysts for determining the amount of free lime in a lime-sulfur solution. The one (Method I)[1] is by titrating with 0.1 *N* hydrochloric acid, using methyl orange as indicator, and with 0.1 *N* ammoniacal zinc chloride solution using nickel sulfate as an outside indicator. In this method, the hydrochloric acid titration indicates the lime combined with sulfur as polysulfides plus the free lime, while the zinc chloride titration indicates only the former. The difference between the two titrations is a measure of the free lime. The other (Method II)[2] is by removing the free lime as calcium sulfate by means of magnesium sulfate solution (the magnesium being precipitated as magnesium hydroxide and filtered out). The solution is titrated with standard acid before and after the removal of the free lime. The difference between the two acid titrations is held by the authors to be a measure of the free lime. The results recorded in Table I were obtained by these two methods on 10 cc. of lime-sulfur concentrates diluted to 200 cc., of which 10 cc. were taken for analysis:

TABLE I

	Method I			Method II		
				0.1 *N* HCl		
SAMPLE No.	0.1 *N* HCl Cc.	0.1 *N* $ZnCl_2$ Cc.	CaO G.	Before adding $MgSO_4$ Cc.	After adding $MgSO_4$ Cc.	CaO G.
A	8.60	8.65	0.0000	8.60	8.60	0.0000
B	8.40	8.40	0.0000	8.40	8.35	0.0001
C	40.35	40.25	0.0003	40.35	37.90	0.0069
D	12.65	12.65	0.0000	12.65	11.90	0.0021
E	18.38	18.40	0.0000	18.38	18.30	0.0002
F	17.98	17.96	0.0000	17.98	17.65	0.0009
G	17.43	17.48	0.0000	17.43	17.00	0.0012
H	12.80	12.82	0.0000	12.80	12.08	0.0020
I	23.43	23.00	0.0012	23.43	22.20	0.0034
J	23.26	23.20	0.0002	23.26	21.85	0.0039
K	10.80	8.70	0.0059	10.80	8.20	0.0092
L	8.40	8.40	0.0000	8.40	8.00	0.0011

In explanation of the above table, it may be well to state that Samples A and B were prepared in the laboratory using an excess of sulfur and were analyzed soon after their preparation. Samples C to H, inclusive, were commercial concentrates which had stood in the laboratory from one to ten years, of which some had previously been opened for analysis and a large amount of oxidation products had formed. Sample I was prepared in the laboratory using an excess of lime and analyzed immediately after its preparation. Sample J was the same as Sample I, except that the analysis was made two days after its preparation. Sample K was the same as Sample A, except that 0.0062 g. of calcium oxide had been added in the form of lime water in diluting to 200 cc. Sample L was the same as Sample A after it had been standing, exposed to the air, for several hours, and oxidation had begun. From a study of this table it will be noted: (1) That neither of the two methods show an appreciable amount of free lime in Samples A and B, which were freshly prepared from materials containing an excess of sulfur. (2) That Method I shows no free lime or only a trace in the commercial concentrates which had stood from one to ten years, some of which had undergone considerable oxidation, whereas Method II shows its presence in all of these samples. (3) That both methods show free lime in Sample I, which had been recently prepared from materials containing an excess of lime, but that Method II shows the larger amount. (4) That Method I shows very little free lime in Sample J (Sample I after standing two days), whereas Method II shows more than when first prepared. (5) That when a given amount of free lime was added to a sample in which neither method indicated its presence, making Sample K, Method I shows nearly all that was added, while Method II shows slightly more than the amount added. (6) That while Method I shows no free lime in Sample L (Sample A after having been exposed to the air for several hours and oxidation had begun), Method II shows its presence.

From the above data it is evident that the two methods do not agree. Which is correct? When we consider the known facts that hydrochloric acid reacts with calcium polysulfides and calcium hydroxide as follows:

$$CaS_x + 2HCl = CaCl_2 + H_2S + S_{(x-1)}$$
$$Ca(OH)_2 + 2HCl = CaCl_2 + 2H_2O;$$

that ammoniacal zinc chloride reacts with calcium polysulfide according to the equation

$$CaS_x + ZnCl_2 = ZnS_x + CaCl_2;$$

and that in the presence of ammonium chloride, ammoniacal zinc chloride does not react with calcium hydroxide, it seems impossible that titrations made with hydrochloric acid and zinc chloride could agree in the presence of free lime. Further, when free lime was added to a lime-sulfur solution, it was practically all accounted for by the difference between the above-mentioned titrations immediately after the addition. Therefore the author contends that Method I is accurate for determining free lime in a lime-sulfur solution.

Since Method I, as given above, has been noted in literature and has been shown to be accurate, it seemed worth while to investigate Method II more thoroughly. Concerning this method Thompson and Whittier[1] state that when magnesium sulfate is added to a lime-sulfur solution containing free calcium hydroxide, magnesium hydroxide is precipitated quantitatively and calcium sulfate formed, thus neutralizing the solution and affording a method for determining the free lime. From other sources in literature, it is well known that magnesium hydroxide is precipitated when a solution of calcium hydroxide is treated with magnesium sulfate. However, this reaction is hardly considered sufficiently complete for quantitative determinations, and too, magnesium[2] salts react with sulfides, as follows:

[1] THIS JOURNAL, **2** (1910), 273.

[2] Delaware Agricultural College Expt. Sta., *Bull.* **105** (1914), 11

[1] Delaware Agricultural College Expt. Sta., *Bull.* **105** (1914), 11.

[2] Prescott and Johnson, "Qual. Chem. Anal.," 6th Ed. (1904), p. 215.

$$MgSO_4 + 2Na_2S + 2H_2O = Mg(OH)_2 + Na_2SO_4 + 2NaSH$$

Divers and Shimidzu, in an article on "Magnesium Hydrosulfide Solution and Its Use in Chemico-Legal Cases as a Source of Hydrogen Sulfide,"[1] state that, "The poly(-penta)sulfide that may be in solution is only very slightly decomposed even at boiling heat," thus indicating that the polysulfide of magnesium is a stable compound. Therefore, it appears possible that when a lime-sulfur solution is treated with magnesium sulfate, chemical action may take place even if there is no free lime present.

In order to throw more light on the above question, the precipitate which came down on adding magnesium sulfate was tested for the presence of sulfur, and was found to contain a small amount. This would indicate that the magnesium sulfate acted on some sulfur compound. However, the precipitate was amorphous and it seemed possible that some of the lime-sulfur solution might have been occluded. Therefore the test was not considered conclusive. The samples of concentrates which formed a precipitate with magnesium sulfate were diluted for analyses, with and without the addition of magnesium sulfate. Some of these were titrated for monosulfide and thiosulfate sulfur with standard iodine solution determining the end-point by disappearance of color and also by the use of nitroprusside of sodium. The following results were obtained:

TABLE II

	I for Monosulfide					I for Thiosulfate	
	—With $MgSO_4$—		—Without $MgSO_4$—			After	After
	Colorless Solution	Sodium Nitroprusside	Colorless Solution	Sodium Nitroprusside		Titrating Column 3	Titrating Column 5
Soln. No.	Cc.	Cc.	Cc.	Cc.	Ppt.	Cc.	Cc.
1...	8.14	8.32	8.50	8.52	Very little	7.05	7.05
						7.05	Lost
2...	25.60	26.35	27.63	27.63	Much	...	....

These data show that when magnesium sulfate are added to lime-sulfur solutions, some compound is formed which causes a blue color with nitroprusside of sodium after the polysulfides have been decomposed and the solution has become colorless; and that the thiosulfate content remains the same. Since the solution is colorless but reacts with nitroprusside of sodium, it apparently contains a compound having the (SH) radical, *e.* g., hydrogen sulfide, calcium hydrosulfide, calcium hydroxyhydrosulfide, or the corresponding salts of magnesium.

Others of the prepared solutions were titrated with hydrochloric acid and with zinc chloride, and the following results were obtained:

TABLE III

	With $MgSO_4$		Without $MgSO_4$	
	0.1 *N* HCl	0.1 *N* $ZnCl_2$	0.1 *N* HCl	0.1 *N* $ZnCl_2$
Soln. No.	Cc.	Cc.	Cc.	Cc.
D.....	11.90	12.12	12.65	12.65
E.....	18.30	18.40	18.38	18.40
F.....	17.65	17.70	17.98	17.96
G.....	17.00	17.20	17.43	17.48
H.....	12.08	12.40	12.80	12.82

These data show that the titration of the treated sample with standard hydrochloric acid is lower than that of the untreated. This indicates the loss of some calcium compound. It also shows that the titration of the treated sample with ammoniacal zinc chloride is slightly higher than with hydrochloric acid. This also is significant. It indicates the formation of some new compound, and this compound must contain the (SH) radical.

The 10 cc. aliquots of a lime-sulfur solution which indicated no free lime by Method II were placed in each of two 100 cc. graduated flasks. One of these (*a*) was diluted to the mark with freshly boiled distilled water, and to the other (*b*) was added a large excess of 10 per cent magnesium sulfate solution and then also diluted to the mark with freshly boiled distilled water. Both solutions were allowed to stand about 12 hrs. The former remained perfectly clear, as was anticipated; the latter also remained clear for several minutes, then gradually became cloudy and by the end of the 12 hrs. a large number of crystals had formed, which, on examination, under a polarizing microscope, were readily identified as calcium sulfate ($CaSO_4.2H_2O$). These solutions were then analyzed and the following results were obtained:

TABLE IV

Sample	Mono-S Gram	$M(SH)_2$-S Gram	Thio-S Gram	Sulfide-S Gram	CaO Gram
a.....	0.0302	0.0000	0.0330	0.1505	0.0813
b.....	0.0279	0.0012	0.0333	0.1377	0.0154

In the above table the samples were titrated with iodine to the end-point determined by disappearance of color and also to the end-point determined by nitroprusside of sodium, and the difference between these two titrations was considered as sulfur in the form of compounds containing the (SH) radical and is indicated as $M(SH)_2$-S. The results in this table show that there was a slight loss in the monosulfide equivalent and in the polysulfide sulfur; that the thiosulfate sulfur remained practically the same; that a small amount of some compound containing the (SH) radical was formed; and that there was a loss of about 81 per cent of the lime. In other words, they show that a large amount of calcium had disappeared while the loss in the monosulfide equivalent, thiosulfate, and sulfide sulfur were comparatively small. A microscopic examination showed conclusively that calcium sulfate was precipitated from the solutions. Now the following calculations may be made:

$0.0333 \times \frac{56}{64}$ = 0.0291 g. CaO necessary to combine with 0.0333 g. S in Thio-S

$0.0279 \times \frac{56}{32}$ = 0.0488 g. CaO necessary to combine with 0.0279 g. S in Mono-S

TOTAL.. 0.0779 g. CaO

From these it will be seen that there should be 0.0779 g. of CaO in the solution, while there are only 0.0154 g. by actual determination. Evidently magnesium has replaced some of the calcium, and the solution now also contains magnesium polysulfide and a small quantity of some compound containing the (SH) radical. These compounds were not present in the original solution and must have been formed by the addition of the magnesium sulfate. It will also be seen that the length of time the solution is allowed to stand and the quantity of magnesium sulfate present are important factors in this reaction. And it appears that the lower polysulfides, or possibly the oxy-

[1] *J. Chem. Soc.*, **45** (1884), 699.

sulfides of calcium are acted on more readily than the higher polysulfides, since solutions prepared by using an excess of lime in which lower polysulfides and possibly oxysulfides are present, react more quickly and with a less concentrated solution of magnesium sulfate than do those in which an excess of sulfur is used and only the higher polysulfides are present. From these data as well as those in Tables I, II and III, we must conclude that magnesium sulfate reacts with some compound in a lime-sulfur solution other than free lime, and in some solutions, at least, this compound is calcium polysulfide. Therefore Method II cannot be considered accurate for determining free lime in a lime-sulfur solution.

Having presented evidence which we believe is sufficient to show that Method I is an accurate measure of the free lime in a lime-sulfur solution, and that Method II cannot be considered accurate for this work, a few more solutions were prepared using different proportions of lime and sulfur, and a few more concentrates were diluted with lime water. These were analyzed by the former method, some immediately and some after standing several days. The results, together with explanatory remarks, are found in Table V:

TABLE V

Sample No.	N/10 HCl Cc.	N/10 $ZnCl_2$ Cc.	CaO Gram	Remarks
1....	20.17	20.17	0.0000	S : CaO = 3 : 1. Analyzed immediately after boiling
2....	20.15	20.15	0.0000	Same as 1 after standing well stoppered for three days
3....	29.90	29.50	0.0011	S : CaO = 1 : 1. Analyzed immediately after boiling
4....	30.00	30.00	0.0000	Same as 3 after standing well stoppered for three days
5....	10.80	8.70	0.0059	Sample K in Table I
6....	10.10	8.50	0.0045	Same as 5 after standing well stoppered for three days
7....	27.95	24.29	0.0103	Commercial concentrate diluted with lime water (0.0106 g. CaO)
8....	3.97	3.95	0.0000	Same as 7 after standing exposed to air for fourteen days

The results in Table V, similar to those in Table I, are in accord with the contention that free lime is present in a freshly boiled lime-sulfur solution prepared by using an excess of lime, but they are contrary to the contention that free lime will remain in such a solution or that it is formed by hydrolysis. The only conclusions that can be drawn from the two tables are that the small amount of free lime which may be present immediately after preparing a lime-sulfur solution, gradually disappears on standing, and that immediately after adding free lime to a lime-sulfur solution nearly all the lime exists in the free state, but that chemical action takes place slowly, and after some time all the free lime has entered into chemical combination. Therefore, the inference is that the ordinary commercial lime-sulfur solution, either concentrated or dilute, does not contain an appreciable amount of free lime.

FREE SULFUR

Thompson and Whittier[1] show that the residue which separates from a lime-sulfur solution prepared with an excess of sulfur in an atmosphere of nitrogen, filtered while hot and kept in a completely filled, tightly stoppered receptacle, is mainly free sulfur. Auld[1] mentions the fact that when a lime-sulfur solution was prepared in an atmosphere of nitrogen and an excess of sulfur was used, a polysulfide was formed which analyzed to be the pentasulfide or slightly higher, and that on standing free sulfur separated out. He believes that sulfur may exist as free sulfur in solution. Harris[2] prepared the pentasulfide by simply using a reflux condenser, and free sulfur crystals were found by the author in some of his solutions after they had stood several years. Tartar and Bradley[3] succeeded in extracting free sulfur from a lime-sulfur solution and found that the quantity extracted gradually decreased with the increase of the time of extraction, but found no definite end-point. Ramsey[4] contends that the so-called polysulfide sulfur is loosely combined and that free sulfur exists in the solution. Green[5] says, "We regard our data as effectually disposing of the contentions both of Auld and Ramsey in regard to loosely attached sulfur, and sulfur in solution." He believes that the polysulfide sulfur is firmly combined and that there is no free sulfur in solution. Thompson and Whittier conclude from their work that no sulfide lower than the pentasulfide is formed and that free sulfur is held in solution.

During the progress of this investigation samples were prepared with and without the use of a reflux condenser, using an excess of sulfur. Those with the condenser approximated the pentasulfide, while those without were lower. In both cases, when the solutions were filtered while hot into flasks which were completely filled and well stoppered and the solutions allowed to cool, crystals which proved to be free sulfur separated out. Even when allowed to cool before filtering and then kept as mentioned above, free sulfur separated out of the more concentrated solutions.

Table VI gives the results of complete analyses on a solution prepared from materials containing an excess of sulfur and kept the lengths of time indicated. The analyses were made on 10 cc. aliquots of the diluted concentrate.

TABLE VI

Soln. No.	Time of standing	Sulfur Crystals	Mono-S Gram	Thio-S Gram	S-S Gram	Total-S Gram	Total CaO Gram	Ratio S-S : Mono-S
1 A(a)..	Still warm	None	0.0441	0.0430	0.2153	0.2620	0.1188	1 : 4.88
1 B.....	12 hrs.	Few	0.0445	0.0492	0.2148	0.2639	0.1212	1 : 4.83
1 C.....	32 days	Many	0.0444	0.0496	0.2110	0.2606	0.1211	1 : 4.76

(a) This solution was less concentrated than the other two because it had not cooled.

This table shows a loss in sulfur from the solution, and the loss lies in the polysulfide sulfur. The fact that before the deposition of the sulfur, the ratio of the sulfide sulfur to the monosulfide sulfur was less than 5, and that as more sulfur was deposited this ratio was lowered, makes it appear that the free sulfur deposited in these solutions probably came from the breaking down of the higher polysulfides and not from free sulfur in solution. However, whether this ex-

[1] Delaware Agricultural College Expt. Sta., *Bull.* **105** (1914), 20.

[1] *J. Chem. Soc.*, **107** (1915), 484.

[2] Mich. Agr. Col. Exp. Sta., *Tech. Bull.* **6** (1911), 10.

[3] THIS JOURNAL, **2** (1910), 274.

[4] *J. Agr. Sci.*, [2] **6** (1914), 194–201.

[5] Union of S. Africa Dept. of Agr., 3rd and 4th Report of the Director of Vet. Research, **1915**, p. 192.

planation is satisfactory or not, apparently makes little difference, since free sulfur in such a solution would undoubtedly have properties similar to those of sulfur loosely combined, as in the case of the higher polysulfides.

OXYSULFIDES OF CALCIUM

Most lime-sulfur investigators agree that when lime and sulfur are boiled in water, with the lime in excess of the ratio 1 : 2.28, and the solution is allowed to stand in a closed vessel, certain oxysulfides of calcium separate out. However, they do not agree exactly as to the constitution of these compounds. It has been suggested that they are not ordinary oxysulfides[1] as carbon oxysulfide COS, uranium oxysulfide U_2O_2S, manganese oxysulfide Mn_2OS, etc., but that they are compounds made up of a calcium polysulfide and calcium oxide; and that the chief difficulty in the question of their composition is to determine what polysulfide enters into their structure and whether or not this polysulfide is constant.

Undoubtedly the most important evidence concerning these oxysulfides has come from an investigation of the crystals themselves, even though the results of different analyses of these crystals do not agree as well as might be desired. Considering the facts that no solvent has been found by which the crystals can be purified by recrystallization and that they cannot even be washed entirely free from impurities, it is almost surprising to find that different chemists agree as well as they do on their composition and properties. However, since there are the above mentioned difficulties in dealing with the crystals, it seemed advisable to compare the work done along this line in this laboratory with that of others. In doing this, lime-sulfur solutions were prepared by taking one part of calcium oxide, one part of sulfur and five parts of water, boiling without a reflux condenser until the escaping vapor showed the presence of hydrogen sulfide, filtering while hot, and placing in well-stoppered flasks, some of which were filled completely while others were only partially filled. In all cases orange-red needles separated, even when the flasks were completely filled, showing that they were not dependent on the oxygen of the air for their formation. (In the more dilute solutions crystals formed only in the partially filled flasks.)

Several batches of these crystals were purified by separating them from the mother liquor by filtering through hardened filter paper in a Gooch crucible, washing a few times with small amounts of cold water (10° C.), a few times with small amounts of 95 per cent alcohol, several times with absolute alcohol, ether, carbon disulfide, and then with ether again. They were dried in a vacuum desiccator over calcium chloride.

The crystals purified as given above had an orange-red color. They were found to be insoluble in and not decomposable by ether, petroleum ether, chloroform, carbon disulfide, carbon tetrachloride, pyridine, or absolute alcohol. They were decomposed by hot and cold water, forming a solution similar in appearance and reaction to a dilute lime sulfur solution, and leaving a white, amorphous residue. When treated with 95 per cent alcohol, pyridine containing water, or with a small volume of cold water they were decomposed, forming a solution similar to the above; but some of the crystals retained their original shape, losing only the orange-red color. On heating, the crystals were gradually decomposed, leaving a white substance which did not melt or burn. Under the microscope the smaller crystals appeared like orange-red four-sided prisms with parallel cleavage. Between crossed Nicols, the extinction appeared parallel in one position and at an angle of about 30° in another. The white amorphous residue, as well as the white crystal-shaped masses which remained after treating with cold water, was found to be calcium oxide.

Samples of different batches of these crystals were analyzed by treating with sodium hydroxide solution, oxidizing with sodium peroxide, acidifying with hydrochloric acid, and then determining the total lime and total sulfur in the usual manner. The results are shown in Table VII:

TABLE VII

Sample No.	Total S Per cent	Total Ca Per cent	Ratio S/Ca
1	20.92	28.28	1.34
2	20.75	27.11	1.27
3	22.09	28.77	1.28
4	21.83	25.47	1.17
5	21.08	25.11	1.19
6	20.70	27.30	1.31
Average	21.23	27.01	1.27

From the above results it is evident that the molecules making up the crystals contain as many atoms of sulfur as of calcium, since the theoretical ratio of sulfur to calcium in such a molecule is 1.25, which is almost identical with the average of the above determined ratios.

On titrating several water solutions of the crystals with standard iodine and comparing the end-point determined by color with that determined with nitroprusside of sodium, it was found that the two end-points were the same, showing the absence of the (SH) radical, and therefore the absence of any of the compounds containing this radical.

That lime is set free when the crystals are decomposed with cold water is shown by the following: Two samples of crystals were shaken in flasks completely filled with freshly boiled distilled water until decomposition was complete. The solutions were then filtered and aliquots titrated with 0.1 *N* hydrochloric acid and with 0.1 *N* zinc chloride. The following results were obtained:

TABLE VIII

Soln No.	HCl Cc.	$ZnCl_2$ Cc.	CaO Gram
1	5.49	2.80	0.0075
2	16.04	7.95	0.0226

The general properties of these crystals seem to indicate that they are the Herschell's[1] crystals described in the literature, and a partial analysis shows that their percentage composition agrees with one of the formulas given by Geuther:[2]

[1] *Ann.*, **224** (1884), 181–192.

[2] *Ibid*

[1] *Ann.*, **224** (1884), 178

($2CaO.CaS_3.11H_2O$)

as is shown by the following:

TABLE IX

Geuther's formula—$2CaO.CaS_3.11H_2O$

	Ca	S
	Per cent	Per cent
Percentage composition—Theory.....	26.9	21.6
Found.....	27.01	21.23

It should be noted, however, that one property is shown by the mother liquor from which the crystals separate which is very difficult to explain if the crystals in solution are considered as being composed of calcium oxide in combination with calcium polysulfide. This is shown by the fact that when aliquots of such a solution are titrated with standard hydrochloric acid, standard zinc chloride, and standard iodine, the three titrations agree. This will be seen in the following table where 10 cc. of lime-sulfur concentrates containing the orange-red needles were diluted to 100 cc. with freshly boiled distilled water and 10 cc. aliquots were titrated.

TABLE X

SAMPLE No.	0.1 *N* HCl Cc.	0.1 *N* $ZnCl_2$ Cc.	0.1 *N* I Cc.
1.....	19.00	18.95	18.95
2.....	18.65	18.70	18.65

If the mother liquor from which the crystals separate contains in solution a compound which has for its formula $2CaO.CaS_3.11H_2O$, it is difficult to explain the above results, since hydrochloric acid, zinc chloride, and iodine could hardly give equal titrations on a solution containing the molecules mentioned. No attempt to explain this will be made at this time, but it should be emphasized that whatever the explanation may be, the fact remains that the three titrations do agree.

SUMMARY

I—Compounds containing the (SH) radical, as hydrogen sulfide, calcium hydrosulfide, calcium hydroxyhydrosulfide, and the corresponding salts of other metals, may be detected in a lime-sulfur solution by comparing the titration of the solution with standard iodine to the disappearance of the yellow color with that when the end-point is determined by the use of nitroprusside of sodium.

II—A "straight" lime-sulfur solution does not contain an appreciable amount of any of the above-mentioned compounds.

III—The difference between the titrations of a "straight" lime-sulfur solution with standard hydrochloric acid and standard ammoniacal zinc chloride is a measure of the free lime in the solution.

IV—When an excess of lime is used in the preparation of a lime-sulfur solution and the solution is freshly prepared, or when recently diluted with lime-water, it contains free lime; but on standing, the free lime gradually disappears. Therefore an ordinary lime-sulfur solution cannot contain free lime.

V—When magnesium sulfate is added to a lime-sulfur solution the following may be noted: (1) There is a slight decrease in the monosulfide sulfur and the sulfide sulfur contents. (2) The thiosulfate sulfur content remains practically constant. (3) The magnesium replaces part of the calcium forming magnesium polysulfide and under proper conditions calcium sulfate crystallizes out. (4) A compound containing the (SH) radical is formed.

VI—The magnesium sulfate method for determining free lime in a lime-sulfur solution is inaccurate.

VII—There appears to be no free sulfur in a lime-sulfur solution, and the sulfur that separates out on standing undoubtedly comes from the higher polysulfides.

VIII—When a concentrated lime-sulfur solution is prepared with an excess of lime, orange-red needles separate out. The properties of these crystals indicate that they are the same as those described in the literature as Herschel's crystals, and as being composed of calcium oxide combined with calcium polysulfide. Their analysis agrees most closely with that of Geuther, who gives for their formula the following: $2CaO.CaS_3.11H_2O$. However, it seems improbable that they exist in solution in the form indicated by this formula.

ACKNOWLEDGMENT

This work was suggested by Prof. A. J. Patten of this laboratory, and was carried out largely under his direction. I wish to express my great appreciation for the continued interest manifested throughout and for his kind advice and criticism.

MICHIGAN AGRICULTURAL COLLEGE EXPERIMENT STATION
EAST LANSING, MICHIGAN

LABORATORY AND PLANT

A STANDARD APPARATUS FOR THE DETERMINATION OF SULFUR IN IRON AND STEEL BY THE EVOLUTION METHOD

By H. B. PULSIFER

Received April 3, 1918

While investigating the determination of sulfur in iron and steel as briefly described in THIS JOURNAL, **8** (1916), 1115, the author was led to make a few determinations by the evolution method. After the several estimations with dilute acid, both direct and annealed, as recorded in the following columns, it was decided to conclude the work with other series using concentrated hydrochloric acid.

The excellent results obtainable with hot concentrated acid have been reported almost since the inception of the method nearly a hundred years ago; but Williams,[1] in 1892, was apparently the first one to compare results and demonstrate that concentrated acid would furnish far higher and more correct results than dilute acid. During the years following, numerous investigators,[2] both American and European,

[1] *J. Eng. Soc. West. Penn.*, **8** (1892), 328.

[2] Schindler, *Z. angew. Chem.*, **6** (1893), 11; Schneider, *Oesterr. Z. Berg. Huttenw.*, **41** (1893), 365; Phillips, *J. Am. Chem. Soc.*, **17** (1895), 891; Petrén, *Jern-Kontorets Annaler*, **60** (1905), 187; Schulte, *Stahl u. Eisen*, **26** (1906), 985; Kinder, *Ibid.*, **28** (1908), 349; Orthey, *Z. angew. Chem.*, **21** (1908), 1359 and 1393.

confirmed his conclusions and, going even further, presented exhaustive data to show that quick solution in hot concentrated acid dissolved all ordinary sulfides and evolved the sulfur as hydrogen sulfide from all sorts of the ferrous alloys. In particular the abundant formation of methyl sulfide generated by dilute acid on materials of high combined carbon was entirely overcome by dissolving in the hot concentrated acid. Several designed and used a form of apparatus to return as much as possible of the distilled acid to the flask, thus maintaining the strength

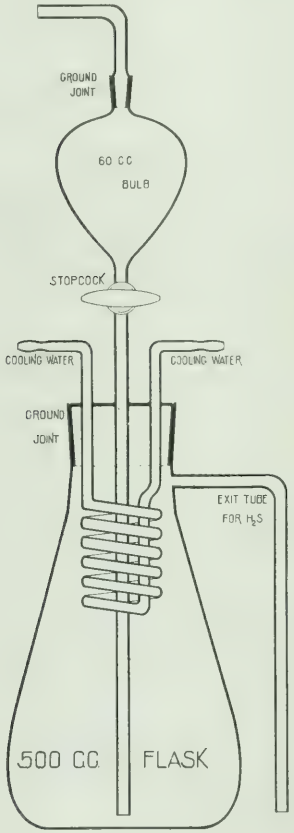


FIG. I

of the solution until the action is complete. The unsuitability of using rubber with the concentrated acid has long been known so that the better types of apparatus have been constructed wholly of glass. Rubber stoppers in contact with hot concentrated hydrochloric acid for 15 min. may easily evolve far more sulfide than most irons contain, 5 g. being taken.

Most of the types of European apparatus appearing rather impracticable and there being none at all available in this country, Messrs. Eimer and Amend, of New York, kindly attempted to construct a special flask after the design shown in Fig. I. They were unable to make one without using a solid stopper and increasing the ground joints from 3 to 8. The flask, however, serves very well; it is seen set up in operation in Fig. II. Shortly afterwards Schaar & Company, of Chicago, were interested in the matter and were able to procure several excellent units, after the exact original design, from Japan. These flasks have only the three ground joints and are highly satisfactory. After making several hundred determinations with the battery of three, one solid and two with hollow stoppers, as indicated in Fig. III, the author has no changes or alterations to make in the original design. If the large main stopper is kept slightly greased it withstands the internal pressure perfectly yet is easily removed with a slight twisting motion. With a battery of 3 units one operator can continuously make 9 determinations per hour, including weighing out the samples and titrating the results. With enough flasks an operator and assistant ought to make more than 20 determinations an hour.

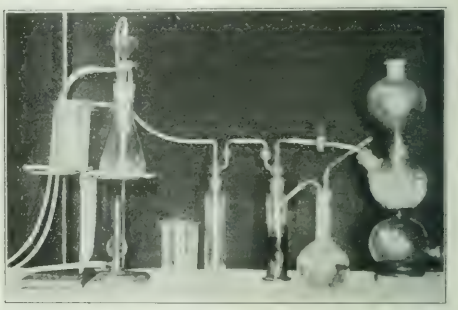


FIG. II

Arrangement of single flask showing hydrogen generator, wash bottles, flask, and beaker of absorbent solution The cooling water is led into the coil through the tubes at the left.

As this type of apparatus and the results obtainable are apparently slightly recognized in this country it is thought worth while to again record the manner of operation and the sort of results one gets. The samples used were either those checked by other methods or supplied by the Bureau of Standards.

With the reflux apparatus and using 40 cc. of hydrochloric acid (sp. gr. 1.19) 5 g. of iron can be dissolved and the solution held at gentle ebullition for 15 min., leaving the final solution of more than half its original strength. The use of hydrogen to wash out the sulfide obviates vigorous boiling as commonly advocated. Thus at the end of the operation the acid is considerably more concentrated than at the start when 1 : 1 acid is used. Without the reflux only from $^1/_4$ to $^1/_3$ of the original acid may remain in the flask at the end under the same heat influence. It is naturally presumed that the hot concentrated acid is responsible for the uniformly high results obtained.

The cooling coil in the neck of the flask assists in holding back droplets of the solution which would otherwise carry ferrous chloride over into the absorb-

ing solution; for this reason the catch-bulb frequently used has been omitted. The amount of iron carried over varies greatly with the character of the dissolving and the heat used. Using the hydrogen or carbon dioxide stream to sweep out the hydrogen sulfide there is evidently no advantage in heating to more than the gentlest ebullition. Many measurements showed from a trace to 5 mg. of iron carried over into the ammoniacal cadmium chloride solution. With only 0.01 mg. or less of iron carried over, as is usually the case with this apparatus, the cadmium sulfide precipitate is a clear lemon-yellow. From 0.02 to 0.05 mg. iron makes the precipitate darken to orange, then becoming reddish with over 1 mg. iron. The ferrous hydroxide present in this small amount quickly oxidizes to ferric and takes no part in the subsequent titration with iodine. As iodine is liberated from iodide solution by both ferric salts and hydrochloric acid the solution should not stand unduly after the addition of the iodine and before the back titration with thiosulfate. The author finds 2 min. ample to effect the solution of the cadmium sulfide with the strength of acid used; with longer standing iodine is gradually liberated and the solutions turn blue again.

PERMANGANATE AND OXALATE

$Na_2C_2O_4$	$KMnO_4$	To color	$KMnO_4$ per cc. (0.4717) (a)
0.3500	45.79	0.02	0.003607
0.3500	45.78	0.02	0.003608
0.3500	45.78	0.02	0.003608
0.3500	45.85	0.02	0.003602
0.3500	45.80	0.02	0.003606
			Av., 0.003606

(a) Factor for changing weight of oxalate to weight of permanganate.

PERMANGANATE AND THIOSULFATE

$KMnO_4$	$Na_2S_2O_3$	Ratio
15.51	49.91	0.3108
15.00	48.22	0.3111
15.04	48.30	0.3114
15.01	48.30	0.3108
15.00	48.21	0.3111
15.02	48.35	0.3107
14.97	48.11	0.3112
		Av., 0.3110

IODINE AND THIOSULFATE

Iodine	$Na_2S_2O_3$	Ratio
49.82	47.10	1.058
49.80	47.21	1.055
49.62	47.08	1.054
49.91	47.22	1.057
49.76	47.11	1.056
49.80	47.22	1.055
49.78	47.19	1.055
		Av., 1.056

1 cc. $KMnO_4$ is equivalent to 0.001829 g. S (factor = 0.5072).
1 cc. $KMnO_4$ is equivalent to 3.395 cc. iodine solution.
1 cc. iodine solution on 5 g. sample in percentage equals 0.01077 per cent.

The standardization of the iodine solution is best accomplished through a thiosulfate and permanganate solution against standard sodium oxalate as supplied by the Bureau of Standards. The author prefers large bottles of all the reagents, in bulk from 20 to 50 liters, and made up some months in advance. If preserved in the dark the solutions will alter so slowly that checking once a week is sufficient. As illustrating the precision and uniformity of the standardization work contrasted with the unequal distribution of sulfur in the metals, the above figures may be presented. It will be noticed that the variations between individual measurements are of the order of 1 part in 1,000 in the standardizations, while on the metal samples the sulfur content as measured by repetition under identical conditions will quite likely vary as much as 1 part in 5.

PROCEDURE

The procedure used on the following samples to obtain the figures in the last column, marked "Conc. HCl," is as follows:

5 g. of the well-mixed sample are weighed on a watch-glass to within 1 mg. and cautiously brushed into the flask so as not to fall against the sides. 40 cc. of hydrochloric acid (sp. gr. 1.19) is poured into the upper bulb. The stopper is placed in position. The absorbent solution is prepared by putting 300 cc. distilled water in a tall form of 500 cc. beaker; to this is added 20 cc. of ammonia (sp. gr. 0.90) and 10 cc. of ammoniacal cadmium chloride solution (300 g. $CdCl_2$, 500 cc. ammonia (sp. gr. 0.90) and 500 cc. distilled water). The exit tube is adjusted in the beaker and a cover glass arranged as well as may be. The cooling water is regulated.

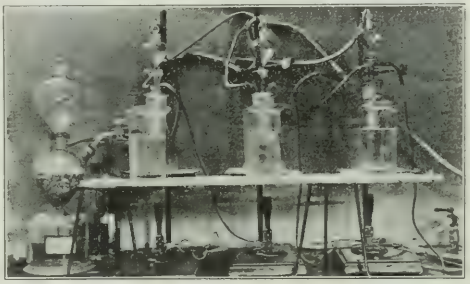


FIG. III

Battery of three flasks with hydrogen generator and water and gas connections. An analyst can maintain a rate of 9 determinations an hour with three flasks.

Hydrogen from HCl on zinc passed through alkaline $KMnO_4$ and a safety bottle is then let in to force the acid down on the metal and the burner beneath is lighted. The burner has previously been adjusted so that it will just keep the solution in gentle ebullition. The stream of hydrogen may be passed through continuously to the end or closed off during the peak of the gas evolution. Within 5 or 10 min. the sample will probably completely dissolve. If a series of bottles be substituted in place of the single beaker the results will come no higher nor will the slightest trace of a precipitate be found in the second bottle. Inserting a wisp of glass wool in the beginning of the exit tube will decrease the amount of iron passing over, but will not influence the results.

At the end of 15 min. the flame is removed; the exit tube is withdrawn from the beaker; the hydrogen is shut off; the stopper is loosened and the coil washed down into the flask, after which the stopper is hung on the side support (Fig. III) ready for the next time; the outside of the exit tube is washed off into the beaker and the flask emptied and rinsed ready for the next run.

With the iodine solution in the burette at a known mark and 10 cc. of starch solution added to the solution beneath, 50 cc. of concentrated hydrochloric acid are poured in and iodine added to a strong permanent blue. Two minutes may be allowed for the complete solution of the cadmium sulfide, after which the blue color is discharged with the thiosulfate solution. If carbon dioxide is used as wash, one must add the hydrochloric acid with much care, especially if bicarbonate has separated and fallen to the bottom. This copious gas evolution, de-

laying the work and once in a while spoiling a run, is a serious objection to the use of dioxide.

The separation of the figures into groups in the column under "Conc. HCl" results from runs made at different times, or from variations in the method such as the use of dioxide, three absorbent bottles, filtering the cadmium sulfide, a filter of glass wool, putting sulfates in the flask. Filtering the sulfide raises the blank and increases the results; no justification for the added uncertainty has been found.

Blanks are carried out exactly as a determination omitting the metal in the flask. They should be inserted often enough to establish a uniform deduction from the total iodine. With the materials used for nearly all of the author's work the blank was between 0.20 and 0.40 cc.

The samples in the following sets of analyses have been numbered to correspond with the work previously reported and referred to in the opening paragraph. Numbers omitted could not be investigated because of inadequate sample.

SAMPLE 2—FOUNDRY IRON, T. C. = 3.45, G. C. = 3.23, Si = 3.56, P = 0.78, Mn = 0.53

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.011	0.018	0.016	Direct	0.021
0.009	0.015	0.017	0.008	0.021
0.008	0.017	0.010	0.010	0.023
0.008	0.020 Av.,	0.014	0.008	0.019
Av., 0.009	Av., 0.018		0.007	0.018
Also			Av., 0.008	0.021
0.005				0.023
0.004			Annealed	0.023
0.007			0.010	0.023
Av., 0.005			0.009	Av., 0.021
Faster soln.			0.010	
0.003			0.008	
0.002			Av., 0.009	
0.004				
Av., 0.003				
Quick soln.				
0.002				
0.002				
0.003				
Av., 0.002				

SAMPLE 3—"VISMERA" FROM INLAND STEEL

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.007	Not run	0.012	Not run	0.034 0.031
0.009		0.018		0.034 0.033
0.012		Av., 0.015		0.033 0.030
Av., 0.009				0.033 0.037
				0.036 0.033
				0.034 0.036
				0.034 0.029
				0.034 0.029
				0.034 0.031
				0.033 0.029
				0.032
				0.033
			Av.,	0.034 0.031

SAMPLE 4—FOUNDRY IRON

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.015	0.021	0.023	Direct	
0.013	0.022	0.022	0.013	0.024 0.028 0.020
0.013	0.021 Av.,	0.023	0.016	0.026 0.026 0.019
0.013	Av., 0.021		0.013	0.024 0.028 0.031
0.011			0.018	0.023 0.026 0.018
Av., 0.013			Av., 0.015	0.021 0.022 0.019
				0.024 0.031 0.032
			Annealed	0.023 0.032 0.020
			0.014	0.032 0.022
			0.015	0.022
			Av., 0.015	Av., 0.023 0.028 0.022
				Av., 0.025

SAMPLE 5—MILD STEEL

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.017	0.021	0.015	Direct	0.049
0.021	0.019	0.016	0.021	0.034
0.017	0.019 Av.,	0.016	0.020	0.037
Av., 0.018	0.021		Av., 0.020	0.037
	0.020			0.040
	Av., 0.020		Annealed	0.036
			0.015	0.038
			0.015	0.038
			Av., 0.015	0.036
				Av., 0.038

SAMPLE 8—IROQUOIS IRON NO. 3

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.030	0.041	0.034	Direct	0.039 0.038 0.034
0.030	0.038	0.043	0.023	0.029 0.032 0.036
Av., 0.030	0.028	0.041	0.022	0.038 0.035 0.036
	0.034 Av.,	0.039	0.020	0.028 0.034 0.032
	0.032		0.020	0.030 0.030 0.038
	Av., 0.035		Av., 0.021	0.036 0.035 0.039
				0.041 0.038
			Annealed	0.023 0.036
			0.023	0.034 0.031
			0.024	Av., 0.033 0.034 0.036
			Av., 0.024	Av., 0.034

SAMPLE 9—SHIP PLATE

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.032	0.032	0.033	Direct	0.044
0.031	0.028	0.027	0.033	0.047
0.032	0.034 Av.,	0.030	0.032	0.046
0.034 Av.,	0.031		Av., 0.033	0.048
Av., 0.032				0.048
			Annealed	0.044
			0.032	0.048
			0.032	0.048
			0.030	Av., 0.047
			0.029	
			Av., 0.031	

SAMPLE 12—BUREAU STANDARDS D, 6A AND 6B, S, OX. = 0.044 AND 0.046

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl	
6a	*6a*	*6a*		*6b*	*6b*
0.038	0.046	0.046	Not run	0.062	0.058
0.040	0.042	0.039		0.057	0.062
0.037	0.046 Av.,	0.043		0.061	0.066
0.039 Av.,	0.045			0.062	0.047
Av., 0.039				0.059	0.056
				0.048	0.045
				0.063	0.051
				0.055	0.057
				0.057	0.059
				0.058	0.063
					0.066
				Av., 0.058	0.057

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
6a				
0.062				
0.055				
0.061				
0.056				
0.053				
0.060				
Av., 0.058				

SAMPLE 13—AM. FDY. ASSN. STAND. A, 2ND

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HC
0.052	0.057	0.052	Direct	0.051 0.049
0.051	0.056	0.049	0.041	0.048 0.053
0.045	0.058	0.054	0.041	0.051 0.051
0.053	0.059 Av.,	0.052 Av.,	0.041	0.055 0.049
0.047	0.062			0.050 0.050
Av., 0.050	0.063		Annealed	0.053 0.052
	Av., 0.059		0.038	0.052 0.052
			0.039	0.057
			0.041	0.051
			Av., 0.039	Av., 0.051 0.052

SAMPLE 15—FOUNDRY IRON, T. C. = 3.69, G. C. = 3.34, Si = 2.06, P = 0.65, Mn = 0.48

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.063	0.068	0.059	Direct	0.069 0.089 0.069
0.060	0.075	0.064	0.047	0.069 0.071 0.068
0.063	0.073	0.061	0.047	0.074 0.076 0.074
0.062	0.067	0.068	Av., 0.047	0.076 0.087 0.083
0.067	0.071 Av.,	0.063		0.069 0.080 0.073
0.066 Av.,	0.071		Annealed	0.070 0.073 0.078
Av., 0.064			0.050	0.081 0.080
			0.050	0.071 0.077
			0.048	Av., 0.076 0.074
			0.045	0.067 0.074 0.068
			Av., 0.048	0.076 0.079 0.071
				0.073 0.068 0.080
				0.071 0.075 0.080
				0.066 0.073 0.083
				0.076 0.067 0.084
				0.080
				0.079
				0.078
				0.089
				0.087
				0.084
				Av., 0.072 0.073 0.080
				Total Av., 0.076

SAMPLE 16—AM. FDY. ASSN. STAND. B, 2ND, S, OX. = 0.070, S, EV. = 0.055

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.078	0.077	0.070	Direct	0.093
0.065	0.069	0.067	0.059	0.087
0.070	0.081 Av.,	0.069	0.059	0.090
0.067	0.080		0.058	0.085
0.070	0.075		Av., 0.059	0.088
Av., 0.069	0.078			Av., 0.087
	Av., 0.076		Annealed	
			0.060	
			0.063	
			0.053	
			Av., 0.059	

SAMPLE 17—SPECIAL SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.075	0.084	0.076	Direct	0.072
0.076	0.083	0.072	0.061	0.084
0.079	Av., 0.084 Av.,	0.074	0.061	0.084
Av., 0.077			0.064	0.080
			0.058	0.077
			Av., 0.061	0.080
				0.076
			Annealed	Av., 0.079
			0.055	
			0.055	
			0.055	
			0.056	
			Av., 0.055	

SAMPLE 18—FOUNDRY IRON, SPECIAL SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.081	0.094	0.079	Direct	**0.077**
0.081	0.093	0.080	0.066	**0.069**
0.082	0.089 Av.,	0.080	0.067	**0.068**
0.084 Av.,	0.092		0.080	**0.085**
0.078			0.066	**0.070**
Av., 0.081			Av., 0.069	**0.076**
				Av., **0.074**
			Annealed	
			0.063	
			0.065	
			0.064	
			0.059	
			Av., 0.063	

SAMPLE 19—FOUNDRY IRON, SPECIAL SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.106	0.103	0.098	Direct	**0.094 0.097**
0.101	0.104	0.097	0.060	**0.096 0.101**
0.097	0.103 Av.,	0.098	0.060	**0.091 0.094**
0.100 Av.,	0.103		0.058	**0.095 0.093**
Av., 0.101			0.063	**0.092 0.091**
			Av., 0.060	
				0.096
			Annealed	**0.094**
			0.075	**0.094**
			0.077	**0.095**
			0.072 Av.,	**0.094 0.095**
			0.066 Av.,	**0.095**
			Av., 0.073	

SAMPLE 20—FOUNDRY SPECIAL IRON, SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.113	0.140	0.129	Direct	**0.092 0.092**
0.116	0.138	0.128	0.074	**0.085 0.090**
0.121	0.131	0.136	0.066	**0.096 0.090**
0.119 Av.,	0.136 Av.,	0.131	0.074	**0.096 0.093**
Av., 0.117			0.065	**0.101 0.098**
			Av., 0.070	**0.097**
				0.111
			Annealed Av.,	**0.097 0.093**
			0.088	
			0.086	
			0.086	
			0.075	
			0.074	
			Av., 0.081	

SAMPLE 21—FOUNDRY IRON, SPECIAL SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.176	0.140	0.199	Direct	**0.132**
0.176	0.138	0.172	0.136	**0.134**
0.182	0.131 Av.,	0.186	0.131	**0.141**
0.171 Av.,	0.136		0.127	Av., **0.136**
0.184			0.131	
0.182			0.139	
0.184			0.126	
Av., 0.179			0.132	
			Av., 0.132	
			Annealed	
			0.158	
			0.141	
			0.155	
			0.156	
			0.152	
			0.137	
			0.151	
			Av., 0.150	

SAMPLE 22—FOUNDRY IRON, SPECIAL SMALL INGOT

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.265	0.269	0.261	Direct	
0.261	0.265	0.260	0.188	**0.163 0.187**
0.255	0.266 Av.,	0.261	0.222	**0.146 0.185**
0.255 Av.,	0.267		0.190	**0.183 0.183**
Av., 0.259			0.205	**0.169 0.186**
			0.188	**0.187 0.186**
			0.172	**0.186**
			Av., 0.194	**0.142**
				0.177
			Annealed Av.,	**0.169 0.185**
			0.234	
			0.196	
			0.243	
			0.208	
			0.227	
			Av., 0.222	

SAMPLE 23—FOUNDRY IRON

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.015	0.024	Not run	Direct	
0.016	0.020		0.010	**0.018 0.014 0.019**
Av., 0.016	0.023		0.010	**0.016 0.018 0.020**
Av.,	0.022		Av., 0.010	**0.017 0.024 0.022**
				0.014 0.020
			Annealed	**0.015**
			0.015	**0.017**
			0.015 Av.,	**0.016 0.019 0.020**
			Av., 0.015 Total Av.,	**0.018**

SAMPLE 24—HIGH S STEEL

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
0.120	Not run	Not run	Not run	**0.125**
0.116				**0.113**
0.109				**0.116**
0.112				**0.123**
Av., 0.114				**0.119**
				0.123
				0.124
				Av., **0.121**

SAMPLE 25—BUREAU STANDARDS B. O. H., No. 15*a*, S FROM 0.021 TO 0.032

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
Not run	Not run	Not run	Not run	**0.044 0.049**
				0.044 0.045
				0.042 0.048
				0.049 0.049
				0.053 0.047
				0.049 0.054
				Av., **0.047 0.049**
				Total Av., **0.048**

SAMPLE 26—BUREAU STANDARDS B. O. H., No. 12*b*, S FROM 0.018 TO 0.025

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
Not run	Not run	Not run	Not run	**0.023 0.028**
				0.025 0.029
				0.026 0.027
				0.023 0.029
				0.024 0.028
				0.023 0.023
				0.023 0.025
				Av., **0.024 0.027**
				Total Av., **0.026**

SAMPLE 27—BUREAU STANDARDS B. O. H., No. 13*a*, S FROM 0.022 TO 0.035

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
Not run	Not run	Not run	Not run	**0.034 0.034**
				0.033 0.036
				0.028 0.034
				0.035 0.033
				0.033 0.031
				0.035 0.039
				0.034 0.033
				Av., **0.033 0.034**
				Total Av., **0.034**

SAMPLE 28—BUREAU STANDARDS B. O. H., No. 14*a*, S FROM 0.031 TO 0.041

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
Not run	Not run	Not run	Not run	**0.037 0.045**
				0.039 0.041
				0.036 0.044
				0.035 0.044
				0.036 0.038
				0.036 0.036
				0.037 0.039
				Av., **0.037 0.041**
				Total Av., **0.039**

SAMPLE 29—BUREAU STANDARDS B. O. H., No. 16*a*, S FROM 0.027 TO 0.033

Nitric	Bamber's	Chloric	Dil. HCl	Conc. HCl
Not run	Not run	Not run	Not run	**0.045 0.049 0.054**
				0.049 0.047 0.054
				0.051 0.054 0.056
				0.044 0.052
				0.044 0.057
				0.049 0.057
				Av., **0.048 0.048 0.055**
				0.055
				0.052
				0.049
				Av., **0.052**
				Total Av., **0.051**

SUMMARY

An evolution flask for the determination of sulfur in iron and steel has been designed and used for over 300 determinations of sulfur in 23 samples of metal whose sulfur content has been carefully ascertained by other methods.

The apparatus is designed to obviate the use of rubber and provide a reflux condenser to maintain the acid solution at maximum strength, at the same time preventing the boiling over of the solution and washing the gas which goes over into the absorbing solution. If a current of hydrogen or carbon dioxide is continuously passed through, the hydrogen sulfide is effectively washed out and it is impossible for the absorbent solution to suck back. The author broke one flask by running in the acid onto the metal when the bottom of the flask was too hot, and another broke when the cooling water connection parted and the cold water ran down the side. The first accident came through attempting to speed up the runs and not cool the asbestos between times. If the flame is shut off immediately on ending a run and only relighted as the last act of starting a new run, this danger

is avoided. After learning this, over 300 determinations were made without accident. The breaking of the water connection resulted from the multiplicity of ground joints in the substitute flask; such an accident is hardly possible with the original design.

The cost of a flask is of no consequence if the results are considered worth having. The cost per determination will depend on the number of runs that can be made before it is damaged. If 1,000 determinations should be the average life on an original cost of $10.00 the cost is 1 cent per determination. The manipulation is simple and only by gross carelessness should an analyst break the apparatus by handling. With the cooling water running and the hydrogen passing through, the flask can be left boiling over the flame indefinitely without damage.

The results which can be obtained with the apparatus are uniformly high, often above those obtainable by any other method. In only two instances with the samples studied did the dilute acid give more sulfur than the concentrated. These were both high sulfur materials and the sulfur from both of these samples easily separates as elemental sulfur; in using the nitric acid oxidation method the globule of sulfur, which may float about if the solution in hot acid is rapid, has to be oxidized by long digestion. The high results which one obtains as in Samples 2 and 3 might keep one in doubt as to the source of all the sulfur, were not the abundant cadmium sulfide precipitates directly in front of one and undeniably of the right proportions. The excellent agreement on some Bureau of Standards samples and the high figures on others emphasizes the advantage of standardization of the iodine solution against sodium oxalate.

A glance at the results shows the fallacy of using 1 : 1 hydrochloric acid, whether the sample has been annealed or not. If the sample is very high in sulfur, dilute acid will liberate more hydrogen sulfide in a 15-min. interval than the concentrated acid, probably because of more elemental sulfur being formed in the latter case. In this case neither will give as high results as an oxidation method but that, too, must be extended to oxidize the separated sulfur. Others have found that a slow digestion carried out for hours will finally bring the evolution sulfur result as high as the oxidation figure, even on these high sulfur materials. For sulfurs not over 0.10 per cent the proposed method is therefore as accurate as any method; for sulfur over 0.10 per cent the analyst must be strictly on his guard.

The advantages of the evolution method are that it gives the true amounts of sulfur present in the sample, the method is exceedingly rapid, the method is the most direct of any yet devised, and only two containers are used. Oxidation methods using nitric acid are all highly liable to loss of sulfur because of the excessive gas formation. The successive filtrations, evaporations, and precipitations in the oxidation and fusion methods (carried to excess in the latter method) render these methods reliable only under the most rigid conditions of laboratory, chemical, and manipulative control. This unfortunate condition is most vividly presented in the distributed results of the Bureau of Standards showing the *average* result as obtained by the best analysts, all using the same method, with the extreme results usually differing by as much as 1 part in 5. There is certainly something more than the inherent heterogeneity of the samples at fault when the average results differ so widely.

MONTANA STATE SCHOOL OF MINES
BUTTE, MONTANA

DETERMINATION OF ACETIC ACID BY DISTILLATION WITH PHOSPHORIC ACID

By W. FAITOUTE MUNN

Received December 12, 1916

On account of the scarcity of literature dealing with methods for the determination of acetic acid in organic mixtures other than the analysis of calcium acetate, it was thought advisable to work along this line and devise, if possible, a new method which would be simple, rapid and accurate, even in the presence of carbon dioxide.

Although the determination as finally carried out bears relation to the regular phosphoric acid distillation method such as is described in the well-known books on technical methods, I think it sufficiently different, due to a number of changes and additions, to describe in detail.

This method has been used by the writer more particularly for determining acetic acid in calcium acetate residues and dry soda and sulfite liquors than for commercial calcium acetate assays and has given in all cases excellent results. Of course, if other volatile organic acids are present they will be estimated with the acetic acid and the analysis will therefore have to be continued so as to further separate these acids before calculating the results as acetic acid. In most cases the amounts of other volatile acids contaminating the acetic acid are very small and for most analyses such as are desired for technical information may be neglected.

The principle of the method is the decomposition of the acetate by means of phosphoric acid, distilling the acid vapors liberated and collecting them in a known amount of a standard barium hydroxide solution which is in excess, finally determining by titrating back with standard acid.

Before describing the method as finally carried out a few remarks relative to the methods now in use and described in books on quantitative analysis will be given.

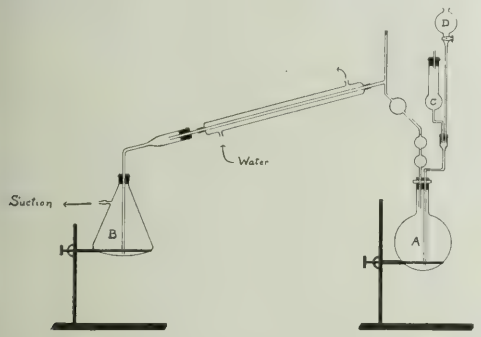
Lunge's "Chemisch-technische Untersuchungsmethoden," dritter Band, Seite 822–823, or the translated edition, Vol. 3, p. 307, directs that the acetate be distilled to dryness two or three times, the resulting distillates being combined and the amount of acid therein determined by titration with alkali.

Allen's "Commercial Organic Analysis," Vol. I, and Treadwell's "Quantitative Analysis" describe methods similar to that of Lunge.

The methods described by A. G. Stillwell[1] and T. S. Gladding[2] differ from Lunge's, mainly in the way of collecting the distillate, *i. e.*, absorbing the acid vapors in standard alkali as they are evolved and collected.

W. M. Grosvenor[3] points out the error liable to be introduced if any appreciable amount of carbon dioxide is present, but does not eliminate this error in his method should such be the case.

The procedures as given above tend to cause a great deal of bumping as the contents of the distilling flask become more concentrated and therefore more syrupy and the distillation often becomes very irregular. This is more noticeable when an organic residue is being acted upon than when acetic acid in acetate of lime is being determined.



There are three improvements in the following method by the writer, *viz.*, (1) making the distillation bulbs and condenser tube in one piece (of 1/4 in. glass tubing and of the shape shown in the drawing), thus making one less joint and, as the apparatus is much smaller bore, enabling one to obtain more concordant and accurate results in a shorter time; (2) the use of a slight suction on the latter end of the apparatus, thus preventing bumping to a very great extent, the accumulation of vapors in the flask and reducing the time required to make the determination; (3) the use of a standard solution of barium hydroxide for absorbing the acid vapors. (On account of the use of a current of air drawn through the apparatus it is necessary to provide the inlet of the flask with a soda-lime tube.)

The flask A, of about 500 cc. capacity, is fitted with a two-hole rubber stopper, one hole of which contains the distillation bulbs and the other a thistle tube bent as shown in the figure. A soda-lime tube, C, and a dropping funnel, D, are connected to the thistle tube. As the dropping funnel contains dilute phosphoric acid, the air drawn through the apparatus during the distillation must enter through the soda-lime tube.

The cooling jacket for the condenser tube is made from 3/4 in. glass tubing. After drawing down the ends and sealing on the water-tube connections, it is slipped on in the usual manner. The remainder of the apparatus needs no explanation as it can be clearly understood by glancing at the figure.

A known amount of a saturated, or nearly so, standard barium hydroxide solution is quickly run into the Erlenmeyer flask B, enough being added so as to still have an excess at the end of the determination.

5 g. of the dry sample, if it is a residue from a dry distillation, or a varying amount depending upon the nature of the substance, are placed in the flask A, and after fitting the corks, a dilute solution of phosphoric acid (20 cc. H_2O plus 40 cc. 85 per cent phosphoric acid) is added through the funnel D. The stopcock of the funnel is now quickly closed and a slight suction (water pump) started through the apparatus. The flask and contents, which should be on a sand bath, are gradually heated until the liquid boils. After the temperature has reached the boiling point the flame is regulated so as to just keep the contents boiling lightly. The rate of suction is then adjusted so that the bubbles issuing from the tube in flask B are not more than 10 to 15 per minute.

As soon as the distillation and suction have been adjusted, a dilute solution of phosphoric acid is made up (50 cc. H_2O to 25 cc. 85 per cent phosphoric acid) and poured into the dropping funnel. This dilute acid is allowed to drop into the distilling flask at the same rate as the condensed vapors distil (about 10 to 15 drops per minute). It may be said at this point that the concentrations just given for the phosphoric acid may vary considerably, depending upon the material under examination.

100 cc. $Ba(OH)_2$ solution used, equivalent to	153.30 cc. $N/10$ $Ba(OH)_2$
$N/10$ HCl used to neutralize excess	90.30 cc.
$N/10$ $Ba(OH)_2$ equiv. to acetic acid plus CO_2	63.00 cc.
N HCl used to dissolve $BaCO_3$	10.56 cc.
N NaOH used to neutralize excess HCl	6.25 cc.
N HCl equivalent to $BaCO_3$	4.31 cc.
$N/10$ HCl equivalent to $BaCO_3$	43.10 cc.
From $Ba(OH)_2$	63.00 cc
Subtract cc. HCl equivalent to $BaCO_3$	43.10 cc.
$N/10$ $Ba(OH)_2$ equivalent to acetic acid	19.90 cc.

$$\frac{19.9 \times 0.006}{5} \times 100 = 2.39 \text{ per cent acetic acid}$$

At the end of the run, which is generally complete in an hour and a half, phenolphthalein is added to the barium hydroxide solution and the excess of alkali determined by titration with $N/10$ hydrochloric acid. Normal hydrochloric acid is now added to dissolve the barium carbonate and the excess of acid then present is neutralized by the addition of normal sodium hydroxide and methyl orange for indicator. (As there is often a yellow color present in the liquid before adding the methyl orange for the second titration, the end-point showing when the excess hydrochloric acid has been neutralized is very indistinct. If the end-point is determined by using the methyl orange on a spot

[1] *J. Soc. Chem. Ind.*, **1904**, 305.
[2] THIS JOURNAL, **1** (1909), 250.
[3] "Analysis of Commercial Acetate of Lime," *J. Soc. Chem. Ind.*, **1904**, 530.

plate, it is very definite.) The acetic acid in 5 g. of sample is estimated on preceding page.

A sample of carbonate of lime (about 40.00 per cent CO_2), part of the residue from the manufacture of acetone by heating calcium acetate, was treated by the above method and the following figures obtained:

$N/10$ $Ba(OH)_2$ used	97.09 cc.
$N/10$ HCl to titrate back	67.02 cc.
$N/10$ $(BaOH)_2$ equiv. to CO_2 plus acetic acid	30.07 cc.
N HCl added	5.64 cc.
N NaOH to titrate back	2.63 cc.
N HCl equiv. to CO_2	3.00 cc. or 30 cc. $N/10$ HCl

30.07 — 30.00 cc. = 0.07 cc. $N/10$ $(BaOH)_2$ or 0.008 per cent acetic acid

As this sample had been re-heated for a long time before this analysis was made, the chance of any acetate still being present was reduced to a minimum. The presence of a large amount of CO_2 therefore does not seem to interfere with the acetic acid determination.

While the above procedure appears somewhat complicated at first glance, it does not prove to be so, as the distillation after once it is adjusted, needs very little attention, thus allowing the person in charge to attend to other duties.

LEDERLE LABORATORIES
NEW YORK CITY

THE DETERMINATION OF ACETONE

By ALLAN J. FIELD

Received June 20, 1917

The purpose of this investigation was to find an accurate method for the determination of acetone in methyl alcohol. All of the published methods were investigated with results as follows:

MESSINGER'S METHOD[1] is a volumetric method depending upon the reaction between iodine and acetone to form iodoform. Messinger claims that accurate results can be obtained by this method. A criticism by Vaubel and Scheuer[2] of this method is that when thiosulfate is used in titrating back, the results are always too low, and, therefore, they recommend the use of arsenious acid instead of the thiosulfate. The writer tested this method, using thiosulfate as well as the arsenious acid, but could not get accurate results. The precautions recommended by Collischon[3] were observed but the results were not satisfactory. I found that if, after the addition of the $N/5$ iodine solution, the mixture is shaken for 5 min., a low result is obtained, while shaking for 20 min. gives a higher result, the percentage varying with the length of time of agitation. These experiments were tried on a pure acetone solution without the presence of alcohol. When methyl alcohol was present the percentage of acetone found was several per cent higher. The increase could not be due to the alcohol furnishing the extra amount of acetone as the quantity it contained was duly considered.

[1] *Ber.*, **21** (1888), 3366.
[2] *Z. angew. Chem.*, **18** (1905), 214.
[3] *Z. anal. Chem.*, **29** (1890), 562.

THE ROBINEAU AND ROLLINS METHOD as modified by L. F. Kebler[1] was found by the author to give the most accurate results. The presence of alcohol and the time of shaking did not influence the percentage of acetone.

The acetone that was used in trying out these methods was Merck's reagent guaranteed by them to be 99 to 100 per cent. The percentages of acetone obtained in four determinations using the Robineau and Rollins method were as follows:

Determination No.	I	II	III	IV
Acetone, per cent	96.37	96.37	95.89	95.74

There remained 4 per cent unaccounted for. The Bureau of Standards at Washington advised checking the purity of the acetone by means of the specific gravity and referred to Timmerman[2] as giving the best value obtainable.

The specific gravity I found was 0.80716 $15°/4°$ and Timmerman's value is 0.79574 $15°.4°$, which would indicate the presence of water. Krug and McElroy[3] found that at 20° C., one per cent of water raises the specific gravity 0.0031. Squibb[4] found that at 15° one per cent of water raised the specific gravity 0.0020. The specific gravity of Merck's acetone was 0.80716 $15°.4°$, therefore, there could be 3.68 per cent of water present, assuming as correct Timmerman's value for anhydrous acetone.

The author wishes to express his thanks to Dr. I. W. Fay, of the Polytechnic Institute of Brooklyn, for his advice during the work.

ROSEBANK
STATEN ISLAND, N. Y.

SOME RESULTS OF ANALYSIS OF AIRS FROM A MINE FIRE

By A. G. BLAKELEY AND H. H. GEIST

Received September 15, 1917

There is no doubt that gas analysis has found considerable use in locating mine fires and especially in following the progress of these underground fires. Not a great deal of data has been published, however. The writers, therefore, considered it proper that they publish some data which may be of interest to those connected with mining work, particularly with anthracite coal mining.

The mine at which the samples were taken is an anthracite coal mine, a mine considered as a rather gaseous mine, or one generating a fairly large quantity of methane or fire damp.

On November 18, 1916, several men were overcome while at work inside the mine. On November 19, a fire was discovered. Batteries were erected for the purpose of smothering out the fire by cutting off all the fresh air supply.

In order to carry out this investigation pipes were extended through the batteries, these pipes being closed by means of valves at the outer ends. From time to

[1] *J. Am. Chem. Soc.*, **19** (1897), 516.
[2] *Bull. U. S. Chem. Lab.*, **24** (1910), 263.
[3] *J. Anal. Appl. Chem.*, **6** (1892), 187.
[4] *J. Am. Chem. Soc.*, **17** (1895), 200.

time these valves were opened and air samples taken. These samples were taken in such a way as to accurately represent the air behind the battery, or in other words, the air from the fire zone.

The carbon monoxide was determined by the iodine pentoxide method, more than one liter of air being passed over the heated iodine pentoxide in each determination.

The results given in Tables 1 and 2 seem to need no further explanation.

The mine fire zone was partially opened in August 1917, and no further air samples were tested.

TABLE 1—7TH LEVEL, GANGWAY BATTERY

DATE OF SAMPLING	Oxygen Per cent	Carbon Dioxide Per cent	Carbon Monoxide Per cent	Methane Per cent	Carbon Dioxide in Black Damp[1] Per cent
Dec. 1, 1916	18.00	0.99	0.008	2.40	8.28
Dec. 5	16.40	1.16	0.0057	2.33	5.85
Dec. 12	15.80	1.34	0.0034	4.27	6.47
Dec. 19	16.00	1.61	0.015	3.28	7.80
Dec. 26	15.66	1.69	0.01	3.66	7.72
Jan. 5, 1917	14.00	1.71	0.006	4.46	5.87
Jan. 11	14.30	2.11	0.004	4.51	7.66
Jan. 18	13.60	2.48	0.002	5.72	8.36
Jan. 25	14.20	2.38	0.002	4.22	8.41
Feb. 9	15.80	3.04	0.005	5.16	9.20
Feb. 22	14.20	2.31	0.001	4.12	8.13
Mar. 8	13.80	2.38	0.0016	3.87	7.78
Mar. 22	13.90	1.60	None	3.55	5.23
Apr. 5	12.42	2.43	None	4.38	6.62
Apr. 18	13.11	2.34	None	3.35	6.79
May 3	13.10	2.67	None	4.12	7.93
May 17	10.20	3.20	None	6.35	7.06
May 31	9.90	2.22	None	4.96	4.59
June 14	8.70	3.42	None	7.87	6.70
June 28	9.00	3.32	None	6.60	6.53
July 12	6.40	4.21	None	8.14	6.82
July 26	4.80	4.47	None	10.90	6.71

TABLE 2—7TH LEVEL, MONKEY BATTERY

DATE OF SAMPLING	Oxygen Per cent	Carbon Dioxide Per cent	Carbon Monoxide Per cent	Methane Per cent	Carbon Dioxide in Black Damp[1] Per cent
Dec. 1, 1916	13.63	2.09	0.019	5.97	7.13
Dec. 5	12.00	2.11	0.009	3.35	5.29
Dec. 12	11.51	2.17	0.0044	6.22	5.52
Dec. 19	14.10	2.30	0.029	4.73	8.14
Dec. 26	13.78	1.98	0.016	5.15	6.73
Jan. 5, 1917	9.80	2.12	0.01	5.62	4.40
Jan. 11	10.80	3.31	0.0068	6.20	7.77
Jan. 18	10.20	3.40	0.006	5.63	7.39
Jan. 25	10.73	3.46	0.007	4.76	7.80
Feb. 9	9.40	4.10	0.008	6.34	8.35
Feb. 22	11.10	3.67	0.0017	5.25	8.72
Mar. 8	10.00	3.43	None	5.76	7.32
Mar. 22	11.40	3.62	None	4.96	8.85
Apr. 5	9.10	3.97	None	6.13	7.82
Apr. 18	10.20	3.65	None	3.81	7.63
May 3	10.00	3.40	None	6.44	7.36
May 17	7.30	4.40	None	7.02	7.52
May 31	7.80	4.06	None	6.87	7.21
June 14	3.30	4.81	None	9.03	6.36
June 28	3.30	4.86	None	10.05	6.47
July 12	3.30	4.96	None	11.88	6.81
July 26	2.80	4.84	None	10.17	6.29

[1] Foster and Haldane, "The Investigation of Mine Air," p. 124.

THE PHILADELPHIA & READING COAL AND IRON COMPANY
POTTSVILLE, PENNSYLVANIA

A DIFFERENTIAL REFRACTOMETER

By G. A. Shook

Received February 16, 1918

This instrument is the result of an attempt to develop a simple but accurate refractometer for measuring the difference in refractive index between two liquids. It is of the Abbé type but so constructed that two liquids may be examined simultaneously and, therefore, if the index of one is known and if both have the same temperature coefficient, the index of the liquid in question may be accurately determined without knowing its temperature.

The instrument as constructed by the writer is shown diagrammatically in Fig. I, and the optical system in Fig. II. The refracting prisms P, P are enclosed in a metal case which opens, as indicated, and which may be rotated by means of an arm terminating in a micrometer screw, M. The smallest division on the micrometer corresponds to a difference in index of about 0.00005. The face of each prism is divided into two parts, A and B, by means of a groove so that a drop of the standard liquid may be placed on one face (either A or B) and a drop of the liquid to be tested on the other face. For example, since the temperature coefficient of most solutions is nearly that of water, water may be used as a standard when measuring the index of solutions.

To obtain a dividing line free from color it is necessary to use a monochromatic source of light, such as a sodium flame, or some compensating device. The former is sometimes inconvenient and the latter would considerably increase the cost of the instrument. A monochromatic red glass, G, was used in connection with an electric light, L, and it was found that the dividing line is nearly as sharp as that which obtains when a sodium flame is used. The lamp used was a 7.5 watt, 110 volt, frosted globe tungsten and

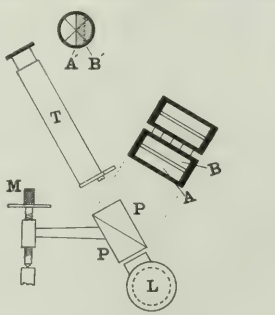


FIG. I

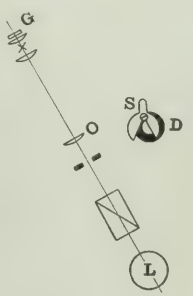


FIG. II

it was made a part of the instrument so that no adjusting was necessary when once in place. It is more convenient than daylight and it also produces a more uniform field.

The refractometer was originally designed to measure the difference in index between hemolyzed and unhemolyzed blood, as it was discovered by Dr. F. H. Howard and the writer, some time ago, that the amount of hemoglobin present in a given sample of blood causes its index to vary markedly and, furthermore, that *the difference in index (hemolyzed and unhemolyzed blood) depends only upon the amount of hemoglobin present.* Since the absorption bands of blood are in the green and blue parts of the spectrum a red glass is well adapted to this sort of measurement.

After passing through the refracting prisms the light enters a telescope, T, provided with cross-wires as shown. Between the telescope objective, O, and the prisms is a diaphram, D, provided with a shutter, S, and by adjusting this shutter the light from either A or B may be cut out. For instance, when the light from B is intercepted, the dividing line A′, due to the light from A, is seen; and when S intercepts the light from A, then B′ is in the field. The distance

between these lines is measured by means of the micrometer M.

When red light is used a difference in index can be measured with an accuracy of about one in the fourth decimal place (*i. e.*, ±0.0001), but with sodium light the accuracy is about ±0.00005; that is, if one measures the difference between the two lines by means of the micrometer, cleans the prisms, and makes a second measurement, the two values of the index difference calculated therefrom will agree within 0.0001 for red light and within 0.00005 for sodium light.

The relation between the micrometer reading and the difference in index is very nearly linear, so that by means of two solutions of known index and a comparison solution, the instrument can be easily calibrated.

WILLIAMS COLLEGE
WILLIAMSTOWN, MASS.

A VOLUMENOMETER

By J. S. ROGERS AND R. W. FREY

Received February 19, 1918

Although there are numerous types of mercury displacement apparatus for measuring volume none has been found satisfactory for comparatively large pieces of leather. The apparatus described here, while based on the well-known displacement principle, possesses, it is believed, some new features. It is not only satisfactory for large pieces, but also permits of a decided economy in mercury since the chamber for immersion is in the shape of a rectangular parallelopiped instead of a cylinder or sphere. The apparatus was designed primarily for measuring test pieces of a maximum size $7^1/_4 \times 3$ in. in connection with the development of methods of determining loss from a mechanical wearing test of leather. It has also been found to be very useful in determining the apparent density of leather.

A description of the volumenometer and photographs (Figs. I and II) follow: The immersion vessel consists essentially of the tank A and top B, both of cast iron and having accurately ground surfaces, C, so that the top, when clamped on by means of the bolts, D, make a mercury-tight joint. The tank A has a chamber, E, $1^1/_8$ in. wide, 8 in. long, and $3^1/_2$ in. deep, and the walls of this chamber are continued in the top B in such a manner that they converge to the small opening F in which is sealed, with shellac, the short thistle tube G. The top has two posts, H, to which the pieces to be measured are fastened.

In the metal tube I, which passes through the wall of the tank from the bottom of the chamber E, is sealed a heavy capillary glass Y-tube, J, fitted with the mercury-sealed stopcocks K. One arm of the Y-tube is connected with the bulb L, and the other arm with the burette M. Both the bulb and the burette are connected with the vacuum system.

By means of N and O the zero points on the two glass tubes may be easily adjusted to coincide with the level of the mercury, which may change slightly from time to time, due to temperature variations and mechanical loss. This adjustable zero device consists of a small threaded metal sleeve fastened on the glass tube and fitted with a nut. Resting on the nut is a loose-fitting glass sleeve having a fine graduation. By turning the nut the graduation on the glass sleeve may be raised or lowered as desired.

All metal surfaces to which the mercury would have access are treated with bakelite, and the entire apparatus is securely mounted on a large wooden tray. The bulb and burette are also properly supported.

The operation of the apparatus is conducted as follows: With the top removed and the stopcocks open, completely fill the tank with mercury, being careful not to form any air traps in the Y-tube. Then draw the mercury well up into the bulb and burette, and after closing the stopcocks add sufficient mercury to fill that part of the chamber in the top of the tank. Place the top in the tank and fasten it securely by the four bolts, D. By opening the stopcocks let the mercury down from the bulb and burette until it stands at the same level in all parts of the apparatus. Set the two adjustable zeros, N and O, so that the graduations on the glass sleeves coincide with the menisci of the mercury, and take the zero reading on the burette. Now draw the mercury again well up into the bulb and burette, close the stopcocks and remove the top. Fasten the piece to be measured onto the posts H (Fig. I), replace and secure the top. Open the stopcock communicating with the bulb L and let the mercury run down slowly to the zero mark at N on the stem of the bulb and close the stopcock. Then open the stopcock connecting the burette and allow the mercury to gradually lower until it fills the tank and rises to the zero mark at O on the tube G, close the stopcock and read the burette (Fig. II). The difference in readings will give the volume of the piece.

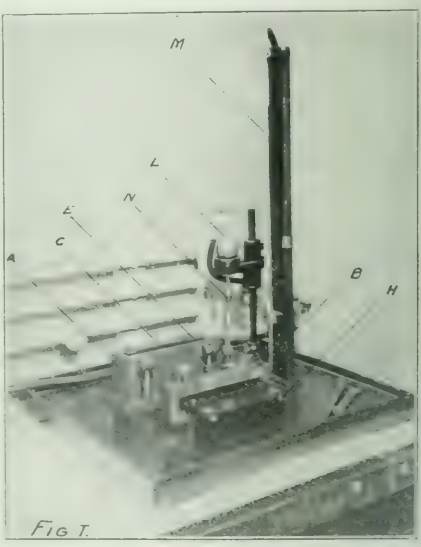


FIG I.

In making a series of measurements, if care is taken in removing the pieces so as to avoid loss of mercury, the zero reading and adjustments need only be made after about every eight measurements.

The dust and dirt which slowly accumulate on the surface of the mercury in the tank may be very easily swept off with a small camel's hair brush. In fact, a slight layer of dust is somewhat desirable as it forms an envelope around the piece when immersed and helps to prevent the absorption of mercury.

An objection to the apparatus is that it requires two persons to operate it most satisfactorily and expeditiously. Furthermore, unless care is exercised in removing the pieces some mercury is likely to be lost. No doubt a more satisfactory means of fastening the piece could be devised which would overcome the tendency to lose mercury which collects around the screws, and which would decidedly shorten the time required for securing and removing the pieces.

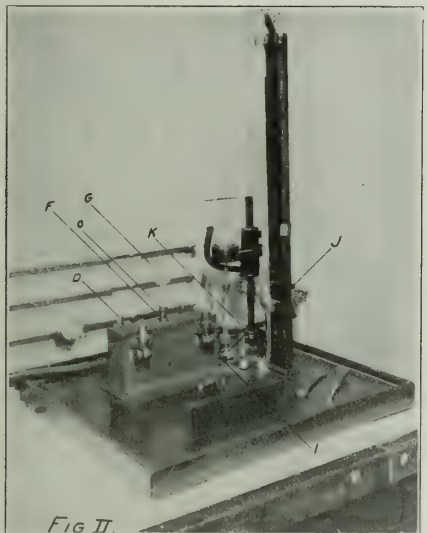


FIG II

A few of the measurements made with the apparatus are given here. These volumes were obtained on the same series of samples on different days, but always under the same temperature and relative humidity conditions of 70° F. and 65 per cent relative humidity, the apparatus being set up in the constant temperature and humidity room.

Samples	Volume in Cc.		Samples	Volume in Cc.	
S1	35.15	35.20	L3	40.05	40.05
S2	29.35	29.40	L4	39.80	39.80
S3	39.75	39.80	L5	42.95	42.95
S4	36.85	36.90	L6	47.85	47.90
L1	39.45	39.50	L7	37.20	37.20
L2	41.85	41.90	L8	34.40	34.40

A piece of hard rubber has been used as a standard to check the apparatus, and its volume determined at frequent intervals during a period of several months has ranged from 89.10 to 89.15 cc. The volume of this same piece calculated from loss in weight in water at 70° F. gave 89.14 cc.

CONCLUSIONS

An apparatus has been devised which is satisfactory for measuring the volume of comparatively large pieces of leather. The measurements can be duplicated and are reasonably accurate.

LEATHER AND PAPER LABORATORY
BUREAU OF CHEMISTRY, DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

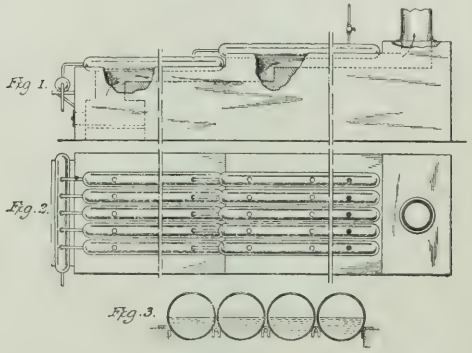
AN EVAPORATOR FOR ACID LIQUIDS

FOR THE ECONOMICAL EVAPORATION OF ACID LIQUIDS OR OF ANY LIQUID DISCOLORED BY CONTACT WITH METALS

By EDWARD HART

Received February 7, 1918

This system of evaporation for which United States letters patent have been granted but not yet issued (Application No. 202,189) is especially indicated where the solvent is water. The tubes (Fig. 3 is a cross-section) which may be of any number and of any desired size and length (3-in. glass tubes 4 ft. long are recommended for most purposes) are supported on gas pipe covered with asbestos paper as shown in Fig. 3; cross-stirrup supports are not shown. There



are three 1-in. openings in each tube to permit the introduction of liquid and the escape of steam. These openings may, of course, take the form of tubes, and the solvent may be condensed if desired.

The fire grate and course of the fire gases are indicated by the arrows in Fig. 1. Two, three or more sets of tubes may be used (two are shown) and the liquid warmed in the first set boils and evaporates in the second, and is collected and discharged by the end manifold, shown in Fig. 2, into crystallizers. The concentration of the discharged liquid is controlled absolutely and with great accuracy by the feed.

HART LABORATORIES
EASTON, PENNSYLVANIA

CONVERSION OF FORMULAS

By WILLIS H. COLE

Received February 8, 1918

In practically all industries in the United States pounds and gallons are still the units of measure, while in the laboratories of these factories the metric system is almost universally used. Thus the industrial chemist is called upon to make many conversions

of formulas as made on a large scale in pounds and gallons, into a size suitable for laboratory batches, in grams and cubic centimeters. I have seen many good chemists waste all the way from minutes to hours doing this, looking up conversion tables and multiplying. By aid of the following simple rule, great saving of time and accuracy is effected. Call the gallons cc., and multiply the pounds by 0.12 (for very accurate work, 0.1198) to get grams. These figures may then be multiplied by any factor which will give a convenient sized batch for laboratory purposes.

EXAMPLE I

	Varnish Formula Factors Batch	Conversion	Convenient Lab. Batch
Kauri Gum	100 lbs	12 g.	24 g.
China Wood Oil	10 gals	10 cc	20 cc.
Prepared Linseed Oil	4 gals	4 cc	8 cc.
Turpentine	25 gals	25 cc	50 cc.
Petroleum Spirits	7 gals	7 cc	14 cc.
YIELD	52 gals	52 cc.	104 cc.

In this case you will see that there are more ingredients measured by volume than by weight. Should this condition be the reverse, it is more efficient to change the rule, calling pounds, grams; and multiplying gallons by $8^1/_2$ (for very accurate work, 8.3455) to get cc. Here follows a formula to illustrate this method.

EXAMPLE II

	Flat White Enamel Factors Batch	Conversion	Convenient Lab. Batch
Zinc Oxide	90 lbs.	90 g.	45 g.
Lithopone	90 lbs.	90 g.	45 g.
Whiting	25 lbs.	25 g.	12.5 g.
Silica	25 lbs.	25 g.	12.5 g.
Varnish	50 gals	100 cc.	50 cc.
Benzine	16 gals	83.3 cc.	41.6 cc.
YIELD	28 gals	233.3 cc.	116.6 cc.

The factors used hold for U. S. Standard gallons only and not for Imperial gallons.

RESEARCH LABORATORY
MOLLER & SCHUMANN CO., BROOKLYN, N. Y.

ADDRESSES

TECHNICAL APPLICATIONS OF NEPHELOMETRY[1]

By PHILIP ADOLPH KOBER

I—INTRODUCTION

Something over two years ago I had the privilege and honor of reading a paper[2] before the New York Section of the American Chemical Society on nephelometry in which I gave briefly the history of photometric analysis and a description of the development of nephelometric instruments. At the invitation and with the encouragement of your honorable Chairman, Dr. Alexander, I shall now venture to put before you some technical applications of nephelometry, which, owing to war and other conditions, I regret, are not nearly as complete as I originally planned to have them.

As most of you know, the method is based upon the measurement of the brightness of the light reflected by cloud—in other words, by the particles in suspension—very much as in an ultramicroscope. The intensity of the light reflected is a function of the quantity of suspended particles, when other conditions are constant.

The principle of the nephelometer can best be shown by the diagrammatic sketch, shown in Fig. I.

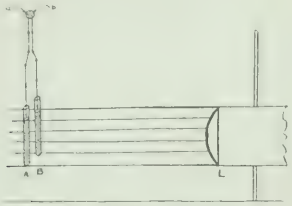


FIG. I

The path of light in nephelometer

Let A and B represent tubes containing a precipitate in the form of a suspension, and L represent a strong light which throws its uniform beam on tubes A and B at right angles; then *a* and *b* will be the light in the eyepiece due to the reflections from the two suspensions. If tube A, for example, contained distilled water and the instrument were perfect, no light at *a* would be visible. As soon as the smallest amount of suspension is produced in the tube A, light is obtained in *a* in approximate proportion to the amount of suspended matter. This light *a* is never measured absolutely, but is always matched at *b*, which is that reflected by the precipitate of a standard solution—a known amount of the substance to be determined dissolved in a known volume.

The matching of the two lights could be done by changing the standard solution step by step until it would be exactly that of the unknown. In practice this would be tedious and, therefore, instruments were designed to eliminate this in whole or in part.

Fig. II shows a diagrammatic sketch of such instrument and lamp house, and is known as a nephelometer-colorimeter,[1] because it is both a nephelometer and colorimeter.

Fig. III shows the instrument without the lamp house, particularly the scales, verniers, and the screw arrangement for raising and lowering the cups, which is used to match the reflected light from the suspensions.

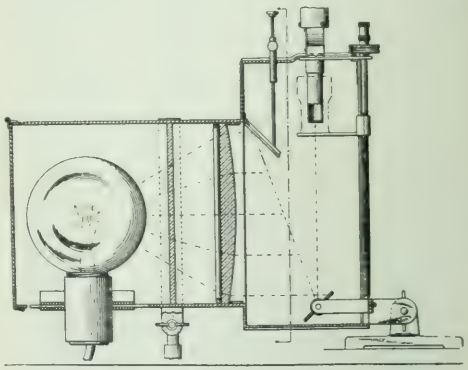


FIG. II

Lamp house and instrument, showing the concentrated filament lamp, air space, condenser, and lamp house. When the doors (not shown) are closed, no light is visible except in the eyepiece. The inclined angle of the instrument, which allows air bubbles to escape from underneath the plungers, and the exact position and angle of reflectors are not shown in the sketch.

[1] Lecture and demonstration given before the N. Y. Sections of the Society of Chemical Industry, American Chemical Society, and American Electrochemical Society, Chemists' Club, October 19, 1917.

[2] Kober and Graves THIS JOURNAL, **7** (1915), 843.

[1] *J. Biol. Chem.*, **29** (1917), 155.

Fig. IV is a photograph of the instrument, with solutions, or, better said, suspensions, viewed from the front.

The cups and plungers for this instrument are shown in Fig. V. The nephelometric cups have transparent sides and opaque bottoms, while the colorimetric cups have opaque sides and transparent bottoms.

In Fig. VI is shown the photograph of the instrument used as a colorimeter, where the adjustable reflectors are in position. The lamp switch may be seen in front, as well as the doors of the lamp house, which when closed cut off any glare from the source of light.

Before going over to the details of the applications, it may be well to point out briefly the correct use of the nephelometer and a few points on the production of nephelometric suspensions.

A large number of workers do not have favorable conditions when they first apply the nephelometer. The work should be conducted in the dark; glares from windows, doorways, and the like, as well as artificial lights, being just as bad for photometric work as for the moving picture show. Some laboratories have permanent special dark rooms, others portable dark rooms, while still others darken the regular laboratory with opaque shades. A few workers forget that the eye is a sensitive instrument, and by using it too much or too continuously, and not allowing a period of rest, like the standard electric cell, it can easily become polarized, or fatigued. When these precautions are taken photometry or nephelometry can be practiced all day without any special fatigue or eyestrain.

A few forget or overlook many of the following obvious details: They ignore the dust in the various parts of the optical equipment and fail to fill the cups, so that the cups are clean on the outside, which thus allows the light to be absorbed. They overlook the fact that any air bubbles and dust underneath the plungers reflect light. The zero point of the instrument, too, as illustrated in Fig. VII, is not adjusted to represent zero light, and other oversights are often present.

Probably the greatest source of error connected with nephelometry or colorimetry is practically an instrumental one, pointed out to me by Mr. Klett, head of the company[1] manufacturing this instrument. He found that most diaphragms or openings at the top of the eyepieces, even in the best of instruments, are too large. He found that by putting a small diaphragm of the size of a pinhole over the eyepiece, he could make one or the other side of the field of almost any intensity.

Only by putting the aperture over the optical center could he obtain equal illumination of both sides of the field. When he moved the pinhole 0.1 to 0.2 mm. to any side, as illustrated in Fig. VIII, he obtained black spots and sides in the field. What errors would be introduced by a nervous individual, who would probably never have the eye twice in the same position, or by a beginner doing the same, can easily be imagined. By the use of such a diaphragm, not only will many discrepancies in readings, such as an occasional off-reading, disappear, but the field will become more flat; and only by its use it seems can the instrument be accurately adjusted and used.

Time does not permit us to dwell on the production of colored solutions suitable for colorimetry, however interesting and important from both theoretical and practical standpoints. As we have pointed out elsewhere,[2] the chief requisite for making nephelometric clouds or colloidal suspensions, and for keeping them as such for a definite time, is that the substance be in a dilute solution, usually not stronger than 100 mg. per liter Therefore, to apply the method to large amounts of substance it is only necessary to dilute suitably. Clouds, produced by one part in 500,000 of liquid, may be determined quantitatively. In some cases one part in 2,000,000 can be easily determined.

[1] Klett Manufacturing Co., Inc., 202 E. 46th St., New York City.

[2] P. A. Kober and Sara S. Graves, "International Clinics," 24th Series, 2 (1914), 121.

Since the amount of substance may vary greatly it is important to know whether the nature of the precipitate imposes any limitations on the method. It is necessary to consider, therefore:

1. COLOR—If the precipitate is highly colored and remains in suspension, it is best determined colorimetrically; if slightly colored, it is best determined nephelometrically.

2. FORM OF PRECIPITATE—It must be colloidal in the form of a suspension. A large number of precipitates found in practical work are colloids, a number are partly so, while some are so entirely crystalloidal, such as barium sulfate, that they settle immediately. According to previous work published, certain solutions of protective colloids can be used, such as egg albumin and soluble starch, which cause crystalloids like barium sulfate and other partly colloidal precipitates to remain in suspension long enough for the application of this method.

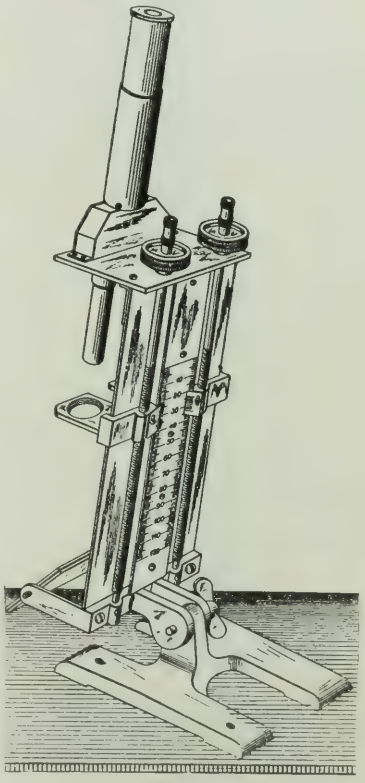


FIG. III

The new nephelometer-colorimeter, showing screw arrangement with adjustable verniers, also the double milled head. There are no open spaces through which dust may enter and light escape when fitted to the lamp house.

While the application of nephelometry is comparatively simple, the correct condition for producing and keeping the colloidal suspension, the fundamental condition of nephelometry, is by no means a simple matter, in spite of Harry Jones' statement[1] that "the colloidal solution or at most the colloidal suspension is the natural condition of solid matter when first formed as the result of a reaction."

[1] "New Era of Chemistry," p. 248. Published by D. Van Nostrand Co., New York City.

Although time does not permit us to consider the details of producing suspensions and the theory of nephelometry, which I hope to present in a special future communication, a few words and an illustration will help to make clear and emphasize the difference between theory and practice, and give an example of the unexpected difficulties encountered in developing nephelometric methods.

Silver chloride has been estimated as a suspension for a correction in atomic weight work since Mulder's time in 1859, yet the production of nephelometric suspensions of silver chloride is as yet far from satisfactory.

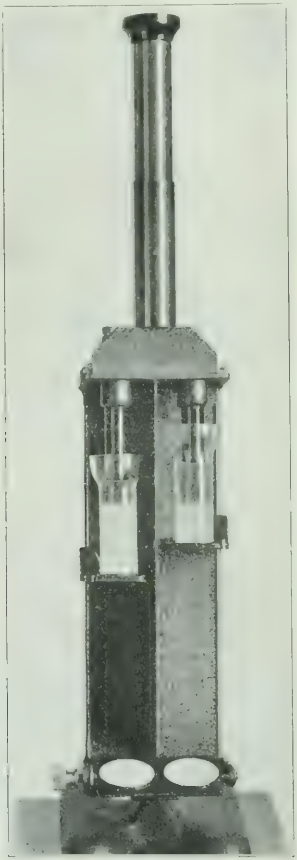


FIG. IV

The instrument used as a nephelometer viewed from in front, in the direction of light, showing standard solution on the right, unknown ready to be matched on the left

It has been assumed by the few adverse critics of nephelometric work, that when chlorides and an excess of silver nitrate are present in dilute solution, silver chloride must be formed, and, being one of the most insoluble substances, it must be in the form of a precipitate, and, therefore, impart reflected light. If the amount of light was changed or was not up to what was expected from previous experiments, the critics of nephelometry assumed that the light-reflecting properties of silver chloride changed. On this assumption they have made the sweeping conclusion that unless both the standard and the unknown were treated exactly the same and in the same medium, a difficult condition to realize, the nephelometric results would be inaccurate, if not valueless. The simpler assumption that a change in the amount of light indicated a change in the amount of precipitate seems not to have been considered at all.

But the following experiment will show that the nephelometric production of silver chloride is not as simple as the formula would indicate it to be. If we take a dilute solution of sodium chloride (0.0005 N = 0.030 mg./L) and add silver nitrate in gradationed amounts, keeping the volume constant, as shown in Fig. IX, we get silver chloride precipitate in all experiments.

But, as may be seen, the maximum cloud is obtained with one equivalent and the amount of precipitate decreases as the excess of silver nitrate is increased. Our experiments indicate that silver chloride in solution, before it precipitates, forms with silver nitrate an unstable, soluble complex, which slowly hydrolyzes, or decomposes, with the production of silver chloride. By adding the same excess of silver nitrate as in the weakest one, slowly, with stirring, the silver chloride is precipitated before it can form the soluble complex with silver nitrate, and, therefore, the maximum suspension is obtained even though the medium is chemically the same in the end as in the weakest suspension. In diluter solutions this phenomenon is still more marked.

It is interesting to note that Professor Richards, in his atomic weight work, avoided this source of error intuitively by allowing his silver chloride suspensions to come to an equilibrium by standing from 24 to 48 hrs. If our explanation of this phenomenon is maintained by further work, as these experiments would indicate, the adverse critics of nephelometry are without much, if any, experimental basis for their criticism. This experiment, like all heretofore, seems to show that the amount of light reflected by colloidal suspensions within moderate limits, *i. e.*, from the time the particles are formed until they are almost visible to the unaided eye, is a function of the amount of precipitate in suspension.

II —APPLICATION

The number of possible applications of nephelometry is too large for consideration here, and, therefore, a few representative estimations have been chosen, *i. e.*, three inorganic and three organic determinations: the estimation, respectively, of ammonia, phosphorus, calcium, acetone, oils and fats, and, finally, proteins. This choice was made not only to cover as broad a field as possible, but also to bring out the nephelometric peculiarities as well, especially the use of protective colloids.

While the "colloidal solution or at most the colloidal suspension is the natural condition of solid matter when first formed as the result of a reaction," as Harry Jones gives it in his book, yet it rarely, if ever, stays in that condition. In most cases it quickly agglutinates and settles, a condition unfavorable to accurate nephelometry. By adding a protective colloid we can delay the agglutination, or, to be more exact, decrease its speed sufficiently to make uniform and constant nephelometric conditions. The protective colloids vary considerably, not only in nature, but also in amount, as will be pointed out in detail in the rest of the paper.

Not all the details of making the reagents and solutions will be given in this paper, as recourse can be had to the original articles on the subject; but for these six analyses, all the steps, more or less, will be mentioned, so that from the six different analyses a clearer judgment may be formed of the value of nephelometric estimations.

a. AMMONIA ESTIMATIONS.—Nessler's reagent for ammonia, developed in the early part of the last century, was applied to water analyses in 1867. It has stood the test of time and has come to be used extensively, but with the development of color-

imetry its disadvantages as well as its value have become apparent and innumerable modifications of the reagent have resulted. Its instability and tendency to produce a cloud in dilute solutions are the chief difficulties.

Recently efforts have been made to apply the reagent in micro-Kjeldahl work, without previous distillation, with varying degrees of success; the precipitate due to salts makes the matching of colors, however, extremely difficult.

A probable explanation of why the colored solution produced by Nessler's reagent becomes cloudy, especially in the presence of salts, may be found in the following considerations:

1—Only the iodide complex of mercury and ammonia is highly colored.

2—The other complexes of mercury and ammonia, like the chloride described in this paper, are colorless insoluble compounds.

Therefore, in the presence of the other salts the colored iodide complex is probably partially changed to and in equilibrium with the colorless complexes such as the chloride or sulfate.

On this basis Sara S. Graves[1] developed a sensitive nephelometric reagent for ammonia as follows:

80.0 g. Sodium Chloride
130.0 g. Water
100.0 cc. Saturated Solution of Mercuric Chloride
Shaking until NaCl is dissolved, then add
70.0 cc. Saturated Solution of Lithium Carbonate (1.0 per cent)
Filter

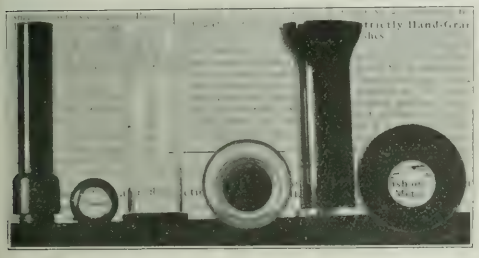


FIG. V

Showing construction and optical clearness of plungers (on the left), of the nephelometric cups (in the center), and colorimetric cups (on the right). The bottoms of all are fused on, though of glass having different coefficients of expansion.

To show the sensitiveness some reagent was added to a liter of water containing 0.006 mg. of ammonia. The cloud which was obtained means that we can detect one part of ammonia in 160 million parts of water.

For the purpose of illustrating how the instrument is used and how the results are calculated, suppose some precipitated standard solutions of ammonia were placed in the instrument. If we had simply added reagent to the known solution of ammonium sulfate, the precipitate would have become agglutinated before the observations were finished. Therefore, just before adding reagent a protective colloid is added. In this case for every 10 cc. of ammonium sulfate solution, 15 cc. of a 0.003 per cent solution of starch will keep the suspension from agglutinating and settling for about an hour. The standard solution contains 9.43 mg. ammonium sulfate, which is equivalent to 2.43 mg. ammonia, or 2.00 mg. nitrogen, per liter. When precipitated with 5 cc. of reagent the resulting suspension is put into both cups of the instrument.

If we put the left cup at any convenient height, say 20 or 25 mm., and move the other cup up or down until the light in the eyepiece, coming from both tubes, is equal, we find that the

[1] *J. Am. Chem. Soc.*, **37** (1915), 1171.

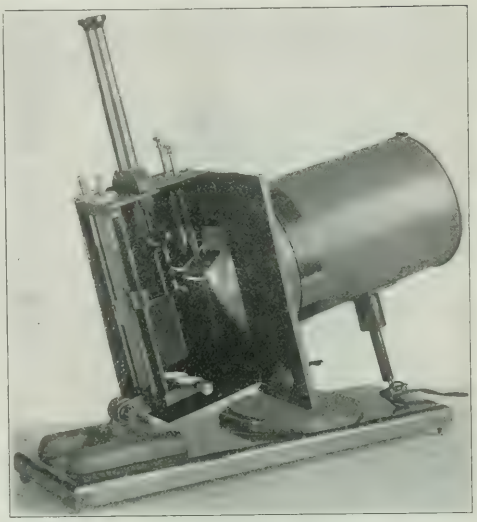


FIG. VI

Showing the instrument with lamp house used as a colorimeter; the adjustable reflectors are reflecting the light to the round instrument reflectors, which in turn transmit the light to the cups and instrument. The light switch can barely be seen on the front of the base.

height on the right is rarely, if ever, equal to the height set on the left side. It is in this respect like the zero point of the analytical balance; it must be determined from time to time, and is seldom constant for a long time. The reading on the right side we will denote as the standard reading, S, but the actual value on the left is of no consequence and may be considered as a tare, so long as it is constant. If in place of the standard on the right we now put another solution of ammonium sulfate, say 0.900 as strong as S, we find a higher reading. If we then put in 0.800, 0.700, 0.600 and 0.500 standard strength, we obtain, respectively, a series of corresponding readings. All of these readings except that from the standard S are indicated as Y in the curve and formula.

If we plot these readings on cross-section paper we obtain a curve which will be very useful in practical work. In Fig. X we have plotted the readings obtained from such a series of gradationed known solutions of ammonium sulfate solutions and drawn a curve through these points. Algebraically the curve is expressed by the formula $Y = \frac{S}{x} - \frac{(1 - x)Sk}{x^2}$, where $k = 0.052$ and $S = 20.0$. The lower curve, shown here, is the colorimetric curve where the readings are inversely proportional to the concentrations.

When the instrument changes so that a restandardization is necessary, the nephelometric formula obviates considerable work, especially the readings for and the drawing of a new curve.

Since the formula is complicated and many prefer to do without mathematical calculations, the following scheme can be used: The instrument is standardized as before, but the curve is used alone in getting the amount of substance equivalent to the readings. When the value of the standard readings changes, due to any change in the instrument, the height of the solution on the left side, the one used as a tare, is adjusted so that the original reading for S is obtained and, therefore, the original curve is applicable. It is equivalent to changing the zero point of a balance by adjustment so as to avoid calculation

In Fig. XI, the same curve is used for practical work, *i. e.*, in expressing the results in per cent of nitrogen, obtained in Kjeldahl nitrogen estimations, using 0.1000 g. of substance or sample.

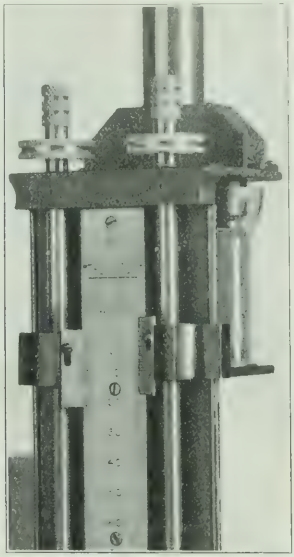


FIG. VII—SHOWING SCALE AND ADJUSTABLE VERNIERS

The one on the right shows the plunger touching bottom of cup, thereby giving more zero or color, with vernier in right position, *i. e.*, exactly on zero. The verniers can be put on zero by loosening the screw of vernier and moving vernier to right position after plunger touches the bottom of the cup, or its equivalent.

Suppose we had a Kjeldahl flask containing 20 cc. concentrated sulfuric acid, a little mercury or mercuric oxide as catalyzer and 0.1000 g. ammonium sulfate. As far as the nephelometric method is concerned, this could as well be the result of digesting an equal weight of almost any nitrogenous substance, such as a sample of fertilizer, leather, rubber, food, beer; any synthetic or natural organic substance, as aniline, dyes, drugs, etc. The melt is now dissolved in water and made up to 500 cc. Although the heat of dilution of sulfuric acid is sufficient to warm the solution considerably, we do not need to bring it to room temperature, provided, of course, we pipette an aliquot portion off at once at the same temperature. Any error due to high temperature in the flask will then be compensated by the same error in pipette and thereby automatically eliminated.

To 5 cc. of this solution are then added 5 cc. of *N* NaOH and then drop by drop of the same solution until it is neutral to litmus paper. The solution is then diluted to 200 cc. with ammonia-free water, and a 10 cc. portion is treated with 15 cc. of 0.003 per cent starch solution, precipitated with Graves' reagent (5 cc.), and matched against 10 cc. of standard solution (containing 2.0 mg. of nitrogen per liter) similarly treated. From the reading and the curve we can find out at once the exact per cent of nitrogen. In the first step we diluted to 500 cc.; and in the second step, when we took 5 cc. for a 200 cc. final volume, we diluted 40 times, thus giving a total volume of 20,000 cc., or 20 liters. If the standard reading S were 20.0 mm. we would get for the unknown 39.10 mm., which would give us 21.36 per cent nitrogen[1] in ammonium sulfate

[1] If the reagents contain ammonia a control estimation using about 1/10 the dilution of above, will give a correction, *i. e.*, a certain fraction of per cent to be deducted from the per cent of total nitrogen

Not only will this method save considerable time, but it will eliminate the expense, attention and errors connected with a bank of Kjeldahl stills

(b) PHOSPHORUS—The estimation of phosphorus in biological and industrial fields, especially of small amounts, is becoming of increasing importance. A large number of volumetric and colorimetric methods have been proposed but thus far none have been satisfactory for micro-quantitative work. While looking for a suitable nephelometric precipitant for phosphorus, Kober and Egerer's attention was called to the reagent developed by Pouget[1] and Chouchak. This reagent consists of a nitric acid solution of strychnine and molybdic acid and produces a very sensitive reaction with phosphates. Pouget and Chouchak found that it will detect one part of phosphorus in 20 million parts of water. As the precipitate is slightly yellow and remains in suspension for a long time, the authors have recommended it for a colorimetric reagent, but really the estimations were turbidimetric, *i. e.*, they measured the absorbed light of the suspension.

On studying the reaction carefully, Egerer and Kober found that (1) it was not constant and quantitative, and (2) the reagent gradually became yellow and deteriorated, probably because of the action of nitric acid. Pouget and Chouchak realized this since their directions state that the mixing of constituents must be made only just before using. After making many variations of all constituents, no marked improvement was obtained, but on substituting hydrochloric for nitric acid, the solution not only remained practically colorless for an indefinite length of time, but was stable and gave quantitative and constant results.

VARIATIONS IN DIAPHRAGMS OF COLORIMETERS AND NEPHELOMETERS

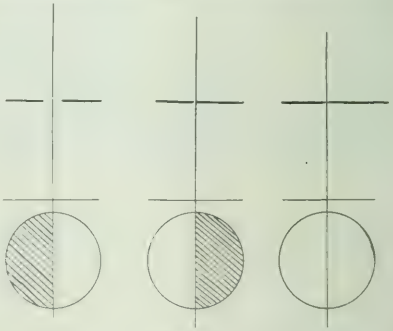


FIG. VIII

Showing a wide aperture as found in most instruments (on the left), next a pinhole aperture off optical center. The pinhole aperture (to the right) in correct position.

The directions for making Kober and Egerer's nephelometric reagent for phosphorus[2] are as follows:

150.0 g. Sodium Molybdate
250.0 cc. Water
100.0 cc. Hydrochloric Acid (1–1)
Add slowly with shaking
150.0 cc. Strychnine Sulfate Solution (2.0 per cent)
Filter

Protective action in addition to any produced by the strychnine does not seem to be necessary. The reagent is so sensitive that ordinary filter paper cannot be used for filtering the reagent, as it extracts from it a substance which seems to be a phosphorus compound, gradually giving a very marked phosphorus reaction.

An idea of its sensitiveness may be obtained by the following

[1] *Bull. soc. chim.*, **5** (1909), 104; **9** (1911), 649.
[2] *J. Am. Chem. Soc.*, **37** (1915), 2375.

experiment: A solution of potassium phosphate, containing 0.0125 mg. of phosphates, 0.003 mg. phosphorus per liter, still shows the reaction very plainly which means one part in 333 million parts.

As an example of its usefulness for technical purposes the determination of phosphorus in a sample of cast iron will be described briefly. The weighing of the sample, its solution in nitric acid, and the elimination of the nitric acid by boiling a few minutes with an equal volume of sulfuric acid require but a few minutes for completion.

The actual details are as follows:

Two (2.00) g. of cast iron borings were dissolved in 100 cc. of $^1/_3$ nitric acid by boiling. After cooling under the tap the solution was brought up to 100 cc. and 5 cc. taken and boiled for 2 min. with 5 cc. of concentrated sulfuric acid. This mixture is then diluted to 100 cc. and filtered through a dry, acid-washed filter paper and 25 cc. are again diluted to 100 cc. 10 cc. are now treated with 35 cc. of 0.5 *N* HCl and precipitated with 5 cc. of reagent. On matching in the instrument with a standard containing 5 mg. of KH_2PO_4 per liter the percentage[1] of phosphorus can be obtained from a curve made similarly to one shown with ammonia.

(*c*) CALCIUM—The estimation of calcium, owing to its wide distribution, is of considerable importance, and, therefore, simple and rapid methods of estimation would be very valuable. Lyman first sought to solve this problem by the nephelometric estimation of calcium oxalate, but was not able to obtain satisfactory results. He then tried, after a preliminary separation of the magnesium, to precipitate the calcium as a calcium soap. This method gave excellent results. It reduced the time required in certain calcium estimations from 3 days to 2 hours for a set of four estimations.

Lyman's nephelometric reagent for calcium[2] is made up as follows:

4.0 g. Stearic Acid
0.5 cc. Oleic Acid
400.0 cc. Alcohol (95 per cent)
Boil, add
20.0 g. Ammonium Carbonate in
100.0 cc. Hot Water
Boil, cool, add
400.0 cc. Alcohol (95 per cent)
100.0 cc. Water
2.0 cc. Ammonium Hydroxide (sp. gr. 0.90)
Filter

To show its sensitiveness the following experiment is made: A solution of calcium oxalate in nitric acid containing 0.2 mg. of calcium per liter still gives a decided reaction, which is one part in 5 million.

For the estimation of calcium in milk, 10 cc. are diluted to 100 cc. with distilled water. Five cc. of this mixture are then treated with 15.0 cc. of 6.5 per cent trichloracetic acid, which precipitates the proteins, and filtered. The calcium is now precipitated as oxalate by McCrudden's method,[3] redissolved, and the calcium determined after precipitation as soap, nephelometrically.

Twenty cc. of standard calcium oxalate solution (dissolved in nitric acid) containing 0.4 mg. of calcium are poured into 50 cc. of Lyman's reagent and gently shaken. This cloud is used for matching an unknown treated in a similar manner. Here, as in the other estimations, only a few circumventions are necessary to eliminate interfering substances.

In this precipitation oleic acid acts as a protective colloid, a small amount delays the agglutination for hours.

(*d*) ACETONE—Marriott has applied the extremely sensitive Scott-Wilson reagent for the nephelometric estimation of acetone. The acetone in each case may be distilled from the original solution into the reagent or may be aerated[1] at room temperature into sodium bisulfite solution, and then estimated nephelometrically.

The composition of Marriott's nephelometric reagent for acetone[2] is given as:

10.0 g. Mercuric Cyanide
180.0 g. Sodium Hydroxide
1200.0 cc. Water, shaking, slowly add
400.0 cc. Silver Nitrate (0.73 per cent)
Filter

To show the sensitiveness of the reagent, a solution of freshly distilled acetone containing 0.010 mg. per liter still gives a marked reaction, which is one part in 100 million.

The standard and unknown solutions are precipitated by distilling into 50 cc. water and 15 cc. of Marriott's reagent, 0.5 mg. of acetone and finally making the solution or suspension up to 100 cc.

Standard solution if made with $N/4$ sulfuric acid so that it contains 0.5 mg. of acetone in 10 cc. will keep for a few weeks at least. Without $N/4$ acid the acetone solutions quickly polymerize.



FIG. IX—SILVER CHLORIDE SUSPENSIONS

The one on the left made by slowly adding 5 Eq. $AgNO_3$ solution with shaking or stirring. All the other equivalents were added at once. Unfortunately, the large volumes photographed, which are more or less opaque, make it difficult to see the differences, except where it shows the curvature of the bottoms.

As may be observed no additional protective colloid is added, as the organic nature of the complex is sufficient protection or, to be exact, makes the speed of agglutination low.

(*e*) FATS AND OILS—In quantitative work where the precipitate is easily thrown down, easily washed, and easily dried and weighed, gravimetric analysis imposes no difficulty, although it may fail to estimate small amounts. Fats and oils are difficult to filter and to free from solvent and, therefore, Bloor devised a nephelometric method which overcomes these obstacles. The fat or oil is extracted with an alcohol-ether mixture and then poured into water, when the fats or the oil separate out in fine globules or suspensions. Bloor's nephelometric reagent for fats[3] is made up as follows:

250 cc. Redistilled Ether
750 cc. Redistilled Alcohol
As accessory
500 cc. Normal Sodium Ethylate

Five-hundredths of a milligram (0.05 mg.) of fat can be easily determined quantitatively, and a marked cloud is produced by one part in a million.

The usual standard and unknown are precipitated by running 5 cc. alcohol-ether solution containing 2.0 mg. of fat or oleic acid into 100 cc. of water and, after adding 10 cc. of 1 : 4 HCl and gently stirring or shaking and allowing to stand for 5 min., are read in the nephelometer.

Murlin and Riche[4] have modified this method by pouring the fat solution into 0.05 per cent gelatin solution.[5] These authors

[1] A check on the purity of reagents should also be made by a blank estimation and corrections made if necessary.
[2] *J. Biol. Chem.*, **29** (1917), 172.
[3] *Ibid.*, **10** (1911), 187.
[1] Folin, *J. Biol. Chem.*, **18** (1914), 263.
[2] *Ibid.*, **16** (1913), 289.
[3] *J. Am. Chem. Soc.*, **36** (1914), 1300; *J. Biol. Chem.*, **17** (1914), 377
[4] Private communication.
[5] 1 g. gelatin in 2 liters of water with 5 cc. glacial acetic acid

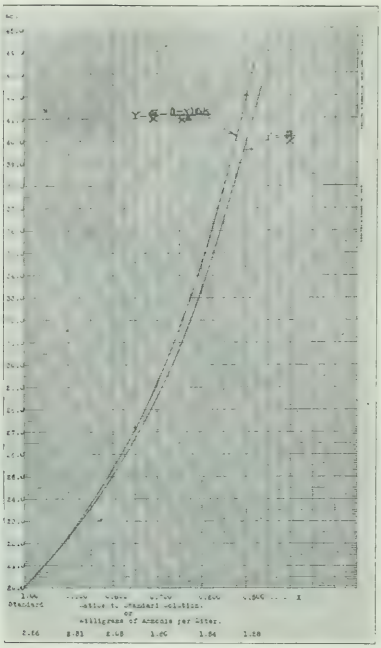


FIG. X

Showing a nephelometric curve (upper) and a colorimetric curve (lower). The abscissas give the concentrations of substance, in this case of ammonia; coördinates give the readings, *i. e.* the heights of solutions. Greater accuracy can be obtained by drawing curve to a larger scale.

found that the addition of this small amount of protein as protective colloid delayed the coalescence of the fat globules and thereby enabled them to keep the suspensions photometrically constant for hours.

Woodman, Gookin and Heath[1] have worked out a similar method for the essential oils.

The solvent and extracting medium for essential oils is alcohol alone and 5 cc. of the standard solution containing 100 mg. in 100 cc. 95 per cent redistilled alcohol are precipitated by pouring into 25 cc. of water, or better 25 cc. of 1 : 4 HCl.

By adding acid as used in the Bloor method, I found that one could use a much weaker standard than the authors recommended and still get suitable nephelometric clouds. They were able to estimate the oils of roses, peppermint, anise, and nutmeg nephelometrically with ease and accuracy.

J. PROTEINS—Proteins like other colloidal substances are extremely difficult to filter, and when filtered are rarely free enough from adsorbed substances to be useful for gravimetric work. Also they are dried only with difficulty. The application of nephelometry to protein estimations has been found to be fortunate for two reasons: 1. It enables us to estimate small amounts of proteins easily since nephelometry fits protein suspensions as a key does a lock. 2. because protein suspensions were so easily produced and maintained that the possibility of nephelometry as an accurate method of analysis became apparent, just as the difficulties mentioned with silver chloride prevented, without much doubt, the adoption of nephelometry for twenty or more years. The former give a true picture and the latter a false picture of its possible accuracy and general usefulness. Kober's nephelometric reagent for coagulable proteins[1] consists of:

2,000.0 cc. Sulfosalicylic Acid
For Casein, 0.3 per cent
For Globulins, 0.6 per cent

Time does not permit me to go into all the details of protein estimations, so only a test of its sensitiveness will be given.

A protein solution containing 1.0 mg. of protein per liter still gives a marked test which is equivalent to 1 part in a million.

In milk the fat is first removed, by adding to the diluted milk (5 cc. of milk in about 200 cc. of water) 10 cc. *N*/10 sodium hydroxide, making it up to 250 cc. and shaking with ether. As further details will be found in the original communication,[2] nothing more will be said except that the nephelometric method reduced the time for the estimation of casein, globulin, and albumin in milk. It requires from 2 to 3 days, if it is done according to the usual technic, whereas with the nephelometric method it can be done in 20 to 30 min.

III GENERAL DISCUSSION

There are many more applications which have not been touched upon, but their development and their application to analyses do not differ essentially from those just given.

It will be observed that practically all of them are of the nature of an organic complex, *i. e.*, the precipitate has an organic constituent in its composition. In gravimetric analysis this would not be an advantage, since it is necessary as far as possible to have the precipitate in relatively large masses for filtering and in a condition easy to dry. In many cases the occlusion and adsorption in gravimetric precipitates is very appreciable.

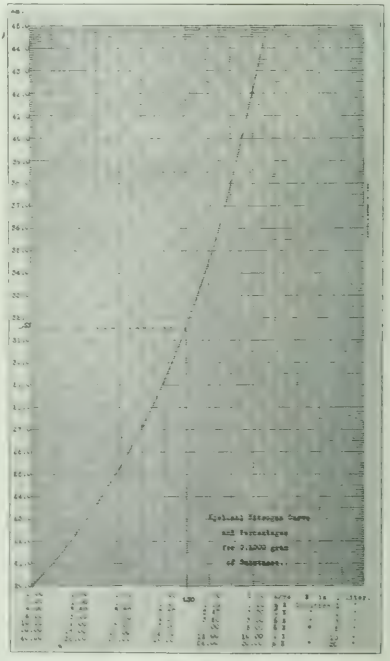


FIG. XI

Showing a similar nephelometric curve but with the abscissas giving the per cent of nitrogen per 0.1000 g. of sample. Greater accuracy can be obtained by drawing curve to a larger scale.

[1] THIS JOURNAL, **8** (1916), 128.

[1] *J. Am. Chem. Soc.*, **35** (1913), 290.

[2] *Ibid.*, **35** (1913), 1589.

In nephelometry, however, occlusions are of no consequence as the standard, having practically the same occlusion or adsorption, would cancel the error. Of course, it does not follow that occlusion or adsorption in nephelometric precipitates causes any difference in the amount of reflected light, as the occlusion may be in a dissolved phase, and, therefore, would not reflect light. Furthermore, as organic reactions as a rule are more specific, and, therefore, more accurate, nephelometry and colorimetry enable us to make use of organic substances, which means that our sources of reagents and possible methods are unlimited.

The great advantage of nephelometric analysis over gravimetric, outside of the enormous saving in time and labor as well as in material, is in its more complete control over the media of precipitation. By the great dilution necessary ordinarily in nephelometry, color and other interfering substances are so reduced that they seldom play a rôle.

The accuracy obtainable in nephelometry, as the instruments and methods steadily improve in efficiency, is growing rapidly. With the instrument, as it now is, when properly adjusted and used, it is not difficult to obtain an accuracy of 0.25–0.50 per cent in a single reading, and with two to three readings 0.1–0.2 per cent. Not all nephelometric suspensions have been developed, however, so that the maximum accuracy of the instrument is utilized. As in gravimetric work, the accuracy obtainable in final results depends on the particular method and precipitant, as well as on the balance. As we have become so accustomed to gravimetric work, to agglutinate or crystallize our precipitates, it is difficult for most of us to consider doing our work in an exactly reverse way. Like all other methods it takes time to get accustomed to a new way of doing things, no matter how good or convenient it is. Much more progress is made when the new way is the only way an experiment can be done at all. We all know when once an old method has been entrenched, as it were, by custom, it takes considerable time for the new to find its way into favor, irrespective of its merits.

Much more work remains to be done, especially the study, from as many angles as possible of the quantitative production of suspensions.

Almost all colloidal chemistry, heretofore, the theoretical or practical study, especially that of colloidal suspensions, has been qualitative and not quantitative. We need a great deal more information about quantitative colloidal chemistry for nephelometry to find its greatest usefulness.

How many more applications nephelometry will find in applied and quantitative chemistry the future alone will tell. This much we are sure of: the nephelometric method must be used for colorless colloidal suspension and for the accurate determination of amounts of material which give no delicate color reaction and are too minute to filter, but which are daily commanding our interest and attention. The use of the method has already been extended to all classes of substances and since, by careful work, considerable accuracy can be obtained, its application promises to be general in the different branches of chemistry.

SUMMARY

To sum up, attention has been called to the following:

I—A few erroneous conceptions about nephelometry and the pitfalls of many beginners in nephelometry.

II—The great sensitivity of:

(*a*) Graves' nephelometric reagent for ammonia, which is able to detect 1.0 part of ammonia in 160 million of water and its usefulness in various tests and Kjeldahl estimations.

(*b*) Kober and Egerer's nephelometric reagent for phosphorus which will detect 1.0 part in 333 million of water and its usefulness in various tests and in phosphorus estimations applied to iron and steel as illustrated by an experiment.

(*c*) Lyman's nephelometric reagent for calcium which will detect 1.0 part in 5 million of water and its usefulness in various tests and calcium estimations applied to water and milk.

(*d*) Marriott's nephelometric reagent for acetone which will detect 1.0 part in 100 million of water and its usefulness in determining acetone quantitatively applied to various distillates.

(*e*) Bloor's method for estimating fats and oils with which 0.05 mg. of fat can be estimated quantitatively and the presence shown of 1.0 part of fat in a million of water, its usefulness in nephelometric fat estimation in milks, and its application in Woodman, Gookin, and Heath's nephelometric estimation of essential oils.

(*f*) Kober's nephelometric method of estimating proteins which will show the presence of 1.0 part of protein in a million parts of water.

III—The advantage of nephelometry, its possible accuracy, its enormous field, and its possible future.

DIVISION OF LABORATORIES AND RESEARCH
STATE DEPARTMENT OF HEALTH
ALBANY, NEW YORK

MUNICIPAL CONTRIBUTION TO CONSERVATION THROUGH GARBAGE UTILIZATION[1]

By EDWARD D. VERY

The word "garbage" is commonly used indiscriminately to define any kind of refuse and is generally considered as a synonym for "offal," but for the purpose of this paper it is used to define the waste of both animal and vegetable matter which results from the preparation of food for human consumption. It is further limited to that portion of this class of waste which is collected and disposed of as a municipal function.

When we take into consideration the fact that this material results from action governed by no set rule or regulation and is, in fact, subject only to the whim of the individual, there would seem to be no general statement possible as to the constituents of garbage, and yet it is found that this class of material, as it is collected in different parts of the country, does not vary widely in quantity per capita, weight per unit of volume, or in mechanical or chemical analysis, and it is possible, within reasonable limits, to make a statement of the average content of garbage.

The average quantity of garbage produced per capita per day is one-half pound.

The average weight of garbage is 1100 lbs. per cu. yd.

The average sample of garbage contains:

16 per cent animal matter
79 per cent vegetable matter
5 per cent rubbish

and it analyzes, approximately:

70 per cent moisture
20 per cent tankage
3.5 per cent grease
1.5 per cent bones
5 per cent rubbish

Published analyses from the cities of New York, Cleveland, and Washington show this comparison as follows:

	New York	Cleveland	Washington
Pounds per capita per annum	181	193	286
Pounds per cu. ft.	41	49	47
Moisture, per cent	67	76	74
LABORATORY ANALYSES			
	Per cent	Per cent	Per cent
Ether extract	4.85	4.00	5.00
Phosphoric acid as P_2O_5	0.59	0.24	0.39
Nitrogen, Kjeldahl method	0.94	0.64	0.71
Potash as K_2O	0.33	0.30	0.28

The figure here given for the pounds per capita per annum for Washington seems at variance with the others, but it must be remembered that this city has an enormous floating population which produces garbage but is not considered in the census. Then, too, in Washington practically all of the hotels and res-

[1] Read before New York Section, American Chemical Society, May 10, 1918.

taurants have their garbage collected by the municipality, whereas in some cities the garbage is not so collected, but is taken by private collectors, under an arrangement with the proprietors of these establishments.

The quantity of garbage produced varies by seasons very materially, the maximum daily amount being collected during the summer months when vegetables and fruits constitute the principal diet, and the minimum amount being collected during the winter months. Usually August is the highest month, with about 11 per cent of the total annual amount, and February the lowest month, with about 6 per cent. The moisture content is high in percentage in the summer months and low in winter, whereas the grease content and the chemical plant food values are low in the summer and high in winter, for obvious reasons.

Fresh garbage, as it reaches the can, will remain, in ordinary weather, at a temperature of about 70° F. for from 12 to 14 hrs. before any change takes place. From that time alcoholic fermentation sets in and this will continue for another period of, approximately, 12 to 14 hrs. If the can is loosely covered, acetic acid fermentation develops, but if cans are fairly well closed, the alcoholic fermentation continues for about 36 hrs., when there is practically no further action. There is no decomposition of the animal matter, as that is inhibited by the alcoholic fermentation. By test it has been found that in garbage which has remained in the can under ordinary temperatures for from 3 to 4 days, and even as long as 21 days, the free fatty acids of the grease are not more than from 5 to 7 per cent, whereas where matter of a like nature is subjected to putrefactive action, the grease analyzes from 30 to 40 per cent of free fatty acids, which indicates the absence of decomposition in ordinary garbage as it is contained in the can.

The fermentation noted develops small amounts of alcohol and acetic acid, with slight changes in the vegetable oils, but none in the animal oils.

The sour odor of garbage is the result of this fermentation developing acetic acid, together with certain fruit esters, aldehydes, and alcohol.

We have then a material made up of a combination of moisture, fat, starch, sugar, albuminoid and nitrogeneous bodies, cellulose, and ash. The problem is to recover from this mass whatever may be of value, in the most economical manner, having at the same time due regard for the sanitary requirements.

Disregarding the method of final disposition of municipal wastes which attempt no reclamation of by-products, we find the methods which have been adopted for the treatment of garbage, as herein defined, are pig feeding, or some mechanical treatment commonly known as reduction.

According to the latest statistics, there are in the United States, 75 cities of 90,000 population and upwards; of these, 13 resort to dumping or burial, 21 have incinerators, 11 feed to pigs, 6 sell or give to farmers, probably to be used for pig feeding, and 24 use a reduction process.

Those who have reduction plants are:

Boston, Mass.	Baltimore, Md.
New Bedford, Mass.	Washington, D. C.
Bridgeport, Conn.	Akron, Ohio
Buffalo, N. Y.	Cincinnati, Ohio
New York, N. Y.	Cleveland, Ohio
Rochester, N. Y.	Columbus, Ohio
Syracuse, N. Y.	Dayton, Ohio
Utica, N. Y.	Toledo, Ohio
Philadelphia, Pa.	Indianapolis, Ind.
Pittsburgh, Pa.	Chicago, Ill
Reading, Pa.	Detroit, Mich
Wilmington, Del	Los Angeles, Cal

The feeding of garbage to pigs is a matter which caused considerable discussion, both as to its economical phase and also as to its propriety from the standpoint of sanitation.

Tersely, the advantages of pig feeding have been stated as "using the pig as a middle-man, we find that 25 per cent of the protein and 45 per cent of the total energy is returned to the consumer as pork. The pig charges 55 per cent brokerage for converting vegetable protein and fat into animal protein and fat."

Of course, we must remember that there is a considerable portion of the garbage that the pig will not consume, such as fish scrap, fruit skins, coffee grounds, and miscellaneous rubbish. Then, too, the garbage must come to the piggery fresh, especially in the summer time.

Again, there is the menace of hog cholera, or the foot and mouth disease, which may cause the total loss of "plant." To be sure, modern science is ready with methods of prophylaxis, which may prove a safeguard, but there is always the peril of slip-shod methods, which result in a partial or complete loss.

The United States Food Administration, in a booklet entitled "Garbage Utilization," issued in February 1918, says:

"We have indicated that the reduction process is hardly suitable for cities of under 100,000 population. A proper question would be, is pig feeding more applicable to cities now reducing than the reduction process?

"In so far as the monetary return applies, the two methods are practically identical. The reduction process possibly has the advantage of improvement to a greater extent than pig feeding. By improving the breed of the hog, gains might be made more economically, but the reduction process requires only simplified machinery, or additional recovery to make a ton of garbage more valuable.

"It also seems that the larger the city the less adapted its garbage to pig feeding. One might say that smaller cities were better managed, but it is obvious that the difficulties of controlling materials placed in the garbage increase more rapidly than does the population. Although a pig is blessed with a digestive system capable of assimilating almost anything, its efficiency cannot be compared with the mechanical digestors of the reduction plants.

"While from a purely conservation standpoint, pork production may seem more important than the production of grease and fertilizer tankage, the use of the grease recovered releases an equivalent amount of edible oils, while our stock of agricultural fertilizers is so depleted, at the present time, that fertilizer tankage is a national resource not to be overlooked.

"The test of the practicability of the feeding method of disposal is the selling possibilities of the pork produced. There is no benefit in feeding if the pork is unfit for food, or if a popular prejudice will prohibit it from selling freely.

"We have not been able to find any market where garbage-fed hogs are being sold at a lower price than grain-fed animals.

"There is at present a mistaken idea throughout the country as to the value of garbage. In a large number of cases it is a question whether the value will be sufficient to pay the cost of collection and transportation. Where collection and disposal both are to be made by the contractor, we doubt if the work will be done without cost to the city, unless the quality of the garbage is exceptional, and there is keen competition for the material.

"The ratio of 1 lb. of marketable pork to 50 lbs. of garbage has already been established. With pork on the hoof at 15½ cents, this would give a gross feed value of $6.20 to a ton of garbage. In a general way, it is safe to assume that the cost of disposal, after the farm is reached, including overhead charges at the farm, would not exceed $3.00 per ton."

Reduction processes now in use in this country are of three types, the drying method, the cooking method, and the Cobwell process.

In the drying method the green garbage is first deposited on a floor or belt to facilitate the picking out of the bottles, tin cans, and similar refuse. The material is then fed into a disintegrator, either of the chopping or the crushing type, wherein the garbage

is ground to a fairly uniform size throughout, to allow of efficient drying and percolating action. From the disintegrator the material passes through a direct heat dryer so that the moisture content may be reduced. It is then fed into a percolator, in which, by the action of a solvent, grease is taken out and reclaimed, leaving a resultant tankage fairly free from both grease and moisture.

The dryer consists of a revolving cylindrical steel shell, fitted with lifting vanes, which keep the material moving toward the discharge end and at the same time draw it to the top of the cylinder and drop it in a film through the hot gases, which are passing through the dryer from a furnace to the stack.

The percolator may be either of two styles, a stationary vertical or a horizontal rotary.

The former consists of a cylindrical tank, into which the garbage is fed through an opening at the top. When filled sufficiently, a heated solvent is introduced through perforated pipes at the top, and this solvent percolates through the mass and is withdrawn at the bottom, taking with it the grease which it has absorbed in its passage. This introduction of solvent is repeated until the outgoing liquid appears to carry too little grease to warrant further attempt at recovery. Live steam is then introduced into the percolator at the bottom, in order to drive off, so far as possible, the solvent which has been taken up by the tankage. The tankage is then taken out of the percolator, through a door near the bottom, by means of a hoe, rake, or some similar tool.

Results from the stationary vertical percolator are unsatisfactory, principally because the solvent jets usually form channels through the material by which the remaining solvent finds its way to the bottom without having been in contact with a considerable portion of the material being treated, thus resulting in an incomplete recovery of the grease. Similar channels are formed by the steam, thus giving an equally incomplete result in the driving off of the retained solvent.

The horizontal rotary percolator consists of a cylinder, having three openings on one side for receiving and discharging the tankage. There are three pipe sections running the full length of the cylinder inside, perforated for the spraying of the heated solvent on to the material being treated. There is also a burlap-covered strainer-plate, made of brass cloth, extending the full length, and so supported as to form a chamber beneath, into which the saturated solvent, after passing the strainer, passes to an outlet at one end of the cylinder. There are vapor lines for the introduction of the steam.

The operation of this percolator is as follows:

The percolator is charged by feeding the material to be treated through the three charging openings. The covers of these openings are then put in place and securely bolted. The cylinder is then revolved a one-quarter turn, thus bringing the solvent pipes to the upper side and the strainer chamber to the lower side. Heated solvent is then pumped into the cylinder in sufficient quantity to fill all the voids and to completely submerge the material. This solvent is allowed to stand for about 10 min. and is then withdrawn by pumps, after passing through the material, becoming thoroughly saturated, and passing through the strainer. This operation is repeated until the outflowing saturated solvent appears to carry insufficient grease to warrant further attempt at reclamation. After the final washing and after all solvent possible has been withdrawn by the pumps, live steam is introduced into the cylinder under a pressure of from 15 to 20 lbs. per sq. in. This pressure forces out the major portion of the remaining solvent through the strainer. The cylinder is then revolved so that the three openings are at the bottom and the tankage is emptied through them onto the floor or into a conveyor.

The saturated solvent from the percolator, in either case, is piped to a still, wherein, by the application of heat, the solvent is driven off as a gas, leaving the grease to be withdrawn, separated from any water present by gravity, and then barreled for shipment. The vaporized solvent is then condensed and re-used.

The last two washings are usually used for primary washing in succeeding treatments because they are imperfectly saturated.

The tankage from the percolator is passed through a dryer and thence to a screen and that portion which fails to pass through the screen is taken to a grinder and pulverized and again sent to the screen.

This method is practically the first used in this country and is still in use in Chicago, Allegheny City, and Buffalo. It is the cheapest when first cost is considered, but the results are in proportion to its cost of installation, and so, while as an investment it may prove satisfactory, it still does not give the full possible recovery of grease. In the drying of the material, carbonization takes place, which affects the quality of the grease and tankage adversely, and also in this part of the process there is a very considerable loss of ammonia.

This method is operated with a considerable resultant nuisance from odors because of the great volume of gases passing off from the dryers, which cannot be economically deodorized.

According to test made in Chicago, which is probably representative, by this process, 46 lbs. of grease per ton were recovered.

In the cooking method the garbage is picked over for the removal of the glass, tin cans, etc., and is then fed into large vertical tanks, known as digestors or autoclaves.

These tanks, when filled, are sealed by a bolted cap, a small quantity of water is added, live steam is introduced and the mass is cooked, under pressure, until the whole has become a pulpy mass, with the grease sacs ruptured and the entrained grease released. The material is then pressed to express what moisture can be mechanically released, the material then passes to the dryer, thence to the percolator, to the redryer, the screen, and then to storage.

The expressed moisture is piped to a settling tank or basin, wherein the grease separates by gravity, is skimmed or pumped off and placed in tanks to allow the final separation of the grease from whatever slight amount of water is present, and then the grease is drawn off and barreled.

These types vary usually and only in the manner of pressing.

In one type the pressing is done in the tank, there being a perforated plate fitted just above the bottom, and pressure is obtained by the introduction of live steam at the top, resulting in the material being compressed and the expressed liquid being forced through the perforations to the pipes leading to the settling tanks or basin.

Another uses a roller press, having an endless perforated metal belt, which, after receiving the material, passes between rollers, causing the fluid to pass through the perforations to the pipes leading to the settling device.

Another uses the old cider press, wherein the mass is fed into forms made up of slats covered with burlap, which are built upon a car and are then placed under a hydraulic ram, causing the expression of the liquid through the burlap.

Then there is the curb press, wherein the material is fed into a latticed steel basket, which later is run under a hydraulic ram.

The steam cone press is also used. This press is in the form of two bottomless cones, lying horizontally, with their bases meeting, and fitted with a bottom of perforated plates. After the material has been fed into this form, steam is applied and the liquid is forced through the perforations.

The operations of this method, which follow the pressing, are similar to those described for the drying method after the disintegration, except that some operators attempt the reclamation of valuable portions of the tankage which are carried away in suspension by the expressed liquid. This reclamation is made up by the use of triple-effect evaporators and results in a gelatinous material, known as "stick," which is added to the tankage before drying and adds something to the fertilizing value.

In the cooking method, the material being subjected to pressure and high temperatures gives a resultant grease wherein the free fatty acids and glycerin are split to a great extent, causing a considerable loss of glycerin, and unsaponifiable bodies are

formed to an undesirable extent. Then, too, the starches and sugars are changed to glucose and dextrin and are more or less caramelized and even carbonized, leaving them indigestible and of small nutritive value. The albuminoids are broken up and rendered difficult of digestion. The final product is made up principally of cellulose fiber with small amounts of nitrogen and bone phosphates. This material is under suspicion as a fertilizer as to its availability because of the length of time necessary for the chemicals to be released in the soil.

This method is in use in all of the cities of the country using reduction methods, except those noted above and New York, Los Angeles, and New Bedford.

The operation of this method is usually the cause of considerable complaint because of the odors which arise from the emission of gases, fumes, and liquids consequent to the different processes, but there are reasonable means for the elimination of those noxious features which can be used, although their use entails a consequent reduction of the value of the reclamations.

Reclamation of grease by this method varies from 50 to 80 lbs. per ton, depending upon the efficiency of the individual plant.

We now come to the Cobwell process, and while I desire to avoid any appearance of taking advantage of your courtesy by introducing a trade argument, I am forced to use this trade name as there is no other means of differentiating this method from the others, because in theory and practice it differs materially from them. In order to carry out my intention to present facts to you without any prejudice, I take the liberty of quoting verbatim from a paper read before Section D, Engineering, of the American Association for the Advancement of Science, in December 1916, by C. R. Tuska, consulting engineer and also lecturer on municipal waste disposal at Columbia University, who is in no way connected with the company which controls this process.

After describing the other methods and their results, Mr. Tuska said:

The operation of this process is as follows:

The raw garbage is placed in a closed tank which is sealed air-tight. This tank or reducer is constructed with jacketed walls and jacketed bottom. Into these jackets the steam, which is used in the reduction of the garbage, is delivered, these jackets being so designed that it is impossible, under proper operation, for the steam to enter the tank or come in contact with the garbage. In the interior of this tank there is an agitating device operated by power from the exterior. When the proper charge of garbage has been placed in the reducer and the covers placed thereon, the tanks are sealed and the solvent is pumped into the reducer and steam admitted to the jacketed walls. The heat from the steam which is transmitted to the garbage through the walls of the reducer, causes the evaporation of the solvent and the water in the garbage.

Garbage is usually composed of over 75 per cent by weight of water. The steam heat vaporizes the solvent and the water from the garbage and these mixed vapors are drawn off from the reducer to the condenser. The economy in this method of evaporation rests in the fact that water is vaporized at a lower temperature when evaporated with a solvent having a low boiling point than when evaporated without such solvent.

The mixed vapors of the solvent and water, while in the condenser together, are conveyed to a closed tank. Owing to the solvent being of lighter specific gravity than the water, the solvent and the water are separated by gravity, the solvent rising to the top from which it is drawn back to the storage tanks from which it is pumped back to the reducers and used over and over again. The condensed water which has been largely diluted, owing to the jet condensers used, is discharged into sewers or waterways.

When the garbage has been thoroughly dried by this method, the solvent is pumped into the reducer and dissolves the grease. The solvent with the grease is drawn off into a closed tank or evaporator where the same is heated by steam pipes, where the steam is kept separated from the grease. The solvent therein is vaporized and carried to a condenser where the same is again liquefied and carried to storage tanks to be used again.

After the grease has been extracted from the garbage in the reducer, the garbage is further dried by means of the steam in the jacketed walls and is now in the form of degreased garbage tankage, which is used for fertilizer purposes, after being ground and screened.

It will be seen from the above description of the process that if there are any leakages or vents in any of the tanks or piping where the solvent is handled, more or less solvent is lost, and thereby a substantial additional expense is imposed upon the operation of the system. It is evident, therefore, that it is to the financial interest of the owner of the plant to see that the same is properly operated.

Furthermore, under this system, the garbage is at no time brought in contact with the atmosphere, from the time of its original entrance into the reducer until, after 12 hrs. of cooking, it is finally discharged therefrom as finished products, dried, sterile, and practically odorless. These finished products are grease and the tankage above referred to.

It will be seen by the description that the process is one of straight dehydration, and from the time the material is at the boiling point, no further chemical action takes place. No process of "digestion" occurs, and, therefore, the odors and gases incidental to such process are not created. Only the volume of gas contained in the raw material is driven out and only the essential oils of an extremely volatile nature are carried over in the current of steam and solvent vapor evolved. That little or no conversion takes place in the operation is shown by the fact that in the dehydrated material, at the end of the operation, there exists practically the same amount of unconverted starchy bodies as existed in the garbage at the time of its entrance into the reducer

The water condensed contains all the gases evolved and has, when fresh, a slight odor of the mixed essential oils. Some traces of alcohol are detected in the effluent and a very small quantity of fixed oils is carried over. Any ammonia evolved, if it has escaped the acid in the garbage, is neutralized by acid carried over in the vapor. Whatever albuminoid ammonia exists in the effluent is carried over by mechanical entrainment, as dust particles, during the steaming out of the solvent.

The effluent from this process consists of almost pure water, this water being the condensed moisture drawn from the reducer while the garbage is being treated and from which the solvent has been extracted as completely as possible. The effluent is cold and gives forth no steam or vapor and is practically odorless, and, as a result, can have no effect when run into a large body of water

Mr. Tuska's paper continues to give some very excellent data on this subject, but I will refrain from quoting further because my time is limited.

The grease, which is the principal by-product from garbage treatment, is a combination of glycerol and fatty acids, the principal fatty acids being palmitic, stearic, and oleic. At the present time this is sold as recovered and the purchaser refines it and obtains glycerin, stearin, stearic acid, red oil, candle tar, and soap fats.

The glycerin content of grease from the reduction methods, other than Cobwell, runs from 5 to 6 per cent, the free fatty acids from 18 to 40 per cent. In Cobwell the glycerin runs from 7 to 8 per cent and the free fatty acids not to exceed 10 per cent. The purchaser demands that saponifiable shall run about 97 per cent

While there are many solvents which might prove available in this work, economy has reduced the number to gasoline or kerosene distillate, and engine distillate has been used. In using an economical solvent due regard must be given to the practicability of freeing the grease and tankage from any residue from it at the end of the process

As to the cost of a reduction plant, it is impossible to make a general statement as so much depends upon local conditions, and also the cost of machinery varies as the market price of

steel fluctuates. However, it is usually estimated that a cooking method plant will cost, approximately, $1,500 per rated ton with steel at 3 cents per lb., while the cost of a Cobwell plant will be about one-third more than this. In net recovery values it is generally stated that for the cooking method $2.00 per ton is a fair average, while Cobwell gives, approximately, $1.00 more per ton. The only safe method of estimating is to analyze the material in each case. I have no definite figures as to the drying method.

While in most of the cities the disposal of garbage is done by contract, and in the majority of cases a bonus is paid to the contractor, the following cities receive payment from the contractor:

New York..... ...At the rate of about 45 cents per ton
Los Angeles.....At 51 cents per ton

Minneapolis has just closed a contract for pig feeding at a revenue of $1.26 per ton, and Richmond, Va., under the same system, expects to receive $2.00 per ton. Denver was the first to adopt pig feeding under contract, without the payment, and is doing so at no cost to the city nor is anything paid to it.

These figures appear very attractive, but it is well to be conservative as to the expected revenues from this source, as this system is, as yet, under trial and the result of the experiment will only be assured when a renewal of such contracts show that the contractor has been successful in operating under such a method of payment. An inspection of successive reports from the cities which operate municipal reduction plants gives a very good idea of the uncertainty of the revenue derived from year to year.

I am very much impressed with the patriotic purpose evidenced by this association in giving so much of its valuable time to the study of the subject of municipal waste disposal, with the intention of performing a civic duty in endeavoring to promote more efficient methods and better financial results, if possible, through the employment of the high professional skill of its members, and I, therefore, take the liberty of calling your attention to the fact that the United States Food Administration recommends that at this time such energy be used in obtaining more efficient operation of existing methods rather than the evolution of new methods.

COBWELL CORPORATION
50 CHURCH STREET
NEW YORK CITY

AMERICAN GARBAGE DISPOSAL INDUSTRY AND ITS CHEMICAL RELATION[1]

By RAYMOND WELLS

It is undoubtedly true that before the world war there were chemists in this country and that they were doing most wonderful and useful work, but we were so bewitched by the work done by German copyists and grinds, that when the awakening came, we were astonished to find that the animals at home were likewise endowed with horns and of no inconsiderable magnitude.

At once every industry that had ever thought of the possibility of chemical assistance obtained three of this rare species, and those that had never thought of it at all clamored for at least one. Every business, industry, and manufacture wished for this strange new thing—"scientific control," obtained it as best it might, and found it good. Of course there may be some things the chemist cannot do, but they do not exist in the popular mind.

An industry at this date without a chemical advisor, director, or, at least, a plain ordinary "lab. man" is in the same class with the great auk, and yet there have been explorers who have claimed to have seen specimens of this rare bird, even at the present time. It does not take an explorer to locate the "garbage industry," but it might prove a stiff task for anyone without the natural instincts of the lowly ferret to find more than one or two even "lab. men" in the business, leaving out of consideration a "regular chemist."

An industry has grown up in this country, taking care of the household table and kitchen waste of 17,000,000 people, serving twenty-nine large cities and returning an annual revenue from the by-products of this service amounting to $11,500,000. At the same time disposition is made of 1,200,000 tons of raw garbage, from which, disregarding the monetary return, the nation is the richer by producing from its own so-called waste 70,000,000 lbs. of grease and 175,000 tons of valuable fertilizer. And such an industry is practically without a chemist or without even being given recognition by chemists as being one of the few unexplored fields, for their efforts, at the present day.

The disposition of garbage with recovery of the by-products is essentially a chemical problem and its neglect has been due to several causes. The attitude of all or of practically all men or corporations engaged in the business, has been one of antagonism toward chemists, either as individuals or as representatives of science. They were not very unreasonable in this, since all of those chemists attempting to work or to improve the garbage business, did so by long range treatment of garbage as it ought to be from a theoretical standpoint, and from their knowledge of some other business in their mind similar to it. It is not like any other business under the sun, so they fell down most lamentably and the so-called "practical swill man" stood off and scoffed. The "swill man," satisfied with partial success, with sometimes profit and sometimes loss, but with the profit just enough in the right pan of the balance to keep the attraction always there, did not like the idea of disturbing things which had been done, and was thus prevented from asking anything of science. His whole attitude has been one of secrecy about the simplest of operations and one of horror at the idea of starting anything which might or might not turn out to their pecuniary advantage.

Don't blame the swill man for his attitude. He set out to make something out of nothing, out of something which everyone turned away from, about which no one knew anything, and in approximately thirty years built up a real industry, without assistance from anyone. It was all "try it and see," and after a period of several years something was arrived at, which was moderately satisfactory and sometimes made a little money. After that, why change? Changes meant increased investment, possible big financial failure—better to jog along and keep quiet, taking all that could be obtained and when not obtained, slip it over quietly to the next chap.

Seeing this attitude and not looking into what promised only to be a dirty, disgusting hot, sweaty business, where things were accomplished by rather circuitous methods at times, viewed from political and engineering standpoints, the chemist withdrew to more savory and apparently more promising fields. As a matter of fact he chose, as usual, the line of least resistance.

In spite of this neglect from the chemist, the business has prospered and is doing very excellent work for the city and for the nation. A short time ago the city and the nation woke up to the garbage situation and were surprised to find that a real industry existed. Immediately propaganda started and continue to start, which is well, for out of them may grow an interest both popular and scientific, valuable to the industry and to the nation.

Before venturing too far in denouncing our nation as a nation of wasters and as a nation neglectful of its waste materials, it is well to consider all of the facts in the case.

For instance, the largest city in the United States has the largest garbage plant in the world and the most up-to-date one from the chemical and engineering standpoints, representing the effort and financial hazard of many men. This plant possesses the *sine qua non* of the swill business, it is sanitary and does not

[1] Remarks following Mr. Very's paper, New York Section, American Chemical Society, May 10, 1918.

commit a nuisance either in the legal sense or actually. It takes care of the waste food material from 6,000,000 people, amounting even at the present time of conservation, to an average of 800 tons daily or 320,000 tons per annum. Not one particle of this material is wasted. Only the water is eliminated and that as distilled water. In one operation the garbage is transformed or separated into 19,200,000 lbs. of grease of a value of $2,200,000 and at the same time 64,000 tons of tankage of a value of $1,000,000 are produced. Several other items, as rags, bones, etc., give an additional value of several hundred thousand dollars. Aside from the money value, this grease recovery means to the nation 1,344,000 lbs. of "dynamite glycerin" and over 150,000,000 cakes of soap. The fertilizer value of 64,000 tons of tankage makes fertile many acres, at a time when the nation is starving for fertilizer. This grease all enters the soap, candle, and glycerin industry and constitutes no small source of supply, and the fertilizer manufacturer regards garbage tankage as a most valuable "base goods." These materials are in no sense low grade and they find a ready market. This one plant employs several hundred men and consumes daily 200 to 250 tons of coal and 3000 to 4000 gal. of kerosene. Kerosene is used for percolation on a huge scale, an innovation in the percolating line which no other industry conceived of or dared to try on a large scale. When it is noted that in the regular course of operation 300,000 to 400,000 gallons of solvent are in constant use, and that still capacity for solvent recovery of 500,000 gal. actual operating capacity per 24 hrs. is required, then one can realize what the industry in one plant means. This is the largest of 29 garbage reduction plants in the country. All of our largest cities have them, only a few of the medium-sized cities still being unenlightened and sticking to the prehistoric and very European method of expensively burning valuable material. These twenty-nine cities produce the quantities of material mentioned in a preceding paragraph. Not all of them have perfect plants, not all of them utilize all of the values in the garbage, but they are performing a public duty and doing it efficiently, as far as their equipment makes it possible.

It is hoped that the preceding statements may lead to the realization that a big industry of great value, not only from the conservation standpoint, but from that of public service and health, has been built up quietly and without attracting, till this time, any public notice or any notice from the scientific world.

The industry is doing very well, it has improved much after a sleep of twenty-five years, it has at last a real method, now operating four years, which is the best yet and promises to be better in the near future, but even now the whole business is nothing more than a healthy embryo, which will require many years of patient work on the part of many patient chemists to incubate to a real live animal and then it will have to grow.

ANALYSIS OF SAMPLE OF AVERAGE HOUSEHOLD GARBAGE

	Per cent
Moisture	71.00
Grease	4.54
Protein	4.24
Ash	2.17
Fiber	3.21
Cane Sugar	0.77
Invert Sugar	0.80
Starch, Dextrin, etc.	10.46
Alcohol	0.23
Acid as Acetic	0.1
Essential Oils	
Ethers, etc.	0.1

a Potash, lime, phosphate, lime, silica, etc.

That it is a chemist's problem the foregoing analysis will demonstrate. Garbage is a conglomerate of all the odds and ends of all the things which men eat, a mixture of every naturally occurring organic material. Think of it in terms of this typical analysis and see if it does not suggest opportunities.

This analysis does not total 100 per cent, since none of the determinations were made "by difference."

The opportunities suggested by such a mixture offer for research almost virgin soil. And this field has never been touched by our erstwhile German rivals. A nation which is lucky to get garbage to eat, has no garbage problem to solve. Many urge that we too should have no garbage cans. It may be so some day, but not for several generations and it is a very nice question, whether with proper methods of utilization, it may not be as economically profitable to so utilize it and not attempt to force on the human anatomy that which is unattractive and unpalatable. It may be better to let a mechanical digestive tract turn less easily digested materials into substances of greater value for other purposes than for food. Maybe it is better to throw away rancid fat, tough sinews, and potato parings and have the same come back as soap, fertilizer, and alcohol and eat the vegetable oils, animal fats, and the grain released by such an exchange. Nothing is ever destroyed. It can be badly mixed up and out of place, that's garbage. It is the duty of science to put it back into place, and chemistry is the one science most urgently called upon.

HOMER, N. Y.

THE POTTERIES AT SHEK WAAN, NEAR CANTON, CHINA

BY CLINTON N. LAIRD

Received March 12, 1918

The prevalence of white ants in South China restricts the use of wood as a building material to a minimum, and therefore all but the most temporary structures are built of brick with tile roofs. The bricks used range from sun-dried, in the poorest villages, to well-burned gray or red of various dimensions. They are made at many different places. The tile are of two kinds, a pan tile, 9 in. square, curved like a shallow trough, and a round tile, approximately half of a truncated cone. The latter are laid in rows over the joint between the vertical rows of overlapping pan tile. These round tile are often glazed but the pan tile very rarely. Most of the common unglazed tile, of different grades, used in and near Canton, are made in Fa Uen district, about 30 miles north of Canton. The only place where any glazed roof or fancy tile or other glazed earthenware articles are made in South China is at the village of Shek Waan, about 20 miles west of Canton.

The pottery industry there is said to be over 700 years old. When the process for glazing earthenware was developed is not recorded, but as one of the temples in Canton has a glazed tile roof (never relaid and still in good condition) known to have been laid 400 years ago, the process is not one of recent origin. At this village are made earthenware jars and dishes of all kinds, clay idols and figures of men and animals, and, in recent years, tile pipe, as well as the glazed ware of many kinds, in color chiefly brown, green, blue and yellow.

For some unknown reason or reasons, possibly through consideration of both beauty and expense, the use of colored glazed roof tile was restricted long ago to temples and imperial buildings. Other blue and green articles made of the same materials in the same way have had a wide use in private buildings, and after the First Revolution (1911) the restriction on the use of glazed roof tiles was removed. General use, except by foreigners, will probably not become common for many years, however, because of the strong association between the tiles and temples. I have been told by one who has travelled widely in the interior of China, that the only place he has seen the green roof tile used on buildings other than temples is at Peking where they are used on the tombs of the imperial concubines. The imperial buildings in

Peking and the imperial temples throughout China were the only buildings having yellow tiled roofs.

The original deposits of clay at Shek Waan were exhausted long ago, and now all the materials are imported. The clay,



FIG. 1—THE MIXING MACHINE[1]

which varies in color from a cream, streaked with red, to a dark gray, comes from two places, the more plastic from Tung Koon district, about 40 miles east of Canton, and the stiffer from Fa Uen district where the ordinary tiles are made. It is all bought at Shek Waan of the people who bring it there in boats from the districts named. The fuel used is wood, which comes down the river in rafts from the province to the west. It is cut to size and dried across the river from the village of Shek Waan. The potteries are low, one story structures, cheaply built and poorly lighted, but the workers are protected from the heat and glare of the tropical sun.

The article to be made will determine the relative proportions of the two kinds of clay used in any batch. Sand is mixed with the clay in the proportions of one part sand to four parts clay to lessen the danger of cracking in the firing. Nearly 2300 pounds of clay and sand are mixed at a time by one man who mixes it with his feet, by tramping on it, adding a little water from time to time to make it work easier. This is said to be the original method, and the workmen claim that it can be done more thoroughly this way than by machinery. Two batches are mixed by each man in a day, working 4 hrs. on each batch. Large lumps of clay, when mixed, are stuck up against a wall to dry for a day or two, depending on the weather, before being ready for use.

Three methods are used at these potteries for making the various articles: some are formed on the wheel, others in a mold, and some are modeled by hand. They are glazed in practically the same way and all are burned in the same kind of kiln. The chief articles made on the wheel are earthenware dishes, pots used in cooking, and covers for certain kinds of jars. The clay comes to the potter wet. His wheel, nearly 2 ft. in diameter, is mounted on a pin which rotates in a block set in the ground so that the upper surface of the wheel is only a few inches from the ground. The potter sits on a low stool. At his left, close to the wheel, is a flat dish about 10 in. in diameter, partly filled with rice straw ashes, and at his right, also close to the wheel, is a vessel containing water. With his left hand he picks up a ball of clay from the dish and with his right hand dips up a little water to moisten the clay. The wet clay is then put on the wheel which is turned by his assistant. Working from the center out he shapes the vessel, holding his thumbs in and his fingers out. The assistant, generally a boy, propels the wheel by striking its upper surface with his right foot as he swings it back, a running motion. Before giving the first impulse to the wheel he picks up a lump of clay which he rolls into a ball while kicking the wheel. He then throws the ball into the dish at the potter's left on to the gritty ashes which make the bottom of the vessel, when finished, a little rough so that it will not stick to the wheel. The boy then takes a piece of flexible bamboo which he holds between his hands in the shape of a U. This acts as a spring to help keep his hands far enough apart so that he will not deform the dish as he picks it up from the wheel and sets it on a board. When the wheel is empty the potter puts on another lump of clay and begins working it. As soon as the boy has put down one dish he picks up another lump of clay and begins kicking the wheel again. The performance is repeated until the board is full, when work stops while the boy puts the board up into a rack over head where the dishes dry until the next day. They are then put out into the sun. I have seen the simplest form of dish, about $1^1/_2$ in. deep and 6 in. in diameter made in 8 sec., though this would be under the average time. A day's work for the pair would be 1500 or more of these dishes. Larger vessels take more time, and more kicking by the boy who has no chance to kick with his left leg occasionally for a change.

These earthenware dishes, used chiefly in the household, are glazed only on the inside. The glazing material is wood or rice straw ashes, mud from the river bottom (the fouler, the better, according to the workmen), and water, forming a muddy cream. Some of this is poured into the sun-dried dish, and, with a short turning motion, most of the inside of the dish is covered with the cream. The rest is poured out. The dish is allowed to dry before being taken to the kiln to be fired. The final color, after burning, is a dark brown.

All the jars, roof and window tiles, tile pipe, etc., are formed in molds. A wooden model is first made and from it the clay mold. This is burned from 4 to 6 hrs. in a moderate fire; too hot a fire will ruin the mold. The clay is worked stiff and shaped into a



FIG. 2 THE DRYING ROOM

large lump with straight sides of such a shape that a slice cut transversely through the lump for use in the mold will be of the right shape and dimensions for the particular article to be made. This lump is placed on a smooth table and cut into slices from $^1/_4$ in. to $^3/_8$ in. thick. The workman then selects two flat bamboo sticks, notched on the sides at the proper intervals, and,

[1] Because of the Chinese superstition that a man will never be able to do a kind of work different from that which he was doing when his picture was taken, it is very difficult to get satisfactory pictures of the men at work.

holding in those notches a wire kept tight by a bow, pulls the whole towards him through the lump of clay, the bottom ends of the guides sliding along the table. He then drops the wire down a notch and cuts another slice, thus working from top to bottom through the lump.



FIG. 3.—CUTTING SLICES OF CLAY FOR USE IN THE MOLDS

The slice of clay is placed in the mold and pressed into position with the fingers. Then it is taken from the mold and sun-dried for 2 hrs. If the article is, say, a lattice work tile to be used in windows instead of glass, the two complementary pieces are then put carefully together and all joints made smooth and tight with a little clay put on with the fingers or a bamboo tool. Jars, smaller at the top and bottom than in the middle are made of five pieces of clay. The lower half is made in one mold of a bottom and two side pieces, the edges being pressed together with the fingers; the upper half is formed in another mold. The two sections, after partially drying in the sun, are put together and the joint made tight. These articles are then ready to be glazed and burned.

Glazes of three colors are common: green, blue, and yellow. Copper is used to get the green and cobalt for the blue. One of the leading tile manufacturers in the village told me that they add lead to get the yellow. The same man informed me that they had always made their own copper oxide by roasting copper, but I have never been permitted to see how they do it. The cobalt is imported under the name "English green" and costs more than the copper, but the yellow is the most expensive color of all, which probably explains why the only yellow articles made are roof tile for imperial buildings and burial urns.

The glazing mixture is made of powdered glass, ashes of either mulberry bushes or rice straw, and the coloring matter, all stirred up in water to form a thick, black cream. This is kept in large jars near the kilns and the articles to be glazed are dipped a short time before being stacked in the kilns. The coating is not uniform in thickness, as the glaze runs somewhat, giving a difference of shade, if the color is green, in the final product. This is not noticeable in the roof tile when laid, but is objectionable in other articles. Some of the green tile will show spots or streaks of blue if the firing is not done properly, but generally the color is nearly uniform in the green and quite satisfactory in both the blue and the yellow. Salt is not used in any of the glazes

The articles modeled by hand are of three classes. Small birds, animals, figures of people, teapots, etc., are modeled by hand, some of solid lumps of clay, and are burned at the bottom of the kiln used for all the other articles. The fancy glazed tile of unusual shape or size are made by hand without a mold but often forms for curves, etc., are used. These are then treated the same as the regular tile. The third kind are the figures and grotesque decorations used on buildings. Some of these are sun-dried, painted, and then burned like the ordinary tile; others are burned without being glazed and then painted or otherwise decorated. They do not have the life of the glazed articles, but the purpose for which they are intended, or the style of decoration, prevents firing after the decoration has been put on.

The most novel feature of the whole process is the kiln. There are seventy of these in the village. They are long tube-like structures, up to 200 ft. long, built on the sides of the hills in the village. As the hills slope at an angle of from 15° to 20°, (the angle may not be the same all the way up), the kilns are really long inclined chimneys. At any place a cross section will be an inverted U. Each kiln is protected from the sun and weather by a low roof, built in a series of steps to allow of better ventilation, supported on pillars without walls. Thatched palm leaf awnings are hung at the sides in summer time for further protection from the sun.

One long kiln was only 3 ft. 4 in. wide and 3 ft. 4 in. high, inside measurements, at the bottom. The dimensions gradually increase towards the top where the kiln was 6 ft. wide and 7 ft. high in the center, also inside measurements. The walls are 8 in. thick, made of vitrified brick locally burned for the purpose. Access to the kiln is secured through openings in the sides, 20 to 24 in. wide by 3 ft. high at the lowest opening, gradually increasing in height to 5 ft. at the opening nearest the upper end. The openings are bricked up when the kiln is being fired. The articles to be burned are stacked on the sloping floor, boys doing the work where the kiln is small, each pile having some old broken burned pieces on top. At every 30 in. up the top of the kiln are transverse rows of holes, each not over 2 in. in diameter, through the top wall into the kiln. There are 3 holes in each row near the bottom and 5 holes in each row at the top. The holes are generally closed with pieces of brick set in loosely.

The fuel used is wood. A fire is built at the bottom and the smoke goes up through the kiln, warming the ware therein.



FIG. 4.—THE YARD OUTSIDE A POTTERY. NOTE LUMPS OF CLAY DRYING ON THE WALL AND MOLDS FOR LATTICE WORK TILE ABOVE THEM, ALSO DRYING IN THE SUN, HALVES OF THE LATTICE WORK TILE, LARGE TILE FOR A RIDGE POLE, AND SMALL IMITATION BAMBOO TILE

When the fire is hot enough and sufficient draft has been created, no more fuel is added to the fire at the bottom, but the burners take their places at the first row of transverse holes and feed the fire by dropping in pieces of wood about 15 in. long. When the master burner thinks the fire is hot enough the burners move to the next row and add more fuel. The fire is thus fed through

each row of holes all the way to the top. It takes 2700 lbs. of wood and 12 hrs. work to fire a long kiln. As the fire at the bottom goes out before long, the cheaper articles which do not require much heat, or these that would be spoiled by too much heat, are packed near the bottom. The top of the kiln heats more slowly, becomes much hotter, and cools more slowly so the better grades, like the colored glazed ware, are burned in the upper part of the kiln, and only in a long kiln.

Following the burners and their helpers, the woodcarriers, come another set of men who put the articles for the next run on top of and beside the kiln to be dried out thoroughly before being fired. (When the accompanying picture (Fig. 6) was taken the packers, working from one side, had taken off half of the articles to put them in the kiln.) A kiln is packed on the first day, fired on the second, allowed to cool over the third, and is unpacked on the fourth day; but ordinarily the packers for the next run are following close on the heels of those who are unpacking the previous run, both crews beginning at the bottom and working up the kiln. A large kiln will hold up to 10,000 articles at a time. If 80 per



FIG. 5—ROOF OVER A KILN SHOWING OVER THE HOUSETOPS

cent of the articles fired are marketable, the yield is said to be good. The kilns are not owned by the shops which employ the labor and make the goods, but must be rented at the rate of $5.00 for each run, renter to furnish fuel and labor.

The population of the village is said to be 15,000. As is usual at industrial centers, most of the men have left their families back in the country villages, so the statement that two-thirds of the people there are men and boys is not an exaggeration. The only industry in the village is the potteries, with the necessary shops that supply food, clothing, etc. There are a few women working in the potteries, chiefly at tasks like luting together the halves of a fancy tile. They also make most of the small figures, but this modeling work is done in their homes.

The workmen are well organized, there being at least sixteen guilds or local unions of the men. The men doing the same kind of work belong to the same guild—there are four guilds of men working on the wheel, the members of each guild making a different article. It is difficult to get accurate general information as no one can speak with authority about conditions in other guilds, and he does not care to tell much about his own. A man must serve an apprenticeship of six years, during which time he is said not to receive any wages (this may mean no cash, though he may get both food and lodging), before he is admitted to the guild. A fee of $75 must be paid the guild at the time of joining, but this is generally paid by the shop or employing company. The wages run up to 40 cents a day for skilled potters (a good carpenter in Canton will get only 25 to 30 cents a day), most of whom are paid by piece work. A semi-skilled workman gets $4.00 a month and his food, and the boys about a dollar a month and food. Any of the workmen can rise to be an employer if he can get a little capital. The employers, too, have their guild house, said to be a very fine one.

These potteries are typical of most of the native industries of China in state of development, ingenuity and skill of her artisans, and labor conditions. This description should also suggest the opportunity in China for American goods. At the present time those interested in reaching this market will probably do best to deal through the foreign (chiefly European) firms established in the port cities, who may, or may not, be interested in pushing American lines.

The future growth of the industries of China may be along one of two lines: either the native industries may be developed along modern scientific lines, or the effort may be made to completely ignore the native industry and establish a foreign industry using a foreign process, foreign machinery, and foreign methods. The latter method will almost certainly fail when applied to most industries at most places because of cheap labor, the close relationship between the guilds of both workmen and merchants, and the fact that the market is conservative and

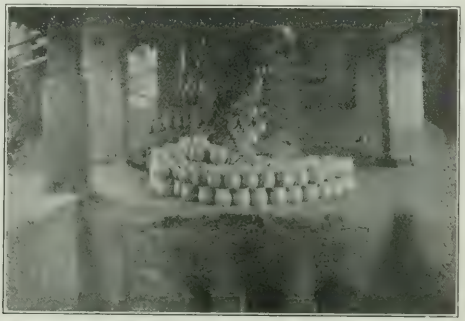


FIG. 6—LOWER END OF A KILN, SHOWING FIRE PIT, HOLES IN TOP THROUGH WHICH FUEL IS FED, AND VESSELS DRYING OUT FOR THE NEXT RUN

demands, in general, a low-priced article. In lines where there has been no native industry it will be necessary to introduce foreign methods, but full recognition must be paid to economic, social, and labor conditions in adapting the foreign process to the local situation.

Those Chinese who have been educated either in the United States, Europe, or the few modern schools in China will be the ones best fitted to develop China's industries. Being conversant with both local conditions and western science and practice they will be able to so remodel the industries that the good points will be conserved, no prejudices aroused, and scientific results obtained. British firms have equipped the engineering laboratories at the University of Hongkong with British machinery, thus training the students at that institution to prefer British goods in future years. So far-sighted Americans, looking for future business in China, should see that American institutions in China lack no facilities for advancing American methods and products, and that at least those Chinese who are studying chemistry in the United States are persuaded to join the AMERICAN CHEMICAL SOCIETY. Those who join will be kept in later years conversant with scientific developments in America and be able, through the advertisements, to know where to get the supplies they need in their own work. The advantages to both countries are unlimited in having an enthusiastic body of Chinese who admire the United States and turn first to Americans when in need.

CANTON CHRISTIAN COLLEGE
CANTON, CHINA

CURRENT INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

NITER CAKE

An interesting discussion on niter cake is reported in the *Journal of Chemical Industry* for December 15, 1917. Various uses for the substance were given, among which the following may be quoted: (1) The utilization of the niter cake as a substitute for sulfuric acid in the manufacture of hydrochloric acid and the salt cake from salt; (2) for obtaining ferric sulfate for sewage precipitation by furnacing burnt pyrites with niter cake, grinding and leaching the product with water; (3) as a diluent for sulfuric acid in the manufacture of superphosphate. Dr. Terlinck stated that he had used niter cake as a substitute for sulfuric acid in the recovery of fats from wool waters and he further proposed to use it in the purification of ammonium salts. In the Nottingham district niter cake was used for lace bleaching, grease extraction from wool, pickling of metals, and mineral water manufacture. Dr. E. Naef proposed utilizing the sodium sulfate which, on reduction, gives sodium sulfide by grinding with anthracite, charcoal or boiler coal and heating at 500 to 600° C., the yield obtained being 95 to 98 per cent. The free acid may be neutralized by adding soda during the grinding. No less than 50,000 tons of sodium sulfide are used for the preparation of sulfur dyes alone per annum. By treating niter cake at 300 to 350° C. with superheated steam, 90 per cent of the free acid is driven off but the product is too dilute to concentrate.

PETROLEUM IN THE BRITISH EMPIRE

The *Bulletin of the Imperial Institute* states: "In 1903, at the request of the Admiralty, the Imperial Institute prepared a memorandum describing the known and prospective sources of supply of petroleum within the Empire. Since that time continuous attention has been given to this subject and a large number of samples of crude petroleum, oil shales, asphalt, etc., have been reported on from British Guiana, Trinidad, Barbados, New Brunswick, Gold Coast, Newfoundland, Somaliland, Nigeria, Australia, Papua, etc. In certain of these cases, important developments have since taken place, notably in Trinidad, while in others, investigations are still in progress, in some instances with considerable promise of success. It cannot be claimed that any source of supply of petroleum of first-class importance has yet been found within the empire, but sufficient has been done to show that including deposits of oil-shale, there is a considerable possibility of further oil production within the Empire.

POTASH LYE

The manufacture of potash lye from vegetable ashes and its application for boiling straw in the paper industry is the subject of an article by Mr. S. Tanaka in a Japanese technical journal. It shows that ashes from vegetable materials have been investigated from the point of view of the manufacture of caustic potash for the digestion of straw for paper making Ashes from soy-bean pods contained 16 19 per cent potassium carbonate, and from chestnut, 13.96 per cent. For the manufacture of caustic potash it is necessary that the ashes should contain more than 10 per cent potassium carbonate Lime may be added directly to the solution of ash in water without separating the insoluble residue. The yield of caustic potash depends very largely on the perfection of the filtration and lixiviation processes. The potash obtained is quite efficient for the manufacture of straw pulp, and its substitution for caustic soda is a question of cost. A constant and sufficient supply of potash from these sources is hardly to be expected and the difficulties of the filtration process increase the cost.

OIL CLARIFIER

According to a German patent, a cylindrical vessel fitted with a removable cover is provided with a false bottom, perforated, and covered with corrugated wire gauze which, in turn, is covered with a layer of felt secured to the false bottom by a metal ring and bolts so as to make a tight joint all round. This arrangement also keeps the felt from pressing tightly against the false bottom and by means of the corrugations in the gauze increases the filtering surface. Above the filter bed, the vessel is charged about $^2/_3$ full with shavings to remove coarse impurities and the oil is kept fluid by a heating coil embedded in the shavings. Taps are provided at different levels to draw off the oil and any separated waters

CANADA'S EXPORT TRADE

The expansion of Canada's export trade, says the *Times Trade Supplement*, during 1917, was even more remarkable than during the preceding year. The latest available figures are those for the twelve months ending November last. These show that the total value of the trade for that period in merchandise alone was $1,575,233,006, which was an increase over 1916 of 46 per cent and over 1915 of 160 per cent. The increase extended to all general classifications except forest products in which there was a slight decrease. The most remarkable increase was in manufactured goods. The total under this classification was $703,147,168, which was an increase over 1916 and 1915 of 72 and 410 per cent, respectively. The value of the manufactured goods exported becomes all the more remarkable when the fact is taken into account that it exceeds by the substantial sum of $104,405,262 the total export trade of all kinds of merchandise in 1915. As a result of this remarkable development in the export trade, there was a favorable balance over merchandise imported of $563,832,904, whereas the year before the war broke out, there was an adverse balance of $300,000,000. The total trade balance for three years ending November amounts to the sum of $1,056,538,845.

IRRIGATION PLANT

According to the *Board of Trade Journal*, there are very promising prospects for business to be done in irrigation plants in Yunnan Province, South China. At present, four irrigation sets, owned by a private company, are in operation within a few hours' journey of the city of Yunnanfu, and it would be comparatively easy to install 100 such sets if the business were followed up and cared for, as there are immense tracts within easy reach of water, but at an elevation of some 15 ft. above the water level. There are also great opportunities for trade in machinery at the tin mines. Innumerable small pumps are needed and mining machinery in general would find a ready market.

RECOVERY OF SOLVENT NAPHTHA

According to a recent German patent, the resinous mass left behind in the still after refining solvent naphtha and benzol with sulfuric acid is subjected to dry distillation and decomposes at 330° to 385° C., leaving a pitchy residue. On redistilling the distillate, two fractions are obtained, the bulk consisting of heavy naphtha with boiling point 160 to 220° C. The second fraction is a heavy oil of mineral character which does not gum even in warm air and does not corrode metals or give any deposit in the cold. It may, therefore, be used as a lubricant and as a rosin oil substitute.

PURE BISMUTH

M. Mylins and E. Groschuff describe a satisfactory method for preparing pure bismuth suitable for electric and magnetic measuring instruments. Bismuth of 99 per cent purity may be obtained fairly easily but the 1 per cent of impurities is difficult to remove. By heating the nitrate of bismuth, the oxide is formed and this can be reduced by hydrogen. The residue is melted and crystallized. The method of purifying bismuth by distillation does not work out in practice as most of the impurities remaining after the ordinary refining process boil at a temperature of less than 1500° C. which is the temperature of boiling bismuth. The method given above is stated to yield a metal which does not contain more than 0.01 per cent impurities and which melts at 271° C. Wire of 1 mm. diameter has an electric resistance of 1.20 ohms at 22° C. If the percentage of impurity amounts to 0.1 per cent, the resistance value is 3 ohms.

VARIOUS CLASSES OF ENGINES

The following average weights per brake horse power for various classes of engines were given in a paper recently published by Mr. P. N. Everett: Triple expansion steam engines for cargo-boats (no boilers or auxiliaries), 130; triple expansion including boilers and auxiliaries, 450; Diesel engines for cargo-boats (no auxiliaries), 250; Diesel engines with all auxiliaries, 400; turbines for cross channel boats with boilers and auxiliaries, 200; Diesel engines for submarines, 50; steam reciprocating engines for destroyers, 35; turbines for destroyers with boilers, etc., 30; petrol engines for motor cars, 15; petrol engines for racing boats, $7\frac{1}{2}$; aero engines, $2\frac{1}{2}$.

REGISTER OF OVERSEAS BUYERS

The first edition of this register, which measures 10 in. × 7 in. and contains close on to 400 pages, has been compiled with the assistance of chambers of commerce and the consuls abroad and is issued at the price of $5 by Messrs. Bemrose and Sons, London. Besides containing a list of the principal imports in allied and neutral countries, arranged geographically under the class of goods they import, the volume includes articles on overseas trade, written under the authority of the chamber of commerce abroad. The requirements of the colonies and foreign countries and how to extend trade with them are dealt with thoroughly, as also are the causes which have hitherto impeded British trade development. A large amount of information is also given on the coinage of various countries, lighthouse, quay and other duties, Government officials, chambers of commerce, banking facilities, newspapers, local trading conditions, etc., all of which will prove useful for the development of trade.

INDUSTRIAL USES OF BISMUTH

The most important use of bismuth at present is as a component of fusible alloys. An alloy of bismuth, lead, tin and cadmium melts below the boiling point of water. It may also be used as a component of the alloy used for silvering mirrors. Safety plugs for boilers are made of an alloy containing bismuth which fuses at a temperature just above the boiling point of water. Automatic sprinklers or fire extinguishers placed in the ceilings of buildings are also sealed with an alloy containing bismuth, the rise of temperature caused by a fire fuses the plugs and jets of water fall over the fire. Bolivia produces the largest quantity of bismuth, the output in 1915 being 559 tons valued at $1,115,755. In Queensland the product in 1915 was valued at $67,445, including some wolfram. In New South Wales, the output in 1916 was $29\frac{1}{2}$ tons valued at $27,365. Smaller quantities are produced in Tasmania, South and West Australia.

RUSSIAN MONAZITE SAND DEPOSITS

It is stated that in Nizhi Tagil district there are deposits of monazite sand with a large cerium content up to 23 per cent. Hitherto little interest has been shown in Russia in the production of cerium which certainly does not exist in large quantities in the ground in any of its combinations, in fact, only monazite and orthite have been found in the country. The latter is sold in small quantities from the mines of the Transbaikal territory, while the former is found in many parts of the Urals where it was known long ago by the natives. It has also been found in the Cabinet lands of Transbaikalia. It is proposed to send the monazite sand to Petrograd for the extraction of the rare metals.

MINERAL OUTPUT OF GREAT BRITAIN

The report of the Inspector of Mines for the year 1916 has just been issued. The total output of coal for the year was 256,375,366 tons which is an increase of 3,169,285 tons over the year 1915. The value of the output was $1,000,073,130, being no less than $210,919,780 more than 1915. The total value of the output of minerals in 1916 was $1,070,072,620, an increase of $217,881,330 over 1915. The quantity of coal exported was 55,001,113 tons against 59,951,925 tons in 1915. The coal was used as follows:

	Tons
Exported	55,001,113
Used for gas coke	39,384,819
Manufacture of pig iron	19,780,690
Domestic purposes	142,208,684

The other principal minerals of value are:

	Tons	Value
Chalk	12,786,321	$ 727,520
Clay and shale	6,500,388	6,236,690
Gold ore	1,338	3,250
Copper ore	787	31,170
Iron ore	13,494,658	27,725,360
Lead ore	17,107	1,695,845
Limestone	11,115,909	6,979,150
Oil shale	3,009,232	5,161,470
Salt	1,960,448	4,520,665
Tin ore	7,892	3,560,710
Tungsten	394	248,495
Uranium ore	51	5,005
Zinc ore	8,476	326,520

Some of the figures show an increase and some a decrease over the figures for the preceding year.

The following table gives the amount and value of the metals obtained by smelting from the ores given above:

Antimony	4 tons	$ 1,700
Copper	278 tons	188,970
Gold	273 oz.	4,420
Iron	4,319,096 tons	175,226,055
Lead	12,573 tons	1,947,245
Silver	86,483 oz.	56,420
Tin	4,697 tons	4,278,280
Zinc	3,000 tons	1,026,750

The total value was $182,729,840, an increase of nearly $45,000,000 over the year 1915.

EFFECT OF INSULATION ON STEAM DRUMS

The *Electrical World* describes an interesting test for determining the loss of heat by radiation from boiler settings and steam drums. The 560 h. p. Babcock and Wilcox boiler tested had steam drums covered with one course of common brick. A rectangular can containing a measured amount of water was placed on the top of one drum and the boiler was run at its rated capacity for three days, the rise in temperature of the water being noted. A course of Armstrong nonpareil insulating brick $2\frac{1}{2}$ in. thick was then placed on the top of the common brick covering and the readings repeated. The result showed that the saving in heat radiated, if converted into the equivalent consumption of fuel per year, would be more than enough to pay for the cost of the insulation brick and the labor required for its insulation.

HARDENING CARBON STEEL

An automatic detector fitted by Automatic and Electric Furnaces, Ltd., Westminster, London, to their electric furnace for use in connection with the hardening of carbon steel depends on the principle that carbon steel at its non-magnetic point is at the best temperature for quenching. The furnace chamber consists of an inner pot, which contains a special mixture of salts having a comparatively low melting point but a high vaporizing point. The pot is wound with a heating coil, and is provided with a special heat-resisting lagging. Round the outside case of the furnace is wound an insulated copper coil, the ends of which are connected to a special galvanometer. A current of electricity passed through the heating coil quickly heats the furnace and renders the salt mixture molten and also magnetizes any steel article that is placed in the pot. When the steel has been heated to the non-magnetic point a small current is induced in the outer winding and the consequent deflection of the galvanometer needle informs the attendant that the best temperature for quenching has been reached. A 4 in. furnace will, it is stated, harden 10 lbs. of tools, gauges, or other articles in an hour.

TUNGSTEN FILAMENTS

A new German process for making tungsten filaments is based upon the idea of forming the lamp filament out of one long crystal. Tungsten crystals can be made to form gradually out of a mixture of tungsten powder and thorium oxide. The mixture is squirted through diamond dies into a filament of 0.02 mm. to 1 mm. in diameter. This filament is then drawn through a chamber in which it is rapidly heated to a temperature of 2400° to 2600° C. and with a velocity of 2.5 miles per hour, which is rather slower than the crystallization velocity of tungsten, so that a single crystal of indefinite length is formed. The chamber is filled with a neutral gas and the heating is performed in two stages by a pair of electrically heated coils, through the center of which the filament is passed. The filament in this state is ready for use in a lamp without further treatment. It is softer than drawn tungsten wire at low temperatures and hard at high temperatures, making it particularly suitable for use in lamps. According to the *Electrician*, filaments consisting of a single crystal of 25 in. length have been produced in this manner.

TAR-STILL CORROSION BY CHLORINE

Some particulars have been communicated to us, says the *Chemical Trade Journal*, **62** (1918), 360, of a useful investigation carried out by Mr. L. Crawford, late of Littburn Colliery Tar Works, Durham, with reference to the chlorine content of tars and the consequent corrosion of tar stills and particularly of the domes. In seven different tars from varying types of by-product coke ovens and from vertical and horizontal gas retorts, Mr. Crawford found the chlorine percentage varying from 0.0053 to 0.148 and, in one case, though the bulk showed only 0.111 per cent, as much as 0.226 per cent was found in a sample from the coolers. The investigator states that his experience with the different tars does not enable him to draw conclusions but, in regard to one showing chlorine content of 0.111 per cent, he has been concerned in the distillation of large quantities for a year and he thinks that a chlorine content above 0.1 per cent is above the limit compatible with longevity in still domes. The results are put forward, he states, in the hope that others with experience in individual tars will contribute theirs, so that by correlation of chlorine content with corrosion effects a maximum permissible percentage might be established. It is recognized that other factors may have an influence on still corrosion, but Mr. Crawford believes chlorine to be the predominant factor.

COTTON-SAMPLING MACHINE

In the course of a paper on some instances of applied science in the cotton trade, read before the Royal Society of Arts, London, Dr W. Lawrence Balls described a machine for sorting cotton hairs according to length. It consists primarily of a pair of rollers which, as they revolve, are transversed or translated bodily along a path at right angles to their axis of rotation. The cotton to be examined is first run through ordinary drafting mechanism so as to cause the hairs to lie parallel and straight and this "sliver" is presented to the rollers at the beginning of a traverse until they have seized a millimeter or so of the front ends of the hairs. The sliver is then drawn away, leaving in the nip of the rollers a tuft of hairs which are all held by their front ends. The rollers continue to revolve and obviously the first hairs to be delivered from them on the other side will be the shortest ones, while the longest ones (since all started with their front ends level) will be the last to escape. But since this feeding action of the rollers is combined with and positively geared to the motion which causes the traverse, it follows that the short hairs will escape on a suitable collecting device at the beginning of the traverse, the long ones at its completion and intermediate lengths at intermediate points. Thus, the cotton is fractionated by a continuous cycle of repeated operations, as many times as is convenient not merely into separate parcels of hairs but into a graduated series which may be subdivided to any degree desired. The device provides a technique by which it is possible to take a sample of raw cotton, make it into a sliver, treat that sliver for 2 min. only in an automatic machine, weigh the graduated produce of the machine's activity, and, at the end of half an hour, plot frequency curves of a reasonable and measurable degree of precision, showing the variation of length of staple within a sample.

THE LONG-RANGE GUN

In the issue of *Le Génie Civil* for April 20, Mr. Nicolas Flamel, a French authority, continues the discussion of the German long-range gun. Interesting information is given regarding the type of gun, powder, shell, etc. It appears that the Germans have taken one of their 15-in. naval guns and, by means of the technical process known as relining, reduced the caliber to 8.2 in. The powder is probably an ordinary slow-burning powder, the weight of the charge being increased to give the desired muzzle velocity to the gun. The shell is in two parts: the special fine-pointed head and the body. The shell has special driving bands turned on projecting portions of the body, in addition to the usual copper bands. The burster is either T. N. T. or trinitroanisol (an explosive similar to T. N. T. but having a lower melting point). The writer of the article does not incline to the theory of a special propellant shell, but the gun has been produced in accordance with the usual practice, with necessary modifications in charge, shape of shell, and other minor details.

BRITISH BOARD OF TRADE

During the month of April the British Board of Trade received inquiries from firms in the United Kingdom and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding the things are requested to communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

Buckles, belt, paper covered
Cider vinegar
Eyelets, small, colored, black and brown
Ink powder for writing and printing
Turf cutting machines
Vegetable ivory discs (for export)
Watch keys (manufacturers only)

MACHINERY AND PLANT FOR:
Manufacture of fasteners for cardboard boxes
Production of fish products (canned)
Making electric blankets

SCIENTIFIC SOCIETIES

FRENCH SECTION, AMERICAN CHEMICAL SOCIETY

PARIS, LE 15 MAI

MAJOR HAMOR
Gas Service, A. E. F.

DEAR MAJOR HAMOR:

Please find enclosed copy of the letter sent to Dr. Nichols, requesting the foundation of a French section of the AMERICAN CHEMICAL SOCIETY. This has been greatly delayed in order to obtain the signature of Mrs. Curie, who is the first French honorary member and of whom it was necessary to ask her compliance.

It took me nearly a month to find the occasion of getting in touch with her, mainly due to my lack of time.

Very sincerely yours,

RENÉ ENGEL

.....

DR. W. H. NICHOLS
President American Chemical Society
Washington, D. C.

DEAR DR. NICHOLS:

According to the constitution of the American Chemical Society and the privileges granted by Article IX for the formation of local sections, the following undersigned members have the honor of requesting the permission of the Council to found in Paris a French section of the Society covering the entire territory of France.

A more propitious time could not be chosen for such a movement, as it would contribute to the formation of an American chemical home for our members belonging to the Expeditionary Forces and bring into closer fellowship the chemists of the two sister Republics.

With our best wishes, we are

Very sincerely yours,

V. Grignard	Raymond F. Bacon
Edward Bartow	Ben H. Nicolet, Capt., C. S. S., U. S. N. A.
Reston Stevenson	G. N. Lewis, Major, C. S. S., U. S. N. A.
George Scatchard	Joel H. Hildebrand, Capt., O. R. C.
W. F. Durand	A. R. Norton, 1st Lt., C. S. S., U. S. N. A.
L. Lapicquy	A. R. Olson, 2nd Lt., C. S. S., U. S. N. A.
Elienne Meens	D. H. McMurtrie, 2nd Lt., C. S. S., U. S. N. A.
Y. Guyot	Leonard H Cretcher, 1st Lt., C. S. S., U. S. N. A.
Baum	G. S. Skinner, 2nd Lt., C. S. S., U. S. N. A.
M. Curie	P. R. Parmelee, 1st Lt., C. S. S., U. S. N. A.
René Engel	Jos. W. MacNaugher, 2nd Lt., C. S. S., U. S. N. A.
J. E. Zanetti	Louis C. Whiton, 1st Lt., San. Cps., U. S. N. A.
W. A. Hamor, Major, C. S. S., U. S. N. A.	C. W. Crowell, Sgt., C. S. S., U. S. N. A.
L. V. Walker, 1st Lt., C. S. S., U. S. N. A.	E. B. Peck, 2nd Lt., C. S. S., U. S. N. A.

May 14, 1918

THE GERMAN UNION OF TECHNICAL AND SCIENTIFIC SOCIETIES[1]

A short account of this important movement is as follows:

On March 4, 1917, at a meeting of the Verein Deutscher Eisenhüttenleute (German Iron and Steel Institute), held at Dusseldorf, Dr. Fr. Springorum said the war had intensified the need for closer coöperation of the German Technical Societies. Preliminary negotiations had therefore led to a combination of such Societies, and the Verein Deutscher Eisenhüttenleute had gladly joined such Union and promised their support.

On April 19, in an article published in a German newspaper, it was stated that the Managing Committee of the Union has decided to create an Intermediary Agency between the technical world and scientific institutions for the carrying out of scientific and technical research work, so that industry not equipped for experimental work, specially smaller concerns, might be afforded an opportunity of having problems solved through the aid of the Union.

In November the Union held its first General Meeting at the premises of the Association of German Engineers in Sommerstrasse under the Chairmanship of Privy Councillor Busley, at which the Imperial Government Offices, Federal Council, and Legislative Bodies were represented. The purposes and aims of the Union were explained. Herr Busley said their object was to establish a balance between science and practice, and that the technical world ought to be represented more than was hitherto the case in the Legislative Bodies.

Professor Dr. Wiedenfeld, of Halle, speaking on "Economics and Technics During and After the War," stated the blockade of the sea had necessitated the remodelling of the foundations of German economic life, the production from her own resources of raw materials and food, the utilization of waste materials and the production of substitutes. Technical science could only meet these new requirements by disregarding the question of cost price and all considerations as to the possibilities of markets and the risks involved.

The above meetings and the objects of this important German Union of Technical and Scientific Societies are described more fully in the accompanying statements:

Statement I

Meeting of the German Iron and Steel Institute held at Düsseldorf, March 4, 1917.

GERMAN UNION OF TECHNICAL-SCIENTIFIC SOCIETIES

Dr. Fr. Springorum, during the course of his address, stated: The war has intensified the need, already felt before, of closer coöperation of the German Technical Societies, and preliminary negotiations on this question have led to a combination of the Technical Societies into a German Union of Technical-Scientific Associations. We have gladly joined this Union and promised our coöperation, feeling sure that the purposes and aims of the Union are the right ones. The Union leaves to its individual members complete liberty in the special domain which each Association has hitherto been dealing with, but wishes to ensure joint action of the Associations (whose number has now risen to eleven) on all important questions.

Statement II

This is a précis of the full Statement III, which describes the objects of the German Union of Technical and Scientific Societies acting as Intermediary for scientific technical research work.

INTERMEDIARY AGENCY FOR SCIENTIFIC-TECHNICAL RESEARCH WORK

1 Managing Committee of German Union of Technical-Scientific Associations decided to create department to act as intermediary between technical world and scientific societies of universities and technical academies for carrying out scientific-technical research work.

2 Knowledge of departments of work so highly specialized, and so many problems at present, that sometimes few operators available for dealing with a certain question in scientific institutes.

3 If can direct all such problems to suitable operators, might gain very material advantage with minimum of labor.

[1] The following statement and translations have been prepared by Sir Robert Hadfield.

4—Great intellectual and material resources of scientific institutions of universities and technical academies, and knowledge and experience of their heads, might be rendered serviceable to German industry more than hitherto.

5—Industry, where not equipped for carrying out the task by means of its own arrangements and staff (particularly smaller concerns less equipped for experimental research), will be afforded opportunity of having questions otherwise left unsolved conducted into proper channels for solution through aid of Union.

6—Sometimes even not undesirable for large industria establishments to come into touch in this way with academicians to judge on complicated questions from scientific standpoint, yet in cohesion with technics.

7—Large number of heads of institutions in departments of (*a*) applied and physical chemistry, (*b*) physics, (*c*) electrotechnics, (*d*) engineering science willing to undertake such work through Intermediary Agency.

8—Further, men of special experience in each of abovenamed departments have placed themselves at disposal of Agency to assist in selecting suitable operators.

9—German Union and heads of scientific institutions hope Agency will be valuable and useful not only during war but in economic life afterwards.

10—Union asks industrial works engaged in departments of (*a*) applied physics, (*b*) electro-technics, (*c*) machinery construction, (*d*) engineering science in general to address inquiries to them

Statement III

The following statement describes the objects of the German Union of Technical and Scientific Societies, acting as Intermediary for scientific-technical research work, April 19, 1917.

This is shown as a précis in Statement II.

GERMAN UNION OF TECHNICAL-SCIENTIFIC SOCIETIES

INTERMEDIARY AGENCY FOR TECHNICAL-SCIENTIFIC RESEARCH WORK

The Managing Committee of the German Union of Technical Scientific Associations has decided to create, at its offices, a department which is to act as an intermediary between the technical world and the scientific institutions of the universities and the technical academies for the carrying out of scientific-technical research work.

Very many problems, and likewise the special knowledge of the departments of work, are nowadays so highly specialized that sometimes there are but few suitable operators available for dealing with a certain question in the scientific institutes. If now it were possible to direct all such problems to suitable operators in each instance, a very material advantage might be gained with a minimum expenditure of labor.

On the one hand the great intellectual and material resources which are extant in the equipment of the scientific institutions of universities and technical academies and in the knowledge and experience of their heads, might be rendered serviceable to German industry to a greater extent than hitherto. On the other hand, industry—as far as it is not itself equipped for carrying out the task by means of its own arrangements and staff or other connections, hence in particular medium sized and small concerns are less amply equipped with experimental research arrangements—will be afforded the possibility of having questions which would otherwise have to be left unsolved, conducted into proper channels for effecting their solution, through the aid of Union. Even to large industrial establishments it might sometimes be not undesirable to come in this way into touch with academicians who are willing to judge as to complicated questions from the scientific standpoint, yet in cohesion with technics.

A large number of heads of institutions in the departments of applied and physical chemistry, physics, electro-technics and engineering science have declared themselves willing to undertake such work introduced to them through the Intermediary Agency. Further, those of special experience in each of the departments named have placed themselves at the disposal of this Agency with a view to assisting it in the selection of suitable operators for the purpose in question.

The German Union and the heads of the scientific institutions hope that this Agency will be of value and prove very useful not only for the duration of the war but also in the subsequent economic life of peace time.

The Union therefore requests industrial works engaged in the departments of (*a*) chemistry, (*b*) applied physics, (*c*) electro-technics, (*d*) machinery construction, and (*e*) engineering science in general, to address inquiries to "Vermittlungsstelle des Deutschen Verbandes, 4ª Sommerstr., Berlin, N. W.," care the Secretary (member of the committee in charge of the secretarial office).

Statement IV

The following is a précis of the full statement V shown the latest information with regard to the work being done by the German Union of Technical and Scientific Societies.

TECHNICS DURING AND AFTER THE WAR

1—German Union of some 13 technical scientific societies recently held its first General Meeting in Berlin.

2—Those present included Privy Councillor Busley (Chairman), Representatives of Imperial Government Offices, Federal Council, and Legislative Bodies.

3—Object—to establish balance between science and practice.

4—Many technical tasks could not be carried through without collaboration of several branches of science; metallurgist required coöperation of technician, architect that of engineer, etc.

5—Influence to be exerted on technical education towards admitting academically trained technicians to all administrative departments of Federal States.

6—Technical world should be more represented in Legislative Bodies.

7—Union should be consulted in preparatory work of drafting regulations or enactments. Imperial Treasury alone had availed itself of their advice in preparatory work, namely, taxation of coal and sources of energy.

8—Desire expressed for an Austrian and Hungarian Section of Union.

9—Professor Wiedenfeld said Germany managed with her own production formerly, then more dependent on foreign countries owing to her increased population; afterwards owing to sea blockade, having to produce her own war materials and food.

10—Technical science could only meet new requirements by disregarding question of cost price, which formerly was one of chief consideration in competing with other countries.

11—All considerations relating to market and risk involved disregarded, and substitutes produced by new methods.

12—Though cannot carry over all new conditions and products into peace times, cannot revert to old economic conditions. "What has been will never return."

13—Technical science had tried to help economic life in three ways:

(*a*) Procuring raw materials formerly obtained from abroad partly by re-establishing unremunerative industries, *e. g.*, manganese production, increasing iron production, sulfur production, agricultural intensification.

(*b*) Increasing use of waste products (term "non-utilizable substance" eliminated by war) such as obtaining lubricants from coal tar, supply of enough clothing by using waste material.

(*c*) Producing substitutes, *e. g.*, nitrogen from the air, substances by synthetic processes where natural way not available, such as cattle food from straw.

14—The speaker recalled the dictum of His Excellency Professor Fischer: "I cannot imagine any substance for which a substitute could not be found." Too much regard paid to quality during early part of the war. This impossible as war continues.

15—Deprecated multiplicity of Government authorities controlling construction. This had prejudiced German production in peace time.

16—Ought to aim, even after war, at reduced use of certain raw materials. Owing to high expense for industrial war installations, production would have an unfavorable aspect in certain departments.

17—Amortization necessary in this respect during war of war installation expenses.

18—Monopolies (not necessarily State ones) for materials produced wholesale.

19—Could only establish steady movement of prices by strictly regulated syndicates, then obtain sure remunerativeness, favorable to technical science, and consequent brisk investment.

Statement V

The following statement shows the latest information with regard to the work being done by the German Union of Technical and Scientific Societies, November 1917.

This is shown as a précis in Statement IV.

TECHNICS DURING AND AFTER THE WAR

The "German Union of Technical Scientific Societies," which has recently been formed by the combining of thirteen associa-

tions and unions, held its first General Meeting this morning on the premises of the Association of German Engineers in Sommerstrasse, where the Chairman, Privy Councillor Busley, after welcoming those present—among whom the Imperial Government Offices, the Federal Council and Legislative Bodies were represented by members—explained the purposes and aims of the Union.

Herr Busley said that their object was to establish a balance between science and practice. Many a technical task could not be carried through without participation and collaboration of several branches of science: the metallurgist required the coöperation of the technician, the architect that of the engineer, etc. An influence was also to be exerted on technical instruction and education, and towards ensuring that the academically trained technician should be admitted to all administrative departments of the Federal States. The technical world ought to be represented, more than was hitherto the case, in the Legislative Bodies. The Union had also applied to the authorities with a view to being consulted in the preparatory work of drafting regulations or enactments. Unfortunately, hitherto, the Imperial Treasury alone had availed itself of their advice, in the preparatory work for the taxation of coal and sources of energy. Finally, the speaker stated that a desire had been expressed that an Austrian and Hungarian Section should be attached to the Union, as to which resolutions were still to be passed.

Professor Dr. Wiedenfeld (Halle) then spoke on "Economics and Technics During and After the War." The speaker showed, in a very exhaustive manner, how, in former days, Germany could manage well with her own production, how subsequently she became more and more dependent on foreign countries owing to the increase of her population, and was then subjected, by the blockade of the sea, to the necessity of remodelling all the foundations of her economic life, of producing from her own resources, raw materials and food. Technical science could only meet these new requirements by fundamentally disregarding the question of cost price, which formerly, in competing with other countries, was necessarily one of the foremost considerations. Disregarding all considerations as to the possibilities of the market and the risk involved, substitutes were produced by calling in the aid of new modes of production and devoting thereto all human powers. Although not all of these new conditions and products can be carried over into times of peace, nevertheless the old economic conditions cannot be reverted to. "What has been will never return," nor would this be even desirable. He said that technical science had been endeavoring to come to the aid of economic life in a threefold manner.

1—By procuring the raw materials formerly obtained from abroad partly by the re-establishment of industries which had become unremunerative (production of manganese, increase of the production of iron, production of sulfur, intensification of agriculture).

2—By promoting the technical tendency, already existing in pre-war times, towards increased utilization of waste products. The term "non-utilizable substance" has been eliminated by the war. The speaker emphasized in this respect obtaining lubricants from coal tar and supplying clothing requirements by utilization of waste material.

3—By producing substitutes, such as for instance nitrogen from the air, and the production of substances by synthetic processes, where the natural way is no longer available, as for instance the cattle food produced from straw.

The speaker recalled a dictum of His Excellency Professor Fischer: "I cannot imagine any substance for which a substitute could not somehow be found." In the speaker's opinion too much regard had been paid during the early part of the war, to the quality of the production, which however became impossible with the continued duration of the war. The speaker also found fault with the multiplicity of Government authorities controlling construction, which had already manifested itself in peace times to the prejudice of German production. With a view to the projects, the speaker demanded that even after the war we ought to aim at a reduced utilization of certain raw materials. Production would assume an unfavorable aspect in certain departments owing to the high expense for industrial war installations. In this respect amortization during the war of these expenses for war installations would be necessary. Further, wherever materials produced wholesale are in question, the speaker would be in favor of monopolies, though not necessarily state monopolies. He held that it would only be by strictly regulated syndicates that steadiness in the movement of prices could be established, and an assurance of remunerativeness, favorable to the display of technical science, and consequent brisk investment of capital, obtained. The speaker concluded by attempting to lay down guiding principles for the collaboration of technical science and enterprise, which cannot do without each other.

Finally Dr. Taaks, Dr. Eng., spoke on "Technical Academic Study After the War."

RESEARCH WORK ON IRON AND STEEL IN GERMANY[1]

The following is an account of an important movement now going on in Germany relative to research work upon iron and steel. This does not appear to have yet been noticed in this country.

The German proposition is to found and establish a special institution and research laboratory to be entirely devoted to researches on iron and steel. Surely we in this country will not allow this action of the enemy to go unchallenged. While Great Britain has several important laboratories devoted to research on iron and steel, there is certainly required a general building and common meeting place for the following important Institutions.

(A) Iron and Steel Institute
(B) Institute of Metals
(C) Institution of Mining and Metallurgy
(D) Institution of Mining Engineers
(E) Faraday Society
(F) Society of Chemical Industry
(G) And others

On March 4, 1917, at a General Meeting of the Verein Deutscher Eisenhüttenleute (German Iron and Steel Institute) held at Düsseldorf (see the accompanying Statement I), Dr. Fr. Springorum, during the course of his address, said the committee appointed by the Board of that Institute had recently discussed the subject and recognized the necessity of promoting progress in metallurgy by the establishemnt of a special research institute probably to be attached to the Kaiser Wilhelm Society.

This was followed on June 19, 1917, by a further meeting of the same Institution (see Statement II) at which a resolution was unanimously passed with regard to the establishment of such an institution and research laboratory to be devoted to research on iron and to be attached to or affiliated with the Kaiser Wilhelm Society, an important new German association.

On July 6, 1917, at a meeting of the Senate of the Kaiser Wilhelm Society, held under the presidency of Professor Von Harnack (see Statement IV) the Senate declared itself in agreement with the proposal of the Verein Deutscher Eisenhüttenleute to establish this institute and laboratory for research on iron and steel.

On July 28, 1917 (see Statement V), reference was made to the meeting of the Verein Deutscher Eisenhüttenleute held on June 19, and after discussing the foundation and site of the building the writer stated that "the means for building and maintaining the Institute, except a small contribution from the Kaiser Wilhelm Society, will be raised by the iron and steel industry of Germany."

Finally, from the latest information in the possession of the compiler of this present statement there was held on November 13, 1917, the first meeting of the "Curatorium" (Trustees Committee) of the Kaiser Wilhelm Institute with regard to the establishment of the research institute and laboratory for research on iron and steel in the "Stahl und Eisen" Building in Düsseldorf, when Dr. Springorum was elected Chairman. (See Statement VII.)

It may be added that the Kaiser Wilhelm Society was founded by the initiative of Emperor William II in January 1911 for establishing and maintaining in a scientific manner independent institutes for research in the sphere of physical science. It has assisted in the foundation of the Institute for Chemistry; Institute for Experimental Therapy; Institute for Coal Research; Institute for Labor Physiology; and now the Institute for Research on Iron and Steel; also (1914) projected the Biological Institute and the Institute for Aerodynamics and Hydrodynamics.

The president is Dr. Harnack and the first vice president is Dr. Krupp von Bohlen und Halbach. Half the members are elected, the other half nominated by the Emperor and the Committee of Management. The election by the Senate and confirmation by the Emperor carries with it the obligation of a contribution of £1,000 with an annual contribution of £50.

Statement I

Meeting of the German Iron and Steel Institute, held at Dusseldorf, March 4, 1917.

INSTITUTION FOR METALLURGICAL RESEARCH

Dr. Fr. Springorum, during the course of his address, stated:

[1] Statement and translations prepared by Sir Robert Hadfield

"The titanic struggle of nations has confronted our iron industry in every direction with particularly great difficulties, and I hope that some day, when the war time records of our works and our associations may be more freely disclosed, not only the full tribute of recognition will be paid for the great things which have been achieved, but that it will also be possible, immediately, to find ways and means of further pursuing, in the interest of the Fatherland, the thousandfold problems which, arising from the emergencies of war, could perhaps be solved only in part during the war. We shall, after the war, far more than hitherto, have to depend on ourselves and to rely on our own strength. Accordingly, the demands on us will be enormous. Industry will only be able to meet them by strenuous work, and will, above all, have to study better utilization of fuels and the further perfecting of metallurgical processes. Coördination between metallurgical practice and metallurgical research, which has always been insisted on and promoted by us, will in future be imperatively needed.

"The weightiness of these facts has revived among our Board an old idea which, to our gratification, has once more been brought forward, of late, by Prof. Oscar Simmersbach, *viz.*, to prepare the soil in order to call into life as quickly as possible, and to promote by financial assistance, an increased activity of research in the domain of the metallurgy of iron and its alloys. For the study of this question the Board has appointed a committee which has recently held an exhaustive discussion on this subject. They were unanimous in recognizing the necessity of promoting with all energy, by scientific research, the progress of metallurgy, with an eye to the exceedingly keen competition in the world's markets, to be anticipated after the war. The only divergency of opinions still existing is as to how such promotion can be effected in the best and most effectual manner; whether by the establishment of a special research institute, possibly attached to the Kaiser Wilhelm Society, or by the expansion of an already existing similar institution, or by studying the problems of research, as they arise, in one or the other scientific laboratory, but always while maintaining the requisite relations with the practical working establishment.

"We may leave the decision as to the course to be adopted to be quietly matured, but the Board recognized that it seemed appropriate just now, in view of the present General Meeting, to acquaint the members with this far-reaching and weighty project, and to gain for it adherents in the widest circles of our works and members. No doubt, funds to a considerable amount will be required for carrying it through; the Board has therefore approved the proposal of its committee that steps should be taken for collecting a nucleus of funds, which should for the present remain at the disposal of the Board of the German Iron and Steel Institute. This fund is to serve in the first place to assist towards turning to account, in practical working, the results of the hitherto purely theoretical labors of the special branch committees of the Institute in the manner appearing most suitable in each case, if a research committee, to be specially appointed for this purpose, endorses the proposal of the respective special branch committee, and if the Board, on its part, considers the granting of funds for the respective purpose appropriate. In this way it would be possible, by enlisting suitable experts or institutions, to take in hand, with the least possible delay, the study of scientific questions important to the iron industry, and at the same time we should, in this way, collect reliable data to serve as a basis for the establishment of a special institution.

"In thus submitting, for the first time in public, the idea of the creation of a fund for an 'Institution for Metallurgical Research,' I feel convinced that, when hereafter the works are called upon to contribute towards the creation of the fund, we may also rely on general and liberal support in the shape of contributions. The German iron industry would thereby erect to itself a worthy war memorial, a cradle for the solution of the manifold problems, still confronting us, and which are of great importance, not only as regards the iron industry, but also as regards the common weal of our Fatherland."

Statement II

Meeting of the German Iron and Steel Institute, held at Düsseldorf, June 19, 1917.

ESTABLISHMENT OF A GERMAN INSTITUTION FOR RESEARCH ON IRON AND STEEL

In the midst of the war, the German iron and steel industry has laid the foundation stone of an important work of peace. At a meeting of leading men of the German iron and steel industry from all parts of the Empire, which was held on June 19, 1917, at Düsseldorf, the establishment of an institution for research on iron and steel was discussed. The invitations to the meeting were issued by the Verein Deutscher Eisenhuttenleute (German Iron and Steel Institute), whose president, A. Vogler, General Manager of Dortmund, took the chair at the meeting.

Dr. O. Petersen, Dr. Eng., secretary of the association, gave an exhaustive exposition of what had hitherto been done in the department of scientific advancement of the metallurgy of iron in the various countries. He pointed out the necessity of rendering foundry technical research more and more profound, in order that we may be well armed in every respect in the inevitable economical struggle of the after-war period. He could only refer briefly to the great and important tasks devolving on a research institution, especially as they are shortly to be dealt with more explicitly in an exhaustive commemorative publication. The speaker pointed out, however, that only a research institution free from any one-sided direction or delimitation of its purpose would be capable of taking these in hand with any prospect of success. The speaker further explained how such an institution should be arranged, developed, and maintained, in detail, thus sketching to the meeting the main outlines of the new research institution itself as well as of the prerequisites of its fruitful working.

The subsequent expression of opinions on the part of those present led, we are glad to say, to the momentous resolution, passed unanimously, that the German iron and steel industry was willing to establish a special scientific institution for iron and steel research, to be attached to (or affiliated with) the Kaiser Wilhelm Society. The preparatory work will be set on foot at once by the Verein Deutscher Eisenhüttenleute, and the association will also be subsequently afforded the opportunity of ensuring, in conjunction with the administrative committee of the institution and a scientific advisory council, the indispensable cohesion between the iron industry and the new research institute.

The locality of the new foundation has not yet been definitely decided upon; the decision hereon has been left to the Verein Deutscher Eisenhüttenleute. But, according to the views expressed in this respect at the meeting, the research institution will be located in the Rhenish-Westphalian industrial region. The Southwestern and Silesian iron industries have unselfishly renounced from the outset, in the interest of the great cause, all claims in this direction.

The considerable funds required for the construction and maintenance of its research institution will be provided by the iron and steel industry alone, apart from a small contribution from the Kaiser Wilhelm Society, while the town in which the institution will be established will have to undertake to provide, in addition to a subsidy towards the building expenses, the requisite ground for its site, and its connection with the railway by a siding, etc. The possibility is not precluded that, later on, other industries engaged in the further elaboration of iron and steel, may themselves take a share in the new research institution.

Thus it seems that all prerequisites are provided for to enable this new creation to exercise a highly momentous and beneficent influence on the further technical development of German metallurgy of iron. It must be considered a high merit of the German iron and steel industry that the project submitted by Dr. F. Springorum, Doc. Eng., Councillor of Commerce, of Dortmund, at the last General Meeting of the Verein Deutscher Eisenhüttenleute, has so speedily been realized.

Statement III

This is a précis of the full Statement IV, report of meeting of the Senate of the Kaiser Wilhelm Society agreeing to proposal to establish an institute for research on iron and steel.

KAISER WILHELM INSTITUTE FOR RESEARCH ON IRON

KAISER WILHELM INSTITUTE FOR PHYSICAL SCIENCE

1—Meeting of Senate of Kaiser Wilhelm Society (founded 1911) held on July 6, 1917, under presidency of Professor von Harnack.

2—Also present, Dr. Schmidt, Ministerial Director, and Richter, Privy Councillor, on behalf of Ministry of Public Health and Education.

Senators:

Dr. Fischer	Dr. Planck von Rath
von Gwinner	Dr. von Schjerning
Koppel	Dr. von Schnitzler
Dr. Krupp von Bohlen und Halbach	Dr. von Siemens
Franz von Mendelssohn	Count Tiele-Winckler
von Moller	von Waldthausen
von Passavant Gontard	Dr. Trendelenburg, District Judge, Gen. See

3—Senate agreed with proposal of Verein Deutscher Eisenhüttenleute to establish the "Research Institute for Steel and Iron," in form of a "Kaiser Wilhelm Institute."

4—Intend to establish jointly with "Leopold Koppel Foundation" an "Institute for Physical Research."

5—To promote investigations of promising problems of theoretical and experimental physics by monetary grants to individual investigators.

6—Professor Einstein, Member of Academy of Sciences, proposed for appointment as Director of Institute.

7—Scientific management to be entrusted to Directorate of eminent physicists; administration to a body of Curators.

Statement IV

The following statement is a report of the meeting of the Kaiser Wilhelm Society held on July 6, 1917, at which they agreed to the proposal of the German Iron and Steel Institute to establish an institute for research on iron and steel.

This is shown as a précis in Statement III.

KAISER WILHELM INSTITUTE FOR RESEARCH ON IRON

KAISER WILHELM INSTITUTE FOR PHYSICAL SCIENCE

On the 6th inst. a meeting of the Senate of the Kaiser Wilhelm Society (founded 1911) was held under the presidency of Professor von Harnack.

Dr. Schmidt, Ministerial Director, and Richter, Privy Councillor, had appeared on behalf of the Ministry of Public Worship and Education.

There were present the Senators Dr. Fischer, von Gwinner, Koppel, Dr. Krupp von Bohlen und Halbach, Franz von Mendelssohn, von Moller, von Passavant-Gontard, Dr. Planck von Rath, Dr. von Schjerning, Dr. von Schnitzler, Dr. von Siemens, Count Tiele-Winckler, von Waldthausen, and Dr. Trendelenburg, District Judge, General Secretary.

The Senate declared itself in agreement with the proposal of the Verein Deutscher Eisenhüttenleute to establish the "Research Institute for Steel and Iron," projected by them in the form of a "Kaiser Wilhelm Institute."

It is intended to establish, jointly with the "Leopold Koppel Foundation" an "Institute for Physical Research." The Institute is to promote the investigation of promising problems of theoretical and experimental physics by monetary grants to individual investigators.

Professor Einstein, Member of the Academy of Sciences, has been proposed for appointment as Director of the Institute.

The scientific management is to be entrusted to a Directorate of eminent physicists, and the administration of the Institute to a body of Curators.

Statement V

Verein Deutscher Eisenhüttenleute (German Iron and Steel Institute), July 28, 1917.

FOUNDATION OF A BUILDING FOR IRON AND STEEL RESEARCH

In the midst of the War, the German iron and steel industry has laid the foundation of a significant peace work. At a meeting of leading men of the industry from all parts of the Empire, which took place at Düsseldorf on June 19, 1917, the foundation of a building for research was discussed. The meeting was convened by the German Iron and Steel Institute, the president of which, General-Director A. Vogler, Dortmund, gave an introductory address.

The business manager of the Institute, Dr. Engineer O. Petersen, gave a detailed account of what has already been done in the way of scientific research for the iron and steel industry in various countries. He showed the necessity which will be increasingly greater for technical research in all directions in order to arm for the business struggle which will follow the War. He could only deal shortly with the great and important tasks which will fall on a research institute, especially as a detailed memoir will shortly be published on the subject. The speaker called attention, however, to the fact that the one aim of such a technical research institute should be to attain success in every task coming before it. How such an establishment is founded, built, and maintained, was the subject of the speaker's further discussion, who unfolded to the meeting in outline a picture of the research building and the requirements for its profitable working.

The concluding speeches of the meeting produced a satisfactory and unanimous resolution that the German iron and steel industry is willing to erect, in conjunction with the Kaiser Wilhelm Society, a special Technical Institute for Ferrous Research. The preliminary work will be put in hand by the German Iron and Steel Union, as then the Union will be able later, in conjunction with the Governing Board of the Institute and a technical assistant counsel, to guarantee proper connection between the steel industry and the research institute.

The site of the new buildings has not yet been settled. The decision has been left to the Committee of the German Iron and Steel Institute. But it is apparent from the views expressed at the meeting that the research building will be established in the Rhenish-Westphalian locality. The Southwest and Silesian industry have renounced their claims in this direction.

The means for building and maintaining the Institute, excepting a small contribution from the Kaiser Wilhelm Society, will be raised by the iron and steel industry, while the town in which it will be situated will be responsible, in addition to a building subsidy, for the necessary land and its connection to the railway, etc. It is not impossible that later other industries will participate in the new research institute.

All appearances show that the new institution will exert a significant and valuable influence on the technical development of the German steel industry. That the plan has matured must be largely attributed to the speech of Dr. Engineer F. Springorum before the last General Meeting of the Iron and Steel Institute (see "Stahl und Eisen," March 15 and April 19, 1917).

Statement VI

This is a précis of the full Statement VII, report of first meeting of Curatorium of Kaiser Wilhelm Institute for Research on Iron.

KAISER WILHELM INSTITUTE FOR RESEARCH ON IRON

1—On June 19, 1917, German iron and steel industry adopted a resolution to found an institution for free scientific research in the domain of iron.

2—On November 13, 1917, a first meeting of "Curatorium" (Trustee Committee) was held in "Stahl und Eisen" Building, Düsseldorf.

3—This research institution will carry on its activity under the title of "Kaiser Wilhelm Institute for Research on Iron."

4—Curatorium consists of:

NAME	QUALIFICATIONS	REPRESENTATIVE OF
Dr. Schmidt (Substitute: Prof. Kruss)	Minister of Education and Public Worship	Ministry of Education and Public Worship
Prof. D. A. von Harnack (Sub.: Dr. Trendelenburg, Sec.-Gen.)	Royal Privy Councillor, President of the Kaiser Wilhelm Society	Kaiser Wilhelm Society
Prof. Emil Fischer	Royal Privy Councillor	
Dr. G. Krupp von Bohlen und Halbach		
Dr. F. Springorum	Dr. Eng. General Manager Councillor of Commerce Member Prussian Upper Chamber (Dortmund)	German Iron and Steel Institute
Dr. O. Niedt	Dr. Eng. General Manager Councillor of Commerce (Gleiwitz)	
A. Vogler	Gen. Manager (Dortmund)	

5—The meeting, at which all above were present, except Prof. Fischer, was also attended by the Secretary of the German Iron and Steel Institute, Dr. O. Petersen, Dr. Eng.

6—Dr. Springorum was elected Chairman of the Curatorium.

7—On November 24, 1917, a second meeting of the Curatorium is to be held.

Statement VII

The following statement is a report of the first meeting of the Curatorium of the Kaiser Wilhelm Institute for Research on Iron, November 13, 1917. This is shown as a précis in Statement VI

Verein Deutscher Eisenhüttenleute (German Iron and Steel Institute.)

KAISER WILHELM INSTITUTE FOR RESEARCH ON IRON

Since the German iron and steel industry, on June 19 last, adopted the momentous resolution to found an institution for free scientific research in the domain of iron, the preparatory work intended to afford to this new centre of research an assured organizatory and financial basis has been advanced by the Verein Deutscher Eisenhüttenleute sufficiently far to admit of the first meeting of the Curatorium (Trustee Committee)

being held on the 13th inst. in the "Stahl und Eisen" Building in Düsseldorf. The Curatorium of the research institution which will carry on its activity under the style and title of "Kaiser Wilhelm Institute for Research on Iron" consists of His Exc. Dr. Schmidt, Minister of Education and Public Worship (Substitute: Prof. Krüss) as representative of the Ministry of Education and Public Worship; His Exc. Prof. D. A. v. Harnack, Royal Privy Councillor, President of the Kaiser Wilhelm Society (Substitute: Dr. Trendelenburg, Secretary General); His Exc. Prof. Emil Fischer, Royal Privy Councillor, and Dr. Gustav Krupp von Bohlen und Halbach, as representatives of the Kaiser Wilhelm Society; and Dr. F. Springorum, Dr. Eng., General Manager, Councillor of Commerce, Member of the Prussian Upper Chamber (Dortmund), Dr. O. Niedt, Dr. Eng., General Manager, Councillor of Commerce (Gleiwitz), and A. Vögler, General Manager (Dortmund), as representatives of the Verein Deutscher Eisenhüttenleute. The meeting, at which all the above-mentioned gentlemen except His Exc. Prof. Fischer were present, was also attended by the Secretary of the Verein Deutscher Eisenhüttenleute, Dr. O. Petersen, Dr. Eng.; Dr. Springorum, Councillor of Commerce, was elected Chairman of the Curatorium. The subject to be dealt with at the meeting was the rules and regulations of the new research institution. A second meeting of the Curatorium, for the discussion of further questions concerning the organization is to be held on November 24, 1917, in Berlin.

AMERICAN PHARMACEUTICAL ASSOCIATION

The Annual Convention of the American Pharmaceutical Association will be held in Chicago, August 12 to 17, 1918. Following is a brief outline of the program:

AUGUST 12: Meeting of the National Association Boards of Pharmacy and American Conference of Pharmaceutical Faculties.

AUGUST 13: Second Session N. A. B. P. and A. C. Ph. F.
Trip to Municipal Pier and Luncheon.
Card Party for Ladies.
Address of President of A. Ph. A.
Nomination of Officers.

AUGUST 14: Session of A. Ph. A.
Section Sessions.
Dinner of Alumni Organizations.
Theatre Party for Ladies.
President's Reception and Ball.

AUGUST 15: Sessions of A. Ph. A.
Section Sessions.
Automobile Ride.
Banquet.

AUGUST 16: Sessions of A. Ph. A
Section Sessions.
Election of Officers.

AUGUST 17: Closing Sessions.

CALENDAR OF MEETINGS

National Fertilizer Association—Annual Convention, Atlantic City, N. J., week of July 15, 1918.

American Pharmaceutical Association—Annual Convention, Chicago, Ill., August 12 to 17, 1918.

American Chemical Society—Fifty-sixth Annual Meeting, Cleveland, Ohio, September 10 to 13, 1918.

National Exposition of Chemical Industries (Fourth)—Grand Central Palace, New York City, September 23 to 28, 1918.

NOTES AND CORRESPONDENCE

IMPORTANCE OF CHEMISTS RECOGNIZED BY SECRETARY OF WAR

WAR DEPARTMENT
THE ADJUTANT GENERAL'S OFFICE
WASHINGTON

May 28, 1918

From: The Adjutant General of the Army.

To: Department Commanders, Commanding Officers of Replacement Training Camps, Depot Brigades and Recruiting Depots, and to the heads of Bureaus and Staff Corps.

Subject: Chemists.

1—Owing to the needs of the military service for a great many men trained in chemistry, it is considered most important that all enlisted men who are graduate chemists should be assigned to duty where their special knowledge and training can be fully utilized.

2—Enlisted chemists now in divisions serving in this country have been ordered transferred to the nearest depot brigade.

3—You will make careful inquiry into the number of graduate chemists now on duty in your command and report their names to this office. The report will include a statement as to their special qualifications for a particular class of chemical work, and whether they are now employed on chemical duties.

4—Enlisted graduate chemists now in depot brigades, or hereafter received by them, will be assigned to organizations or service by instructions issued from this office. The report called for in paragraph 3 herein will be submitted whenever men having qualifications for chemical duties are received by depot brigades, or replacement training camps, or by the training camps organized by the various staff corps.

5—Enlisted men who are graduate chemists will not be sent overseas unless they are to be employed on chemical duties. Prior to the departure of their organization for overseas duties, they will be transferred to the nearest detachment or organization of their particular corps.

6—The Chief of the Chemical Service Section will be charged with the duty of listing all American graduate chemists, including those in the Army and those in civil life.

7—Whenever chemists are needed by one of the bureaus or staff corps, requests will be made on the Chief of the Chemical Service Section for recommendation of a man having the qualifications necessary for the particular class of work for which he is desired. If men having chemical qualifications are wanted for only a short period of duty, they will be temporarily attached to the bureau or staff corps; where the duty is of a permanent nature, instructions covering their transfer will be issued. Whenever the chemists thus attached or transferred are no longer needed for purely chemical duties a report will be made to the Chief of the Chemical Service Section in order that they may be assigned to chemical duties at other places.

By order of the Secretary of War.

ROY A. HILL
Adjutant General

War Department, A. G. O., May 29, 1918. To the Chief, Chemical Service Section, 7th and B Streets, N. W., Washington, D. C., for his information and guidance. When reports showing the number of chemists now at recruit depots, depot brigades, and other places are received, they will be furnished you, in order that proper notation may be made in your register of chemists and for consideration in connection with recommendations for assignment of chemists which you may, from time to time, be called upon to make.

By order of the Secretary of War.

ROY A. HILL
Adjutant General

COÖPERATION OF AMERICAN CHEMICAL SOCIETY WITH THE CHEMICAL SERVICE SECTION

The following letter to Secretary Parsons, of the AMERICAN CHEMICAL SOCIETY, has been placed in our hands by Lt. Col. Bogert, of the Chemical Service Section, N. A., with a request for its publication in the belief that it will be of interest to the members of the AMERICAN CHEMICAL SOCIETY.—[Editor]

WAR DEPARTMENT
CHEMICAL SERVICE SECTION, N. A.
Unit F, Corridor 3, Floor 3,
7th and B Streets, N. W.
Washington, D. C.

May 24, 1918

Dr. Charles L. Parsons, Secretary
American Chemical Society
Washington, D. C.

DEAR PARSONS:

There has just been placed on my desk a memorandum of a conference between you, representing the American Chemical Society, and Major Victor Lenher and Captain Frederick E. Breithut, representing the Chemical Service Section of the National Army. From this memorandum I note that a routine mode of procedure has been agreed upon whereby the American Chemical Society and the Chemical Service Section will coöperate in order to keep in touch with every available chemist in the country.

May I take this opportunity to express to you my sincerest appreciation of all that you have done to aid the Chemical Service Section. When, in February 1917, before the United States entered the war, you, with rare foresight, sensed the future course of events, and began the taking of a census of our chemists, few of us realized how speedily such a census would be needed nor how dependent we would be on your records for the successful prosecution of our work.

The experiences and mistakes of France and England were known to us all. The sending of chemists to the line in a war which can be most accurately described as a chemical war, was a suicidal blunder which we all hoped would not be repeated in this country. But this feeling on our part could have meant but little when translated into action, had we not had the necessary facts regarding the chemical man power of our country. These facts you gathered, card-catalogued, and indexed in a manner which made immediately available precisely the data which were needed.

In thanking you for this latest offer of cordial coöperation, I desire also to express my great pleasure in being able to be associated with you in an undertaking which must mean much, not only for the winning of the war but also for the elevation of the chemical profession to its true status.

One of our aims in the Chemical Service Section is the organization and maximum utilization of the chemical man power of the country for the general good. In endeavoring to realize this, your work is going to count more than any other single factor.

Cordially yours,

MARSTON T. BOGERT
Lt. Col., Chem. Serv. Sect., N. A.

DU PONT FELLOWSHIPS

The situation in regard to the supply of chemists and chemical engineers both for the present and for the future has been giving many industrial concerns a great deal of uneasiness. It is a well-known fact that the number of men studying chemistry and engineering in the advanced classes of all the colleges and universities is on the decline, due to the inroads made by the draft and by enlistments. The du Pont Powder Company, one of the largest employers of chemists in this country, has been finding very great difficulty in obtaining a sufficient number of experienced chemists to meet the requirements involved in the enormous expansion required to meet the situation brought about by the war. As one means of inducing young men to continue the study of chemistry, the du Pont Company has recently set aside a sum of money to establish fellowships and scholarships in a number of colleges and universities throughout the United States. The fellowships are intended for graduate students and have been offered to a number of the larger universities which have strong and well-developed graduate schools of chemistry. The scholarships may be granted either to seniors or to graduate students and have been offered to a number of the best of the smaller schools which have the reputation of doing high-grade undergraduate work. The fellowships amount to $750 each and the scholarships from $300 to $350. The money appropriated for the scholastic year 1918–19 has been offered to a list of forty-eight of the representative institutions of higher learning.

The object of this plan is to promote the study of chemistry and to assist deserving students who have shown special aptitude for chemistry to pursue further work. The scholarships and fellowships have been granted entirely without restriction except that they are to be awarded by the college authorities to advanced students of chemistry and it is hoped that the plan may prove an initial step toward the true spirit of coöperation between American educational institutions and industrial concerns. The du Pont Company feels that the accomplishment of these objects should materially assist in placing the manufacturing and commercial interests of the United States on a firmer basis.

FOUR HUNDRED THOUSAND DOLLAR GIFT TO THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a recent meeting of the Corporation of the Institute, President Maclaurin announced a gift of $400,000 from an anonymous benefactor. The income of this fund is to be available for the general purposes of the Institute during the war and thereafter is to be applied to the development of courses in chemistry and physics.

It is a matter of the first importance in a school of applied science to develop the fundamental sciences of physics and chemistry as thoroughly as possible. The Institute has already a strong staff in these departments.

A great group of the graduates of the chemistry department are now serving the country in the development of its chemical industries and in the prosecution of research with reference to war problems, among this number being ten of the professors of chemistry who have been wholly relieved from regular academic duties to devote themselves to the national cause.

The building up of strong departments of physics and chemistry at a school like the Institute of Technology which draws men in large numbers from all parts of the country is a matter of national importance. There is not only a great need for well-trained chemists and physicists to solve the vital problems of the war, but there will be a similar need in the industrial struggle that will come when peace is declared. The opportunities presented by the war are being seized upon by alert Americans, and great chemical industries are being built up which will need the support of the most highly trained experts to carry them on successfully under the conditions that will later prevail. It is interesting to note that the rising generation also recognizes the opportunity as evidenced among other things by the fact that out of 620 freshmen at the Institute of Technology this year, 160 are being trained for the profession of the chemist.

COAL-TAR PRODUCTS FOR 1917

The United States Tariff Commission announces the completion of its census of coal-tar products for 1917. This group of products includes not only the coal-tar dyes and the crude and intermediate materials required for their manufacture, but also all of the medicinal and photographic chemicals, explosives, synthetic resins, synthetic perfume materials, and flavors which are in any way derived from coal-tar products. There were produced in the United States (not inclusive of explosives and synthetic phenolic resins) 54,367,994 lbs. of dyes and other finished products, which have a total value of $68,711,228. The production of the materials known as intermediates amounted to 322,650,531 lbs., with a value of $106,942,918.

The annual production was reported for the following groups of products made in whole or in part from materials derived from coal tar: 45,977,246 lbs. of dyes valued at $57,796,027; 5,092,558 lbs. of color lakes valued at $2,764,064; 2,236,161 lbs. of medicinal chemicals valued at $5,560,237; 779,416 lbs. of flavors valued at $1,862,456; 263,068 lbs. of photographic chemicals valued at $602,281; and 19,545 lbs. of perfume materials valued at $125,960.

There were 81 establishments engaged in the manufacture of coal-tar dyes in 1917 and their production during that year was practically identical with the amounts annually imported before the war. The imports for the fiscal year 1914 amounted to 45,840,866 lbs. and the production in the United States in 1917 was 45,977,246 lbs. However, an analysis of this total reveals that the domestic production, though equal in quantity to the preceding imports, differs in the relative amounts of the various classes of dyes. Only a small production was reported for indigo, and the alizarin and vat dyes derived from anthracene and carbazol—classes of dyes which include some of the best and fastest colors known to the textile trade. The United States produced only 2,166,887 lbs. of these dyes in 1917; and the elimination of 1,876,787 lbs. of extract made from imported indigo, reduces the output of these dyes to less than 3 per cent of the pre-war imports. Dyes of this class are dutiable at 30 per cent in the Tariff Act of 1916. The lack of development in the manufacture of these particular dyes promises to be remedied to a considerable extent in 1918, for a number of firms have begun their manufacture and a large increase in production can clearly be foreseen.

In the classes of dyes which if imported would be dutiable at 30 per cent plus 5 cents per lb., the American manufacturers have shown remarkable progress, producing 43,810,359 lbs. at a total value of $57,639,990. That this represents something of an excess over the American needs is evidenced by the fact that during the fiscal year 1917, American-made dyes to the value of $11,109,287 were exported to other countries. Thus the exports exceeded the pre-war imports in total value although not in tonnage nor in the variety of the dyes.

The development of the manufacture of intermediates is equally marked, for before the war almost all of these necessary materials were imported from Germany. The Tariff Commission finds that intermediates were manufactured by 117 firms in 1917 and that the production amounted to 322,650,531 lbs. valued at $106,942,918. These figures, however, are somewhat misleading as there is inevitable duplication in the totals. It is well known that many of the intermediates are derived from other products of the same class. Thus starting with benzol the following succession of products is obtained: nitrobenzol, anilin, acetanilid, nitroacetanilid, and nitranilin. Each of these products had to be reported by the manufacturer and hence there has been some cumulative counting.

The totals for all of the coal-tar products will be published in the final report which may well be expected to offer accurate evidence on the progress of the American dyestuff industry.

WASHINGTON LETTER

By Paul Wooton, Union Trust Building, Washington, D. C.

Revenue legislation, industrial curtailment, restriction of imports, stimulations of domestic production and freight rates have vied with each other during the past month in their bids for public attention. Representatives of the chemical industries have been prominently associated with these activities. Edgar Gilbert, the general manager of the Lyster Chemical Works of New York, brought to the attention of the Ways and Means Committee some interesting facts with regard to the taxation of capital invested in secret processes. While Mr. Gilbert appeared primarily in his own behalf, he stated that the matter was one of peculiar importance to the chemical industry. In part, Mr. Gilbert said:

"The process patent is of such a nature very frequently that when it is disclosed it makes it very difficult to protect the inventor. I might cite an illustration that is old and familiar to all of us, that of the nitration of cotton.

"We will go back to the time when nitrocellulose was first introduced; it is an unknown thing, and we will assume it was to be used in this marketed product, because it had no use as nitrocellulose, but in a solvent form it was used as a nitrocellulate. Now, the inventor, if he discloses it to the world, discloses at once the nature of his patent and of his process. But he maintains his secret and patents it and puts his nitrocellulose in another product, such as celluloid. Now if he patents that he has no means of protecting himself against infringements because nitrocellulose appears on the market and someone is producing it, but it would be difficult to know that it had not been produced by some other patent. In that case the inventor would naturally keep secret the nature of his invention and find a market for it in the tensioned form of some other product. There is an illustration of that recently in the act of Congress in recognizing the inventor of this substance we have known as Cordeau and recognizing in the inventor the right of protection. The nature of the thing may be such that protection can be afforded neither by a patent nor by a secret process, because the disclosure would cut short the presentation of the product. So I think the right of protection is so well established that it is only a step to say that the patent and the secret process are identical from the inventor's point of view. He takes whatever course seems to give him the greatest security.

"Now, about his assignee. The inventor discovers a process for doing a certain work. In one case he patents it and in another case he keeps it secret. Now, he sells to a corporation for a certain consideration and then that becomes an item of invested capital for the corporation. Now, in the last bill secret processes were not mentioned at all, and my point simply is that in the redraft of the new bill secret processes should be classified as such, because they form, in the chemical industry especially, a considerable item in the assets of the corporation.

"I had this matter up with Mr. Roper's committee for rulings, and they felt that it was proper, they were identical, but they had no power to reach it, they thought, to reach a secret process, to classify it; it had to go into the patent processes."

Industrial curtailment is still in an uncertain stage. To relieve this undesirable condition, official promise has been given that announcement will be made of the amount of curtailment it is necessary to make just as soon as the matter can be weighed sufficiently to permit of an intelligent ruling. Careful surveys have been made by the War Industries Board and the Fuel and Railroad Administrations. It is shown conclusively that the fuel supply is not adequate for all purposes. At the same time, steel and other materials cannot be manufactured in sufficient volume to meet all requirements. In deciding which industries should be curtailed, great difficulties have been experienced. The Fuel Administration has a list of some 360 industries which are classed as non-war activities. The list has not been made public and the amount of curtailment that will be expected from each has not been determined, with the exception of a few cases. The manufacture of pleasure cars has been reduced to 25 per cent of the volume of last year. Other restrictions are expected to follow promptly.

By heavier loading this year, the fertilizer manufacturers of the country have saved space equivalent to 87,000 cars. The average loading this year was 30.02 tons, as compared with 21.31 tons in 1917. This shows an increased loading efficiency of 40.8 per cent.

Hearings on the War Minerals bill continued throughout the month of April, but delay in the consideration of the bill by the committee was occasioned by the enforced absence of Senator Henderson, the chairman of the Committee on Mines and Mining. Great uncertainty exists among members of the committee as to this legislation. Some of the most capable men in the country appeared before the committee and urged that no legislation be enacted which would permit governmental interference with delicately poised industries which handle the war minerals. The power to fix prices and to regulate the industry otherwise might have such far-reaching consequences that some of the members of the committee, at least, are of the opinion that such measure of control as is needed can be exerted under existing law by the War Industries Board.

Announcement was made by the War Industries Board of a schedule of manganese prices, which ran from 86 cents per unit for 35 per cent metallic manganese to $1.30 per unit for 54 per cent metallic manganese. While the schedule did not cover the chemical ores, it has direct bearing on them.

In the trade agreement recently consummated with Norway, the War Trade Board was particularly liberal in allowing the exportation to that country of chemicals. Among the chemical substances which may be exported under this agreement are: linseed oil; turpentine; palmitic acid; stearic acid; paraffin wax; varnishes; rapeseed oil; ceresine and carnauba wax; rosin; animal and vegetable oils; fats and fatty acids; Chinese wood oil; small quantities of starch, chalk, pyrites, copper, borax, nitrate of soda, bleaching powder, sulfuric acid, and silicate of soda; alum; sulfur; lead; and Solvay soda. Most of the chemicals are to be shipped into Norway consigned to the Oil and Color Merchants' Association and to the Norwegian Papermakers' Association.

Additional restriction on imports have been announced by the War Trade Board. They include castor beans, castor oil, caffeine, and gypsum. All outstanding licenses allowing ocean shipment of castor oil and castor beans have been revoked. Imports may be made only on the approval of the Bureau of Aircrafts Production.

Imports of caffeine, theine, and trimethylxanthine have been cut off entirely.

Importation of gypsum from overseas has been stopped, with the exception of that which can be carried on sailing vessels or barges, which may be designated for that purpose.

Daniel C. Jackling, director of the Explosive Plants Division of the War Department, announced on June 11 the completion, two months ahead of schedule, of the big plants at Charleston, W. Va., and at Nashville, Tenn. Sulfuric and nitric acid production at these plants began early in June.

Nitrate plant No. 3 is to be constructed and operated by the Air Nitrate Corporation. The plant is to consist of two units, one to be built near Cincinnati and one near Toledo. In each instance, construction work has started. Each of the plants will require the services of 1700 operators.

Exports of chemicals during April fell off decidedly, as compared with forwardings abroad during the corresponding month of last year. According to preliminary figures, based on returns to the Department of Commerce, chemical exports in April of this year were valued at $12,646,505. This compares with $16,159,506, the value of chemical exports in April of last year.

F. J. Goodfellow, Secretary of the National Wood Chemical Association, has been appointed charcoal representative of the Fuel Administration.

PERSONAL NOTES

John Harper Long, dean of the Northwestern University School of Pharmacy and a member for many years of the AMERICAN CHEMICAL SOCIETY, died at his home in Evanston, Ill., June 14, 1918, after an illness of nine months. He had been making definite progress toward recovery and was looking forward to complete restoration of his health when a sudden attack of the heart trouble from which he had been suffering caused his death.

Funeral services were held on June 17. Professor Long's sons and son-in-law, Dr. Holgate, president of Northwestern University, and Dr. Ira Remsen, past president of the AMERICAN CHEMICAL SOCIETY and a close friend of Dr. Long, were the active pallbearers. The colleagues of Professor Long on the University staff and Dr. Julius Stieglitz, past president of the AMERICAN CHEMICAL SOCIETY, who had been closely associated with Dr. Long in many scientific undertakings, were the honorary pallbearers.

John Harper Long was born near Steubenville, Ohio, in December 1856. In 1877 he received the degree of B.S. at the University of Kansas; during the years 1877–1880 he studied at Tübingen, Würzburg, and Breslau, receiving the degree of Sc.D. at Tübingen in 1879. In 1881 he became professor of chemistry at Northwestern University Medical School and in 1913 was made dean of the School of Pharmacy at the same institution.

Professor Long was a member of the referee board of consulting scientific experts for the U. S. Department of Agriculture, the revision committee for the U. S. Pharmacopoeia, the council on pharmacy and chemistry of the American Medical Association. He belonged to the Deutsche chemische Gesellschaft, the Washington Academy of Sciences, the Society of Biological Chemists, the American Association for the Advancement of Science of which he was a Fellow, and the American Chemical Society of which he was a past president.

Charles Christopher Trowbridge, assistant professor of physics in Columbia University and a noted ornithologist, died suddenly on June 2 in Roosevelt Hospital, New York City, of blood poisoning. Professor Trowbridge had been a member of the teaching staff of Columbia since 1892. He was in his forty-ninth year.

Mr. Lester F. Weeks, assistant professor of chemistry in the University of Maine, has been appointed assistant professor of chemistry at Colby College to succeed Dr. Robert G. Caswell, who has resigned.

Mr. S. H. Diehl was killed in the explosion at the Aetna Chemical Works in Oakdale, Pa., on May 18, 1918.

At the annual meeting of the American Academy of Arts and Sciences held on May 8, 1918, acting on the recommendation of the Rumford Committee, it was unanimously voted to award the Rumford Premium to Theodore Lyman for his researches on light of very short wave-length.

Mr. Frank Maltauer, formerly employed as bacteriologist in charge of research work on biological chemistry problems at the New York State Laboratories and Research Division of the Heath Department, is at present serving as a private at General Hospital No. 14, Fort Oglethorpe, Ga.

The name of Dr. A. B. Lamb, who has given generously of his time and energy to the work of the Bureau of Mines Experiment Station in Washington, was inadvertently omitted from the list of representative leaders in that work mentioned in the editorial "America in Safe Hands" in the June issue of THIS JOURNAL.

Mr. John H. Card, teacher of chemistry at the High School, Brockton, Mass., has joined the Chemical Service Section, N. A. He has been assigned to the Offensive Research Investigations at the American University Experiment Station, Washington, D. C.

Dr. Geo. R. Bancroft has resigned the professorship of chemistry and physics in Transylvania College, Lexington, Ky., to accept a position in the University of Kentucky as assistant professor of organic and physical chemistry.

The honorary degree of Doctor of Chemistry was conferred upon Mr. Arthur D. Little, of Cambridge, Mass., by the University of Pittsburgh at the commencement exercises on May 31, 1918.

Mr. A. Gordon Spencer, consulting chemist and metallurgist, 619 Transportation Building, Montreal, P. Q., is giving up his consulting practice to devote all his time to the munition and other work of the Peter Lyall and Sons Construction Co., Montreal, as their consulting metallurgist.

Mr. C. A. Clemens, formerly instructor of chemistry at Rensselaer Polytechnic Institute, Troy, New York, who is now with the Gas Defense Service, Sanitary Corps, has been sent to the Lakehurst Experimental Grounds, Lakehurst, N. J.

Mr. Chas. E. Waller, formerly with the Pennsylvania Trojan Company at Allentown, Pa., is now with the Non-Freezing High Explosive Corporation at Kingston, N. Y.

Mr. William A. Waldie, formerly chemist for the Glidden Varnish Company, but more recently with the Thibaut and Walker Company, has again returned to the Glidden Company as chief chemist.

In *Science* for May 10 Associate Director Edward R. Weidlein of the Mellon Institute, who is Acting Director in the absence of Director Bacon, gives the following summary of the industrial fellowships in operation at the Institute on March 1, 1918.

No.	Names of Industrial Fellowships in Operation	Industrial Fellows, Names and Degrees	Foundation, Sums and Dates of Expiration
92	Leather Belting	E. D. Wilson (Ph.D., University of Chicago)	$3,800 a year. April 1, 1918
95	Magnesia	G. D. Beazley (E.E., University of Illinois)	$4,750 a year. November 1, 1918
99	Glyceryl Phosphates	F. F. Rupert (Ph.D., Massachusetts Institute of Technology)	$1,500 a year. Bonus, 10 per cent of profits. October 1, 1918
102	Fruit Juice	R. R. Shively (Ph.D., University of Pittsburgh)	$5,000 a year. April 1, 1918
114	Enameling	R. D. Cooke (M.S., University of Wisconsin)	$2,200 a year. April 1, 1918
115	Bread	H. A. Kohman (Ph.D., University of Kansas), Senior Fellow R. R. Irvin (M.S., University of Kansas) (Vacancy)	$7,500 a year. Bonus, $10,000. March 1, 1919
116	Refractories	R. M. Howe (M.S., University of Pittsburgh), Senior Fellow (Vacancy)	$6,000 a year. May 1, 1918. Bonus, $500
117	Window Glass	A. C. Nothstine (B.S., Ohio State University)	$3,000 a year. Bonus, $2,000. June 1, 1918
118	Leather Soling	C. B. Carter (Ph.D., University of North Carolina)	$3,500 a year. June 4, 1918
119	Iron Ore	F. M. Meclenahan (M.A., Yale University)	$3,000 a year. June 15, 1918
120	Dental Products	C. C. Vogt (Ph.D., Ohio State University)	$2,400 a year. Bonus, royalty on sales. July 1, 1918
121	Copper	C. L. Perkins (B.S., New Hampshire College) J. W. Schwab (B.S., University of Kansas)	$5,400 a year. July 1, 1918
122	Soda	C. W. Clark, Ph.D., University of Pittsburgh)	$3,500 a year. September 1, 1918
123	Oil	Harry Essex (Ph.D., University of Göttingen) I. W. Humphrey (M.S., University of Kansas) (Vacancy)	$10,000 a year. Bonus, $10,000. September 1, 1918
124	Cement	E. O. Rhodes (M.S., University of Kansas)	$4,000 a year. Bonus, $3,500. August 1, 1918
125	Hair	B. A. Stagner (Ph.D., University of Chicago)	$3,000 a year. October 1, 1918
127	Collar	H. D. Clayton (B.A., Ohio State University)	$2,800 a year. October 1, 1918
128	Coffee	C. W. Trigg (B.S., University of Pittsburgh)	$4,800 a year. Bonus, 2 per cent of gross receipts. October 1, 1918
129	Illuminating Glass	A. H. Stewart (A.B., Washington and Jefferson College) (On leave of absence)	$900 a year. October 1, 1919
130	Food Container	F. W. Stockton (A.B., University of Kansas)	$5,000 a year. October 16, 1918
131	Gas	J. B. Garner (Ph.D., University of Chicago), Senior Fellow (Vacancy)	$7,500 a year. September 15, 1918
132	Yeast	F. A. McDermott (M.S., University of Pittsburgh) Ruth Glasgow (M.S., University of Illinois) T. A. Frazier (B. Chem., University of Pittsburgh) P. H. Brattain I. S. Hocker (B.S., University of Pennsylvania)	$12,700 a year. Bonus, November 1, 1918
133	Glass	E. E. Bartlett (Pet.E., University of Pittsburgh)	$3,000 a year. November 1, 1918
134	Glycerin	J. E. Schott (M.A., University of Nebraska)	$3,000 a year. November 15, 1918
135	Fiber	J. D. Malcolmson (B.S., University of Kansas)	$2,500 a year. November 15, 1918
136	Copper	G. A. Bragg (B.S., University of Kansas), Senior Fellow of all Copper Fellowships (Vacancy)	$5,000 a year. November 1, 1918
137	Toilet Articles	L. M. Liddle (Ph.D., Yale University)	$3,500 a year. December 1, 1918
138	Silicate	M. G. Babcock (M.S., Iowa State College)	$2,500 a year. December 1, 1918
139–A	Organic Synthesis	G. O. Curme, Jr. (Ph.D., University of Chicago), Senior Fellow J. N. Compton (M.S., Columbia University) H. R. Curme (B.S., Northwestern University) E. W. Reid (M.S., University of Pittsburgh)	$10,000 a year. Bonus, $5,000 January 1, 1919
139-B	Organic Synthesis	H. A. Morton (Ph.D., University of Pittsburgh), Senior Fellow C. J. Herrly (B.S., Pennsylvania State College)	$5,000 a year. Bonus, $5,000. January 1, 1919
140	Silverware	H. E. Peck (B.S., Clarkson Memorial College of Technology)	$2,500 a year. December 11, 1918
141	Insecticides	O. F. Hedenburg (Ph.D., University of Chicago)	$3,000 a year. January 1, 1919
142	By-products Recovery	Walther Riddle (Ph.D., University of Heidelberg)	$3,000 a year. January 1, 1919
143	Coke	F. W. Sperr, Jr. (B.A., Ohio State University), Advisory Fellow Marc Darrin (M.S., University of Washington) O. O. Malleis, (M. S., University of Kansas) L. R. Office (B.S., Ohio State University)	$7,000 a year. January 1, 1919
144	Fertilizer	H. H. Meyers (B.S., University of Pennsylvania)	$3,000 a year. Bonus, $5,000. January 5, 1919
145	Soap	(Fellow to be appointed)	$2,000 a year. January 5, 1919
146	Glue	R. H. Bogue (M.S., Massachusetts Agricultural College)	$2,500 a year. January 5, 1919
147	Distillation	David Drogin (B.A., College of the City of New York) H. F. Perkins	$5,300 a year. January 18, 1919
148	Tobacco	W. B. Pattison (M.A., University of Nebraska)	$2,100 a year. Bonus, $2,000. February 1, 1919
149	Laundry	H. G. Elledge (M.S., University of Pittsburgh), Senior Fellow K. R. Beach (A.B., Southwestern College)	$5,000 a year. February 15, 1919

Kenneth D. Kahn, research chemist and metallurgist for the Cleveland Brass Manufacturing Company, Cleveland, Ohio, has been appointed assistant chemical engineer at the Bureau of Mines Experiment Station, American University, Washington, D. C., engaged in the manufacture of war chemicals.

Mr. William Rhafferty, who was formerly chief chemist at the Camden Works, General Chemical Company, and was later transferred to the Bayonne Works, has resigned his position to take up work as assistant to the superintendent of Chas. Lennig and Company, located at Bridesburgh, Pa.

Mr. M. E. Jennings, formerly with the Central Pharmacal Co., Seymour, Indiana, is now a Sergeant in Company E, 30th Engineers, and is located at Fort Meyer, Va.

Mr. F. A. Fererer has left Eli Lilly and Company and is in the Medical Department of the Army, located at Newport News

Mr. C. M. Sharp, formerly an instructor at Shortridge High School, is in the chemical service of the Medical Corps, located at St. Louis.

Mr. V. P. McManus, well known in drug and chemical circles and for many years associated with McKesson and Robbins, has severed his connection with that house and is now with H. W. Henning & Son, 80 Maiden Lane, New York City.

Henry Coit MacLean, for two years assistant manager of the Foreign Trade Bureau of the Merchants' Association of New York, has assumed his new duties as manager of the New York Office of the United States Bureau of Foreign and Domestic Commerce. Mr. MacLean is thoroughly familiar with the work of the Bureau of Foreign and Domestic Commerce and has been in close touch with questions confronting exporters and importers arising from war conditions.

Mr. Howard A. Winn, formerly of H. H. Hay Sons, manufacturing pharmacists, Portland, Me., is now with the United Drug Co. in the pharmaceutical department.

Dr. A. S. Eastman has given up his position as professor of chemistry at the University of the South, Sewanee, Tenn., and is now connected with the research laboratory of the Hercules Powder Co., Kenvil, N. J., in charge of the research work on T. N. T.

Dr. Robert G. Caswell has resigned as assistant professor of chemistry at Colby College, to accept a position as one of the research chemists for E. I. du Pont de Nemours & Co., Wilmington, Del.

Prof. Herman I. Schlesinger has been promoted to assistant professor of chemistry at the University of Chicago.

INDUSTRIAL NOTES

Statistics compiled by the Bureau of Foreign and Domestic Commerce show that nearly twice as much sulfuric acid was produced in the United States in 1917 as 1913, which is taken as a normal before-the-war-period.

Contracts have been awarded by the Ordnance Department for the establishment of two large picric acid plants at Little Rock, Ark., and Brunswick, Ga. It is expected that the Little Rock plant will be in operation in September 1918. These will be the first Government-controlled picric acid plants to be established in this country.

How 2,000,000 gallons a year of cymene which is now going to waste in the manufacture of paper pulp can be used to produce a line of dye colors very close in their properties to aniline dyes has been worked out in the Color Investigations Laboratory of the Bureau of Chemistry, United States Department of Agriculture. This is the first and very important result of extensive research, investigation, and experimentation conducted in this laboratory under the direction of Dr. H. D. Gibbs.

Paul Wenger and Co., 35 Nassau Street, New York City, well known in the metal trade, have opened a chemical branch in which they will act as buyers, sellers, exporters, and importers. They intend eventually to enter into the manufacture of chemicals and drugs. Charles W. Buck, who up to now has been manager of the Coöperative Drug Company, at South Norwalk, Conn., has been appointed manager of the new plant.

The Cobwell Corporation will have completed in Cleveland within the next 35 days a plant of 25 to 35 tons' daily capacity handling garbage, butcher's offal, and dead animals. This will be of most modern construction and will incorporate all of the newest features covered by the patents of Raymond Wells including a complete equipment for the manufacture of alcohol as an additional product. This plant has been undertaken as a large scale demonstration and experimental plant and will be open at any time to those interested in the business or its development.

On June 2 the J. K. Mosser Tanning Company's plant at Noxen, twenty-five miles from Wilkes-Barre, Pa., was destroyed by fire. The loss is estimated at $3,000,000. The cause of the fire is believed to have been due to crossed wires in the hair-drying room. The plant was controlled by Armourand Co.

For the first quarter of 1918 the metalliferous production of the Province of Ontario was $17,909,000, a gain of $2,315,000 over the same period last year. Gold production amounted to 113,387 ounces, and of that amount the Hollinger mines contributed 68,804 ounces, or a little more than half of the total. The increase was principally silver, owing to the higher price obtained. Gold, on the other hand, in the aggregate fell off, owing to labor difficulties. The three months' silver total was $3,740,000, against $2,831,000 in 1917. Total gold production fell from $2,601,000 to $2,265,000. Nickel and copper show a small decrease. Hollinger is now producing gold at the rate of approximately $6,000,000 annually.

H. Koppers Company announce that they have been awarded a contract by the Jones and Laughlin Steel Company for the construction of a by-product coke plant of 300 ovens. This plant will have a carbonizing capacity of approximately 2,000,000 tons per year, and will replace beehive coking capacity to that amount. The plant will be complete in every respect, and will be equipped for the recovery of ammonia in the form of ammonium sulfate, of tar, and of benzol and toluol as pure products. The ammonium sulfate and pure toluol from this plant will be sold to the Government for war purposes. The steel company proposes to use the gas in its steel plant operations. It has also been announced recently that H. Koppers Company are to build two more batteries of by-product ovens for the plant of the Steel Corporation at Clairton, Pa. This will give the Steel Corporation a plant of 748 ovens which, when completed, will be the largest by-product coke plant in the world. The plant of the Illinois Steel Co., Gary, Ind., which has recently added 140 Koppers ovens to its original installation of 560 ovens, is at present the largest by-product coke oven plant in the world.

The War Industries Board has announced that a commodity section on medicines and medical supplies has been created, with Lieut. Col. F. F. Simpson as its chief. The work of this section will be closely coördinated with that of the Chemical Division. This new section will deal incidently with chemicals as they enter into medical compounds, preparations, etc., and will work in conjunction with the section of the Chemical Division dealing with fine chemicals and bulk medicinal chemicals.

Any doubt about the status of the steel industry in relation to the Government was cleared away Friday, May 24, at the annual meeting and banquet of the American Iron and Steel Institute. A good index to the situation was furnished by Judge E. H. Gary, representing the steel interests; Charles M. Schwab, representing the Emergency Fleet Corporation; and J. Leonard Replogle, director of steel supplies for the Government. The steel manufacturers pledged their support to the Government to the extent of 100 per cent of their respective outputs. They also agreed that steel would be allotted to consumers in order of the importance of its use for national purposes, the judge being the director of the steel supply. Preference is now given to shipbuilding steel, following which in importance comes shell steel, and then steel rails. Mr. Replogle has announced that to fill the Government's demands will require the entire capacity of the steel mills for at least a year. The prospects of manufacturers engaged upon other than Government work keep growing dimmer, though producers are anxious to aid them so far as possible. Steel for Japan has begun to go forward. Already 20,000 tons have been shipped from the Pacific Coast, and the balance, 155,000 tons still due, will follow later.

The Independent Filter Press Company has removed from 47 West 34th Street, New York City, to 418 Third Avenue, Brooklyn, N. Y.

Like most other countries Japan has suffered from the shortage of dyes and chemicals due to the European War. Prior to the war, Japan imported annually dyes valued at $3,500,000, nearly all of which came from Germany. As most of these dyes were used in the important textile industries of Japan and prices had been advancing by leaps and bounds, the Government passed a law in 1915 providing for the grant of subsidies to companies engaged in the manufacture of dyes (including aniline salt, aniline dyes, alizarine dyes, and synthetic indigo) and chemicals in Japan, and requiring that more than half of the capital of any such company be subscribed by Japanese subjects. The amount of the subsidy to be granted is sufficient to enable the companies to pay a dividend of 8 per cent per annum on their paid-up capital. The subsidies are for a period of ten years from the date of the promulgation of the law. Medicines or perfumery specified by Imperial Ordinance, manufactured from by-products of coal tar, are regarded as manufactured dyes and chemicals. The manufacture of the materials of gunpowder and explosives and of certain medicines, to be determined by Imperial Ordinance, are also regarded as the manufacture of dyes and chemicals. One of the results which attended the efforts made by the Japanese Government to solve the dyestuff problem was the formation of the Japan Dyestuff Manufacturing Company, Ltd., with a capital of 8,000,000 yen (about $4,900,000), subsidized by the Government.

The War Department authorizes the statement that operations in the Government's new powder plants near Charleston, W. Va., and Nashville, Tenn., have begun two months ahead of schedule. The Nashville plant started June 5, and the Charleston plant started June 12. These plants will produce sulfuric and nitric acids. The capacity of these two plants is expected to equal that of all the other American smokeless powder plants combined.

At a meeting of the Iron and Steel Institute on May 3, awards of $500 from the Carnegie Research Fund were made to Mr. George Patchin, of London, an associate of the Royal School of Mines, and formerly head of the metallurgical department of Birkbeck College, to enable him to pursue research on "Semi-steel and its heat treatment;" to Mr. Samuel L. Hoyt, U. S. A., to enable him to study "The foreign inclusions in steel, their occurrence and identification;" and to Professor J. A. Van den Broek, of the University of Michigan, for research work on "The elastic properties of steel and alloys."

During May nine new companies were organized for the manufacture of drugs, chemicals, and dyestuffs. The aggregate for the entire war period now stands at $378,987,000. The figures for May compare with eighteen concerns formed in April for an aggregate capitalization of $3,980,000. The average incorporation per company in May was $133,333. This figure compares with $221,111 in April and $439,838 in March. Two war companies were created during May. They were the Swift Aircraft Manufacturing Company with an authorized capital of $50,000, and the United States Ammunition Company, with a capitalization of $2,500,000. The addition of these two concerns brings the total of investments in this industry up to $269,625,000.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

COUNCIL OF NATIONAL DEFENSE

List of Staple Surgical and Medical Supplies. Reprint with revisions of the lists of medicines, antiseptics, disinfectants, chemicals, etc., selected to meet war conditions by the Committee on Standardization. 27 pp.

Laboratory Supplies. Reprint of list selected by the Committee on Standardization. 26 pp.

PAN AMERICAN UNION

Some Andean Sulfur Deposits. B. L. Miller and J. T. Singewald, Jr. Reprint from January 1918 number of Bull. of the Pan American Union. 16 pp.

PUBLIC HEALTH SERVICE

A New Disinfectant Testing Machine. A. M. Stimson and M. H. Neill. Public Health Reports, **33**, 529–39 (April 12).

Arsphenamine (Salvarsan) and Neo-Arsphenamine (Neo-Salvarsan). Public Health Reports, **33**, 540–2 (April 12). Licenses ordered and rules and standards prescribed for their manufacture.

The Dietary Deficiency of Cereal Foods with Reference to Their Content in "Antineuritic Vitamine." G. Voegtlin, G. C. Lake and C. N. Myers. Public Health Reports, **33**, 647–66 (May 3).

The Present Status of Our Knowledge of Fatigue Products. E. L. Scott. Public Health Reports, **33**, 605–610 (April 26).

1—Substances carrying hydrogen ions, as lactic and β-oxy-butyric acids, potassium dihydrogen phosphate, and carbon dioxide stand as causal agents of fatigue.

2—Certain products of protein disintegration, as indol, skatol, and phenol may produce fatigue symptoms and may be active agents in producing normal fatigue.

3—There is some evidence that the negative ion of lactic and β-oxy-butyric acids and that certain positive ions, especially that of potassium, are capable of producing certain fatigue phenomena.

4—There is no evidence that the negative ions of carbonic, phosphoric, or sulfuric acids are fatigue substances.

5—There is no evidence at present for the existence of specific fatigue substances as proposed by Weichardt.

6—There is very little probability that creatin or creatinine have any relation to fatigue or to muscle work in general.

7—There are no doubt numerous bodies, as purine bases, uric acid, etc., which may be increased by work, but which have no causal bearing on fatigue.

GEOLOGICAL SURVEY

The Lake Clark-Central Kuskokwim Region, Alaska. P. S. Smith. Bulletin 655. 147 pp. and 2 maps. With special attention to mineral resources.

Cannel Coal in the United States. G. H. Ashley. Bulletin 659. 116 pp. Paper, 15 cents. The present paper is not intended as an original contribution to the subject, though the writer has drawn on his own notes in describing many of the deposits mentioned, particularly those in Pennsylvania, Indiana, and parts of West Virginia and Kentucky. It consists of a preliminary review of well-known facts about the character, uses, and value of cannel coal and brief descriptions of workable deposits of cannel coal, including cross sections of the beds, and it gives such analyses of the coal as are available.

The Structural and Ornamental Stones of Minnesota. O. Bowles. Bulletin 663. 199 pp. Prepared in coöperation with the Minnesota State Geological Survey.

Manganese at Butte, Montana. J. T. Pardee. Bulletin 690–E. From Contributions to Economic Geology, 1918, Part I. 20 pp. Published April 9. A search through the published reports describing the ore deposits of Butte, supplemented by a brief field examination in August 1917, revealed the fact, perhaps not generally appreciated heretofore, that the amount of material in the lodes that is sufficiently rich in manganese to be considered a possible source of that metal is very large. The smaller part of this material, which is found in the outcrops and upper parts of the lodes, consists of manganese oxides associated with more or less quartz.

By far the most of the manganiferous material below the oxidized zone at Butte consists of rhodochrosite and rhodonite, the carbonate and silicate of manganese, respectively, associated in different proportions with quartz and sulfides. The most interesting and promising feature concerning the occurrence of manganese at Butte is the fact that portions of this unoxidized material consist of fairly pure rhodochrosite and are, therefore, very valuable as a source of the metal. Reported analyses of material of this character in the Emma mine run from 34 to 41 per cent manganese and as low as 1 per cent silica. According to reports this material when lightly roasted gives off its carbon dioxide, and as a result the percentage of manganese is increased in the product. The known workable bodies of this ore aggregate several thousand tons, and there is reason to expect that future developments will disclose large additional amounts.

Whether the general run of the unoxidized manganiferous material can be considered under any conditions as a possible source of manganese is a question for metallurgists to answer. The amount of material that contains 15 per cent or more manganese and occurs within the depths ordinarily reached in mining is indicated, by the evidence available, to be millions of tons. Because they lie at the surface the oxide ores can be mined as rapidly as desired, and the extensiveness of the underground workings, of which many that are temporarily abandoned could probably be made usable in a short time, will permit the carbonate and silicate ore also to be rapidly extracted. Therefore, whether Butte can be counted upon without delay for a considerable production of manganese depends on the solution of problems concerning the metallurgy rather than the mining of its manganiferous deposits.

The Structure of Parts of the Central Great Plains. N. H. Darton. Bulletin 691–A. From Contributions to Economic Geology, 1918, Part II. 26 pp. Published April 2. Mainly of geologic interest.

Gold, Silver, Copper, Lead, and Zinc in Idaho and Washington in 1916. C. N. Gerry. From Mineral Resources of the United States, 1916, Part I. 52 pp. Published March 14. Mines report; general report later.

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Agriculture: The Teaching of Agriculture. A. W. NOLAN. 12mo. 277 pp. Price, $1.30. Houghton, Mifflin Co., Boston.

Blast Furnace: Principles, Operation and Products of the Blast Furnace. J. E. JOHNSON, JR. 8vo. 551 pp. Price, $5.00. McGraw-Hill Co., New York.

Carbon and Its Allies. R. M. CRAVEN. 8vo 468 pp. Price, $5.00. J. B. Lippincott Co., Philadelphia.

Chemical French. M. L. DOLT. 8vo. 398 pp. Price, $3.00. Chemical Publishing Co., Easton, Pa.

Chemistry: What Industry Owes to Chemical Science. R. B. PILCHER. 8vo. 164 pp. Price, 3s. Archibald Constable & Co., London.

Chemistry of Food and Nutrition. H. C. SHERMAN. 2nd Ed. 12mo. 545 pp. Price, $2.00. The Macmillan Co., New York.

Concrete and Cement; a List of Books. 12 pp. Gratis. The Public Library, Brooklyn, N. Y.

Enamels. R. D. LANDRUM. 8vo. 106 pp. Gratis. The Harshaw, Fuller & Goodwin Co., Cleveland.

Fuel Oil: Elements of Fuel Oil and Steam Engineering. ROBERT SIBLEY AND C. H. DELANY. 8vo. 320 pp. Price, $3.00. Technical Pub. Co., San Francisco.

Gear Cutting, In Theory and Practice. J. G. HORNER. 8vo 404 pp. Price, 8s. 6d. Emmott & Co., London.

Kiln Drying of Lumber. H. D. TIEMANN. 8vo. Price, 18s. J. B. Lippincott Co., Philadelphia.

Lubricants: American Lubricants. L. B. LOCKHART. 8vo. 236 pp Price, $2.00. Chemical Pub. Co., Easton, Pa.

Measurement of Gas by Orifice Meter. H. P. WESTCOTT. 12mo. 408 pp. Price, $3.50. Electric Metal Works, Erie, Pa.

Mechanics: Cours de mecanique professé á l'ecole polytechnique. LEON LECORNU. 8vo. 676 pp. Price, 25 fr. Gauthier-Villars, et Cie, Paris.

Metallurgical Study of the Steel Base as Related to Galvanizing. G. A. WHITE. 4to. 58 pp. Price, $2.00. Matthews-Northrup Works, Buffalo, N. Y.

Metallurgy of the Non-Ferrous Metals. WM. GOWLAND. 2nd Ed. 8vo. 619 pp. Price, 25s. Chas. Griffin & Co., London.

Oil: A Short Hand-book of Oil Analysis. A. H. GILL. 8th Ed. 12mo. Price, $2.00. J. B. Lippincott Co., Philadelphia.

Plant Products: An Introduction to the Chemistry of Plant Products. PAUL HAAS AND T. G. HILL. 2nd Ed. 8vo. 411 pp. Price, $3.50. Longmans, Green & Co., New York.

Rubber: Its Production, Chemistry and Synthesis. (Amer. Ed.). A. DUBOSE AND A. LUTTRINGER. 8vo. 383 pp. Price, $6.50. J. B. Lippincott Co., Philadelphia.

Steel and Its Treatment. E. F. HOUGHTON & Co. 3rd Ed. 12mo. 165 pp. Price, $1.50. The Author, Philadelphia.

Sugar Beet Seed, History and Development. T. G. PALMER. 12mo. 120 pp. Price, $1.35. John Wiley & Sons, New York.

Trioxymethylene: The Action of Trioxymethylene on Various Hydrocarbons in the Presence of Anhydrous Aluminum Chloride. V. R. KOKATNUR. 8vo. 45 pp. Price, $0.50. University of Minn., Minneapolis.

Water Analysis: A Simple Method of Water Analysis. J. C. THRESH. 9th Ed. 18mo. 69 pp. Price, 3s. J. and A. Churchill, London.

RECENT JOURNAL ARTICLES

Air Washer: High Velocity Air and Gas Washer. J. L. ALDEN. *The Iron Trade Review*, Vol. 62 (1918), No 23, pp. 1428–1429.

Amylo Saccharification Process. J. S. HORN. *The Chemical Engineer*, Vol. 26 (1918), No. 6, pp. 204–207.

Analysis of Sulfonated Oils. G. W. SCHULTZ. *Journal of the American Leather Chemists Association*, Vol. 13 (1918), No. 5, pp. 190–192.

Atmospheric Nitrate: The Beginning of the Atmospheric Nitrate Industry in America. O. P. AUSTIN. *The American Fertilizer*, Vol. 48 (1918), No. 10, pp. 33–35.

Black Dyes. C. S. WEHRLY. *Color Trade Journal*, Vol. 2 (1918), No. 6, pp. 208–212.

Calcium Arsenate. R. H. ROBINSON. *Journal of Agricultural Research*, Vol. 13 (1918), No. 5, pp. 281–294.

Chemical Industry in War. HENRY HOWARD *The Iron Trade Review*, Vol. 62 (1918), No. 19, p. 1188.

Coal Tar Colors: Application of the Coal Tar Colors to Wood Staining. F. E. BURNHAM. *Color Trade Journal*, Vol. 2 (1918), No. 6, pp. 227–228.

Coke: The Determination of Moisture in Coke. A. C. FIELDNER AND W. A. SELVIG. *The Chemical News*, Vol. 117 (1918), No. 3046, pp. 172–175.

Condensers: Design and Layout of Condensers. D. D. PENDLETON *The Iron Trade Review*, Vol. 62 (1918), No. 23, pp. 1361–1365

Copper: New Method of Determining Copper. JAMES MOIR *Mining and Scientific Press*, Vol. 116 (1918), No. 21, pp. 725–726.

Dilution Figures for the Sulfate Process. JAMES BEVERIDGE. *Paper*, Vol. 22 (1918), No. 13, pp. 11–12.

Dry Sizing as a Means of Preparing Feed for Concentration. G. V. BLAND. *Engineering and Mining Journal*, Vol. 105 (1918), No. 20, pp. 908–911.

Electro-Plating Engineering. C. B WILLMORE. *The Metal Industry*, Vol. 16 (1918), No. 5, pp. 209–211.

Fiber Board. OTTO KRESS AND G. C. MCNAUGHTON. *Paper*, Vol. 22 (1918), No. 11, pp. 11–16.

Glass: Some American Contributions to the Glass Industry. E. W. TILLOTSON. *The Kansan Chemallurgist*, Vol. 3 (1918), No. 1, pp. 4–6.

High Temperatures and Artificial Gas. E. R. ROSENBAUM. *The American Drop Forger*, Vol. 4 (1918), No. 5, pp. 186–189.

Iron: Economic Factors in the Iron Industry. MALCOLM KEIR. *The Iron Age*, Vol. 101 (1918), No. 21, pp. 1342–1344.

Japanese Development in Steel Making. T. T. READ. *The Iron Age*, Vol. 101 (1918), pp. 1259–1262.

Lubrication and Manufacturing Efficiency. E. E. GRIGNARD. *Textile World Journal*, Vol. 53 (1918), No. 48, p. 69.

Manganese Conservation Necessary. C. R. ELLICOTT. *The Iron Trade Review*, Vol. 62 (1918), No. 23, pp. 1439–1441.

Materials: Requirements in Testing of Materials. J. F. BEALL. *The American Drop Forger*, Vol. 4 (1918), No. 5, pp. 183–185

Milling in Cyanide Solution. A. W. ALLEN. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 10, pp. 515–519.

Mine Valuation: Formulas for Mine Valuation. W. W. WHITTON. *Mining and Scientific Press*, Vol. 116 (1918), No. 20, pp. 691–694.

Nitrogen and Its Compounds. HORACE FREEMAN. *Canadian Chemical Journal*, Vol. 2 (1918), No. 5, pp. 123–125.

Oil Shales: The Economic Position of Oil Shales. J. C. MORRELL AND G. EGLOFF. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 11, pp. 601–607.

Oils: A Process for Deodorizing Fatty Oils. W. P. SCHUCK. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 11, pp. 608–609.

Paper: Government Paper Bibliography. H. E. STOCKBRIDGE. *Paper*, Vol. 22 (1918), No. 11, pp. 38–40.

Petroleum Chemistry in the Schools. W. F. FARAGHER. *The Kansan Chemallurgist*, Vol. 3 (1918), No. 1, pp. 8–10.

Potash from Wood Ashes. C. T. EDGAR. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 10, pp. 537–539.

Power Requirements of Hydroextractors. T. A. BRYSON. *Textile World Journal*, Vol. 53 (1918), No. 48, pp. 61–67.

Pulpwoods: The Principal Properties, Structure and Identification of Canadian Pulpwoods. H. N. LEE AND R. W. HOVEY. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 20, pp. 446–448.

Pulverized Coal: Using Pulverized Coal Efficiently. H. R. COLLINS. *The Iron Trade Review*, Vol. 62 (1918), No. 20, pp. 1243–1245.

Reforestation: Economic Aspects of Reforestation. J. W. TOUMEY. *Paper*, Vol. 22 (1918), No. 13, pp. 14–17.

Refractory Silica Brick Composition. J. S. MCDOWELL. *Mining and Scientific Press*, Vol. 105 (1918), No. 21, pp. 954–956.

Research Work on the Sizing of Paper. F. C. CLARK AND A. G. DURGIN. *Paper*, Vol. 22 (1918), No. 10, pp. 11–17.

Rubber: Defects in Industrial Rubber Goods. FREDERIC DANNERTH. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No 10, pp. 531–534.

Sodium Cyanide. W. J. SHARWOOD. *Mining and Scientific Press*, Vol. 116 (1918), No. 19, pp. 655–656.

Steam Cylinder Lubrication. W. F. OSBORNE. *Lubrication*, Vol. 5 (1918), No. 7, pp. 2–12.

Steam Engine Design. F. S. BAUER. *University of Colorado Journal of Engineering*, Vol. 14 (1918), No. 3, pp. 33–37.

Steam Turbine Oil Filtration. E. M. MAY. *Lubrication*, Vol. 5 (1918), No. 7, pp. 12–16.

Stellite. Alloys of Cobalt, Chromium, Tungsten and Molybdenum. ELWOOD HAYNES. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 10, pp. 541–542.

Steel: Its Selection and Treatment. J. F. KELLER. *The American Drop Forger*, Vol. 4 (1918), No. 2, pp. 52–55.

Storage of Bituminous Coal. E. MATHESON. *Paper*, Vol. 22 (1918), No. 11, pp. 35–38.

Steel: Manufacture, Inspection, Etc., of Crucible Steel. F. B. LOUNSBERRY. *Journal of the Cleveland Engineering Society*, Vol. 10 (1918), No. 5, pp. 309–314.

Sulfate of Ammonia: Increasing the Sulfate of Ammonia Supply. W. B. PHILLIPS *The American Drop Forger*, Vol. 48 (1918), No. 4, pp. 32–33.

Sulfur and Copper Oxide Determination. C. G. MAIER *Engineering and Mining Journal*, Vol. 105 (1918), No. 8, pp. 372–373.

Sulfuric Acid: Calumet and Arizona Sulfuric Acid Plant. C. DEKALB *Mining and Scientific Press*, Vol. 116 (1918), No. 13, pp. 437–444

MARKET REPORT—JUNE, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JUNE 17, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lbs.	4.00	@	4.50
Aluminum Sulfate, (iron free)	Lb.	3¼	@	3½
Ammonium Carbonate, domestic	Lb.	nominal		
Ammonium Chloride, white	Lb.	19½	@	20
Aqua Ammonia, 26°, drums	Lb.	nominal		
Arsenic, white	Lb.	9½	@	16½
Barium Chloride	Ton	65.00	@	85.00
Barium Nitrate	Lb.	11	@	12
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent	100 Lbs.	1.80	@	2.00
Blue Vitriol	Lb.	8.80	@	9.00
Borax, crystals, in bags	Lb.	7¼	@	8¼
Boric Acid, powdered crystals	Lb.	13½	@	15
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	85
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00	@	25.00
Caustic Soda, 76 per cent	100 Lbs.	4.35	@	4.40
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	20.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	1.25	@	2.50
Green Vitriol, bulk	100 Lbs.	1.15	@	1.25
Hydrochloric Acid, commercial, 20°	Lb.	2	@	2½
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	18
Lead Nitrate	Lb.	nominal		
Litharge, American	Lb.	7¾	@	8
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	21
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	8½	@	9
Nitric Acid, 42°	Lb.	9	@	10
Phosphoric Acid, 48/50%	Lb.	8½	@	12
Phosphorus, yellow	Lb.	1.05	@	1.30
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate, casks	Lb.	44	@	45
Potassium Bromide, granular	Lb.	1.35	@	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	40	@	50
Potassium Chlorate, crystals, spot	Lb.	39	@	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	80	@	82½
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk	Lb.	2.50	@	3.00
Quicksilver, flask	75 Lbs.	119.00	@	122.00
Red Lead, American, dry	100 Lbs.	10.79	@	12.75
Salt Cake, glass makers'	Ton	22.00	@	25.00
Silver Nitrate	Oz.	62¼	@	65
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.25	@	2.45
Sodium Acetate	Lb.	nominal		
Sodium Bicarbonate, domestic	100 Lbs.	3.00	@	3.25
Sodium Bichromate	Lb.	27	@	28
Sodium Chlorate	Lb.	24	@	25
Sodium Cyanide	Lb.	40	@	43
Sodium Fluoride, commercial	Lb.	17	@	18
Sodium Hyposulfite	100 Lbs.	2.50	@	2.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.75	@	5.00
Sodium Silicate, liquid, 40° Bé	100 Lbs.	2.50	@	3.00
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal		
Sodium Bisulfite, powdered	Lb.	11	@	12
Strontium Nitrate	Lb.	22	@	28
Sulfur, flowers, sublimed	100 Lbs.	4.05	@	4.50
Sulfur, roll	100 Lbs.	3.70	@	4.10
Sulfuric Acid, chamber 66° Bé	Ton	37.00	@	40.00
Sulfuric Acid, oleum (fuming)	Ton	60.00	@	65.00
Talc, American white	Ton	18.00	@	20.00
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	28	@	30
Tin Oxide	Lb.	1.00	@	1.10
White Lead, American, dry	Lb	9¼	@	10¼
Zinc Carbonate	Lb.	28	@	30
Zinc Chloride, commercial	Lb.	15	@	16
Zinc Oxide, American process XX	Lb.	14	@	15

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	68	@	70
Acetic Acid, 56 per cent, in bbls	Lb.	nominal		
Acetic Acid, glacial, 99½%, in carboys	Lb.	65	@	70
Acetone, drums	Lb.	nominal		
Alcohol, denatured, 180 proof	Gal.	67	@	68
Alcohol, sugar cane, 188 proof	Gal.	4.87	@	4.92
Alcohol, wood, 95 per cent, refined	Gal.	90½	@	91
Amyl Acetate	Gal.	5.25	@	5.30
Aniline Oil, drums extra	Lb.	26	@	28
Benzoic Acid, ex-toluol	Lb.	3.30	@	3.50
Benzol, pure	Gal.	23	@	28
Camphor, refined in bulk, bbls	Lb.	1.12		
Carbolic Acid, U. S. P., crystals, drums	Lb.	48	@	50
Carbon Bisulfide	Lb.	8½	@	9
Carbon Tetrachloride, drums, 100 gals	Lb.	15½	@	16
Chloroform	Lb.	63	@	65
Citric Acid, domestic, crystals	Lb.	82	@	83
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	18	@	20
Dextrine, corn (carloads, bags)	Lb.	8	@	9
Dextrine, imported potato	Lb.	19	@	20
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	16½	@	16¾
Glycerine, dynamite, drums included	Lb.	61	@	62
Oxalic Acid, in casks	Lb.	43	@	45
Pyrogallic Acid, resublimed, bulk	Lb.	3.10		
Salicylic Acid, U. S. P.	Lb.	90	@	1.00
Starch, cassava	Lb.	—		
Starch, corn (carloads, bags) pearl	100 Lbs.	6.50	@	7.00
Starch, potato, Japanese	Lb.	15	@	16
Starch, rice	Lb.	8	@	10
Starch, sago flour	Lb.	9¼	@	9½
Starch, wheat	Lb.	5	@	6
Tannic Acid, commercial	Lb.	60	@	75
Tartaric Acid, crystals	Lb.	75	@	78

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63	@	65
Black Mineral Oil, 29 gravity	Gal.	22	@	23
Castor Oil, No. 3	Lb.	29	@	33
Ceresin, yellow	Lb.	17	@	18
Corn Oil, crude	100 Lbs.	16.75	@	17.00
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	21.00	@	22.00
Menhaden Oil, crude (southern)	Gal.	95	@	1.00
Neat's-foot Oil, 20°	Gal.	3.45	@	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	12¾	@	13
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	10.00		
Rosin Oil, first run	Gal.	56	@	—
Shellac, T. N.	Lb.	63	@	64
Spermaceti, cake	Lb.	32	@	34
Sperm Oil, bleached winter, 38°	Gal.	2.23	@	2.25
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	23	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	35	@	36
Turpentine, spirits of	Gal.	63	@	64

METALS

Aluminum, No. 1, ingots	Lb.	33	@	34
Antimony, ordinary	Lb.	13	@	13¼
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	23.06		
Copper, lake	Lb.	23½	@	—
Lead, N. Y.	Lb.	7.25	@	7.50
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	99½		
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	20.00	@	23.50
Zinc, N. Y.	Lb.	7¾	@	8

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.50	@	7.75
Blood, dried, f. o. b. Chicago	Unit	6.70	@	6.75
Bone, 3 and 50, ground, raw	Ton	37.00	@	40.00
Calcium Cyanamide	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.20	@	10.00
Phosphate, acid, 16 per cent	Ton	16.00	@	17.00
Phosphate rock, f. o. b. mine:	Ton	nominal		
Florida land pebble, 68 per cent	Ton	3.50	@	3.75
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	nominal		
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.60		

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | AUGUST 1, 1918 | No. 8

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD H. K. BENSON F. K. CAMERON B. C. HESSE A. D. LITTLE A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- Political, but Not Politics 590
- By Order of the President 590
- The Demise of the "Garabed" 590
- The Cleveland Meeting 591
- Living from Hand to Mouth 591
- The Approaching Exposition 592

ORIGINAL PAPERS:
- Recovery of Solvents from Air-Vapor Mixtures. E. L. Knoedler and C. A. Dodge 593
- Determining the Comparative Melting Points of Glues as a Measure of the Jelly Strength. C. Frank Sammet 595
- On the Influence of the Temperature of Burning on the Rate of Hydration of Magnesium Oxide. Edward De Mille Campbell 595
- The Determination of Phthalic Anhydride in Crude Phthalic Acid. Charles R. Downs and Charles G. Stupp 596
- An Improved Distillation Method for the Determination of Water in Soap. Ralph Hart 598
- The Use of Sodium Sulfate in the Kjeldahl-Gunning Method. C. T. Dowell and W. G. Friedeman 599
- The Structure of Scarlet S3R (B) and Ponceau 3R(By). H. W. Stiegler 600
- Ammonia and Nitric Nitrogen Determinations in Soil Extracts and Physiological Solutions. B. S. Davisson 600
- Studies in Synthetic Drug Analysis. V—Estimation of Theobromine. W. O. Emery and G. C. Spencer 605
- Studies in Synthetic Drug Analysis. VI—Evaluation of Hexamethylenetetramine Tablets. W. O. Emery and C. D. Wright 606
- An Improved Method for Determining Citral—A Modification of the Hiltner Method. C. E. Parker and R. S. Hiltner 608
- The Identification and Determination of Potassium Guaiacol Sulfonate. Samuel Palkin 610
- The Occurrence of Carotin in Oils and Vegetables. Augustus H. Gill 612
- Determination of Loosely Bound Nitrogen as Ammonia in Eggs. N. Hendrickson and G. C. Swan 614
- A Method for the Detection of Foreign Fats in Butter Fat. Armin Seidenberg 617
- Comparison of Percentages of Nitrogen in Tops and Roots of Head Lettuce Plants. H. A. Noyes 621
- An Anaerobic Culture Volumeter. Zae Northrup 624

LABORATORY AND PLANT:
- An Electrical Conductivity Recorder for Salinity Measurements. E. E. Weibel and A. L. Thuras 626
- An Alinement Chart for the Evaluation of Coal. A. F. Blake 627
- Note on the Use of the Dipping Refractometer. Wyatt W. Randall 629
- Decanting. H. Tillisch 631
- A Device to Insure Tight Connections between Glass and Rubber Tubing. C. C. Kiplinger 631
- A Simple and Entirely Adjustable Rack for Kjeldahl Digestion Flasks. Frank E. Rice 631
- Relative Viscosity of Oils at Room Temperature. C. Frank Sammet 632
- An Aspirator. J. M. Johlin 632
- Pipette Used in Titration of Oils for Acidity. J. Jacobsen 633
- A Safety Valve. E. Rittenhouse 633
- A Test for Wool. Harry LeB. Gray 633

ADDRESSES:
- Gilman Hall: The Research Unit of the Chemistry Group at the University of California. Merle Randall 634
- Dyeing of Khaki in the United States. John C. Hebden 640
- The Status of Chemical Engineering in Our Universities and Colleges Immediately Prior to the Declaration of War. Harper F. Zoller 644
- College Courses for Industrial Chemists. Charles W. Hill 646

CURRENT INDUSTRIAL NEWS 648

SCIENTIFIC SOCIETIES:
- Fourth National Exposition of Chemical Industries; American Institute of Chemical Engineers; Cleveland Meeting, American Chemical Society; Northern Ohio Section, American Ceramic Society; Calendar of Meetings 651

NOTES AND CORRESPONDENCE 653

WASHINGTON LETTER 656

PERSONAL NOTES 658

INDUSTRIAL NOTES 659

GOVERNMENT PUBLICATIONS 662

BOOK REVIEWS 666

NEW PUBLICATIONS 669

MARKET REPORT 670

EDITORIALS

POLITICAL, BUT NOT POLITICS

The joyous news from France of the transformation of the allied defensive into a crushing offensive, and especially of the part played by American troops in this great movement, thrills the hearts of Americans who are devoting their every energy and talent to furnishing adequate supplies to these men whose fresh spirit and dashing attack has proved so great an inspiration to all.

It is a long way to Berlin, however, and doubtless a long time before the day of that full victory for the ideals so nobly expressed by President Wilson which guide us in this bloody strife. During the coming days many grave questions of most serious import must be rightly determined by those who represent us in our national legislative body; many pitfalls in the form of plausible peace proposals must be avoided if we are to secure that righteous peace which constitutes the justification of lives laid down and sacrifices made.

As a citizen, every chemist must contribute his best judgment of men in the selection by vote of those who are so to represent us. Study the record, the character and ability of each man whose name is presented for office and see to it, so far as we are able to affect the choice, that only such as are thoroughly loyal at heart to the principles for which we are contending gain place in the councils of the nation.

BY ORDER OF THE PRESIDENT

President Wilson, acting under the authority delegated to him by Congress in the recently enacted Overman bill, has issued an executive order transferring the Experiment Station at American University (gas warfare research) from the Interior Department to the War Department. Accompanying the order of transfer (page 654, this issue) the President sent to Director Van. H. Manning, of the Bureau of Mines, a letter of unstinted commendation of the splendid results achieved under his guiding hand. Equally generous in its praise was a letter to the President from the Secretary of War.

The action was based solely upon the ground of organization need in the formation of the new Chemical Warfare Service, directly in charge of Major General William L. Sibert, one of the most distinguished engineers in the War Department. That the President felt convincingly the need of such reorganization is evidenced by the fact that the transfer was ordered in the face of a unanimous recommendation to the contrary by the body of eminent chemists comprising the Committee Advisory to the War Work of the Bureau of Mines: Drs. Wm. H. Nichols, *Chairman*, E. C. Franklin, William Hoskins, C. L. Parsons, Ira Remsen, T. W. Richards, H. P. Talbot and F. P. Venable

Frankly, we had hoped that the President would decide to leave this organization in the congenial atmosphere in which it began and which had contributed so much to its rapid growth. This hope was based upon the conviction that its unlimited service stood freely at the disposal of General Sibert, regardless of departmental connections. We believed also that the spirit of the Bureau of Mines was through its very nature more conducive to research than that of the War Department, the strictly military division of the Government. Then, too, we feared the numbing effect of the much discussed "red tape" of War Department methods upon the spirit of originality, daring and speed in following new trails, so essential to the successful prosecution of research.

We sincerely hope that these fears will prove entirely groundless, that no slowing up of this fast machine will be permitted, for otherwise a national disaster would result. On the other hand, we hope with equal sincerity that under General Sibert's leadership the pace will even be accelerated, for intensive research is the sure foundation of this new development in warfare.

Aside from all this, the one outstanding feature of this situation is the fact that the President, the Commander-in-Chief of the Army, has under due authorization from Congress ordered this transfer, and it is needless to say that all American chemists, soldiers and civilians alike, will continue to give to this work patriotic support and service to the very limit of their abilities.

THE DEMISE OF THE "GARABED"

The Garabed's completely dead. 'Twas put to sleep through just one peep by a bloomin' committee that had no pity—No, this is not poetry but merely the reflex action on a hot summer night from reading one of the speeches in Congress advocating the guarantee of special government protection to the free energy machine which was to revolutionize the world, if a committee of five distinguished scientists should give us O. K. after a demonstration.

Unfortunately the committee reported "We do not believe its principles are sound, that his devices are operative, or that they can result in the practical development or utilization of free energy." But this decision is neither here nor there. The machine did create free energy even in advance of inspection. Here is the proof in the form of quotations from the introduction of the speech above referred to, printed in the *Congressional Record* of December 15, 1917, page 370, reproduced for the benefit of the scoffers who insist that the *Record* is dry reading.

Mr. Speaker, the miracle of yesterday is the commonplace of to-day. There was a time when man was perfect in all his parts and elements. He was complete physically. The poet, the painter, the sculptor, the dreamer, in the wildest flights of superb fancy, never caught more than a fleeting vision of that beauty which was given by the Lord to the first man and first woman.

Not only was man complete physically at one time, but he was perfect mentally. He knew all philosophy and all science. Mathematical exactness was instinctive with him. He knew and could interpret bird song. He knew where the flower bloom came from, and why. He understood the passions of the tiger. He saw all problems with clear and unmistakable vision.

He was complete spiritually. He discussed with the Divine the themes of the divinity. He communed with the angels.

He was so complete in his structure that he possessed the power to destroy his own perfection, and he exercised this power. He sinned. That is to say, he violated some law of harmony. What it was we do not know. Perhaps we never shall know. But we know that it was the exercise of a power by which the integrity of his triple structure was destroyed.

There was some power by the exercise of which the integrity of the triple structure was destroyed. I think that touched his every phase and characteristic. It devitalized him physically. The majestic brow receded; the form became bent. Warts and vile protruberances grew upon the skin. The nerves lost control over the muscles, and these, uncontrolled, fell to hideous expression.

All of which and much more was apropos of the Garabed.

On the day of the demonstration Mr. Finney of the Department of Justice was on hand to corral the committee and to insure a demonstration by the inventor, but he was not allowed to witness the test. We venture the statement that that was the first time this alert branch of the Government ever failed to "get a look in."

THE CLEVELAND MEETING

By unanimous vote of the Directors the Annual Meeting of the Society will be held in Cleveland, September 10 to 13, 1918. Many important matters await the action of the Council, while the lapse of a year since a general meeting was held insures a program of unusual interest.

Cleveland's central location and accessibility, and its reputation for unbounded hospitality, should bring together a great gathering of chemists whose deliberations will have notable bearing upon the welfare of the country and upon the advancement of chemistry in our midst.

LIVING FROM HAND TO MOUTH

25,000 ounces of platinum in hand, 15,000 ounces more under control, and Government needs for the year beginning March 1, 1918, 60,000 ounces—these were the figures set forth in the testimony of Messrs. L. L. Summers and C. H. Conner of the War Industries Board, Platinum Section, before the Ways and Means Committee on July 17, 1918. This impending shortage of 20,000 ounces is admitted within earshot of the remarkable order which immediately released to the jewelers twenty-five per cent of their commandeered unmanufactured platinum, in order not to disturb too greatly this individual item of the jewelry trade. No stronger testimony could be offered to the foresight of those who have been advocating preparedness in this all-important matter.

During the past month the question of our platinum resources has received much consideration. Recently Congress has enacted legislation placing platinum under the Explosives Act and requiring the Bureau of Mines to issue licenses governing the sale, possession and use of platinum. The rules and regulations for the operation of this statute have not yet been issued.

The Ways and Means Committee has held Hearings on the subject of taxation of jewelry. On July 10 representatives of the jewelry trade appeared before the Committee ostensibly to discuss taxation but, as events proved, chiefly to defend their trade against charges which they considered had been unjustly lodged. Some of the statements made by the jewelers involved the AMERICAN CHEMICAL SOCIETY so incorrectly and unfairly that we received permission to correct these misstatements. This was done. Attention was also called to a section of the brief read by Mr. Rothschild, the representative of the jewelers, setting forth a letter written early this year by the Chairman of the War Industries Board, stating "it is necessary for the Government to have command of every bit of platinum that can possibly be had" and expressing the desire that "no further use of platinum should be made in the manufacture of jewelry." In response to this letter the jewelers' representatives had visited the War Industries Board, and had "recommended that all the unmanufactured platinum held by jewelers be commandeered," but the objection had been made by the War Industries Board that it did not wish to disturb the jewelry industry to such an extent. This revelation was so surprising that we went on record as gladly willing to make editorial apology to the jewelers for past criticisms of their attitude toward the commandeering orders, in case the statements were confirmed by the War Industries Board. A transcript of the statement was forwarded to the Chairman of the War Industries Board for his confirmation. Later we wired asking a reply to our letter, but up to the present no answer has been received. Meanwhile representatives of that Board testified before the Ways and Means Committee on July 17, and although the printed testimony is not yet available we learn from a correspondent present at the Hearings that a denial was made of the commandeering recommendation of the jewelers. In view of this denial the apology is withheld.

A new turn was given to the discussion by the interesting testimony of Mr. Louis J. Weinstein, Director of Advanced Courses in Dentistry, Columbia University, concerning the substitution of certain alloys for pure platinum in dentistry. By such substitution the practice of dentistry would in no wise be injured, while some 15,000 ounces of platinum annually would be conserved for munitions manufacture. Mr. Weinstein's testimony, and the patriotic spirit which prompted it, made an evident impression upon the Committee.

The most surprising statement throughout the Hearings was to the effect that platinum is not necessary in the manufacture of explosives. This statement was ascribed by some of the newspapers to Mr. Summers (an electrical engineer) and by others to Mr. Conner (a banker). Telegrams were immediately sent to each, asking if he had been correctly reported. Mr. Conner replied referring us to the full testimony

before the Committee (which by the way was not to appear for several days), while Mr. Summers not only referred us to the same source of authoritative information but added the entirely irrelevant sentence "Do not feel that War Industries Board platinum section should be party to controversy between chemists and jewelers."

Of course, from an academic standpoint, explosives can be manufactured without the use of platinum. Sulfuric acid was manufactured many, many years before the contact process was known. So too is the oxidation of ammonia to nitric acid by the catalyzing action of platinum a very recent matter, on which process, however, our Government is now spending millions of dollars for plants in Alabama, Ohio and Maryland. That is not the point. We are not raising an army to quell a revolution in the island of Guam, but an army already more than a million strong, and soon to be two millions. Ex-President Taft advocates five millions, and President Wilson says "Why limit it to five millions?" In other words, this country is determined to win the war, no matter how many of our men are required, and therefore an indefinite expansion of the munitions program must be provided for. The forceful editor of the *Manufacturers Record* ably states the case in a recent editorial condemning the use of platinum in jewelry.

> There are two ways of battering through Germany's entrenched army and carrying our flag across the Rhine. One is through a tremendous amount of explosives sufficient to blow out everything ahead of our men. The other way is through using the bodies of millions of American soldiers against the tremendous fighting ability of the German army.
>
> Which will America choose?

Preparedness of even the most elemental type demands that an ample reserve of platinum be provided, and we repeat the conviction that the immediate place for such a reserve is in the vaults of the Treasury Department, absolutely under the control of our Government, rather than distributed throughout the country in the show cases of 36,000 jewelers, offered freely for sale to any purchaser, loyal or disloyal.

The blood of American soldiers weighs too heavily in the balance against the hand-to-mouth policy now being pursued.

THE APPROACHING EXPOSITION

As the summer advances the question is often asked, and happily always in a sympathetic tone, "What kind of an Exposition are we going to have in September?" To such a question there is only one answer—"Excellent." The list of exhibitors shows a marked increase over previous years, exhibitors are being urged to ship exhibits amply in advance to avoid present shipping delays, and the management has arranged for storage of shipments which may through some perversity of transportation ways come through on the schedules usually allotted for shipments. For the first time an approach will be noticed toward at least some slight coördination of the multifarious exhibits, a matter fraught with many and perplexing problems. A better auditorium is promised for the many speakers of national prominence whose addresses contribute so much to the permanent value of the Exposition.

Again, following unvarying precedent, the Exposition will be devoted not to popular entertainment of the idly curious, but to the serious function of a clearing house of information as to progress in all lines of the chemical industries, thereby enabling still greater progress in the year ahead of us. If the Exposition did not have this solid background of patriotic purpose its continued existence at such a time as we are now passing through could not be justified. No matter how great the progress made in the past three years, we need to speed up more, and still more. The rapid increase, present and prospective, of our army in France entails a similar expansion of the chemical industries at home if that army is to fight with the material all Americans would have them furnished.

There is only one fly in the Exposition ointment—the action of the Railroad Administration in forbidding the use of railroad funds for exhibiting the undeveloped resources along the several railway lines which await the touch of the chemist to change these lowly products into national assets of far greater value at a time when the nation's resources should be mustered to the highest possible limits. It was the unanimous testimony of all at the last Exposition that the railroads' exhibits of resources in contiguous territory pointed the way to a great and rapid industrial expansion. Plans were immediately set on foot to perfect and enlarge these exhibits, when suddenly the command "Halt" was given, and so in the midst of an era of chemical expansion the chemists of the railroads engaged in this work of development were told to seek other fields for their talents, even with the prospective passage of a bill by Congress appropriating millions of dollars for encouraging domestic production of many lines of mineral wealth in order to save shiping space, hitherto devoted to importations, for the transport of men and supplies to European battlefields. We could better afford to take pattern of our neighbor, Canada, who, in spite of the great drain upon her resources from four years of participation in the war, is making increased effort to enlist the interest of the chemists in her development.

Only a few days ago we were visited by a chemist from the laboratory of a railroad in the South, whose exhibit last year attracted the attention of every chemist, and were told of the chemical library, and the modern laboratory equipment, which are soon to be packed away or sold, as a result of the new order of things. Such a step backward seems to be incomprehensible in this day, yet such is the fact. Surely this matter of the chemists' aid in development work must have been overlooked among the great problems incident to the reorganization of the railroad operation under government control. We are not yet willing to believe that a false sense of economy is responsible for this amazing situation. We appeal to Mr. McAdoo to correct this error of executive policy which is fraught with certainty of national loss.

ORIGINAL PAPERS

RECOVERY OF SOLVENTS FROM AIR-VAPOR MIXTURES

By E. L. Knoedler and C. A. Dodge

Received March 29, 1918

At the present time the great scarcity of solvents and the enormous demand for them for military purposes makes necessary the highest possible degree of conservation by those industries in which they are used. Furthermore, the high prices which these solvents now command add to the other reasons for conservation the important inducement of large manufacturing economies.

This conservation may be effected either by a reduction in consumption or by the recovery of the solvent vapors from those processes in which they are driven off. The first method in many cases would involve a reduction in volume of business, unthinkable except in cases of dire necessity; the second, on the other hand, actually adds to the available supply and holds out the prospect of increased business, at the same time making possible substantial economies in manufacturing cost.

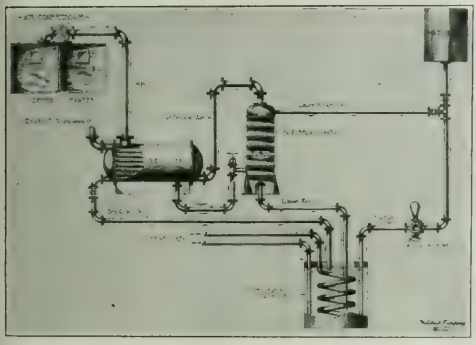


Fig. I

General layout of recovery plant showing course of vapors from box through pre-cooler and towers, then back to pre-cooler and to atmosphere; also of scrubbing liquors from pump to towers, then to cooling basins where the pump takes its suction

To those who may have considerable quantities of solvent vapors available, the description of a successful recovery plant may be of interest. The plant has been in operation several years and has recovered many thousand gallons of these precious materials.

The solvents which are being recovered are mixed vapors of methyl alcohol, ethyl alcohol, acetone, and camphor, which are driven off in drying the collodions used in coating gas mantles. The proportions of the several solvents have varied from time to time, but the outfit has operated with success on any mixture so far attempted.

The drying of the collodions was first carried on in the open air, then in chambers with open ends, through which the collodionized mantles were passed as they dried. Under these conditions it was found difficult to recover much of the vapors because of their very low concentration; and this led to the development of tightly closed, steam-heated, drying chambers, efficiently insulated with asbestos and equipped with quick-acting, close-fitting, sliding doors, through which are fed the wheeled carts carrying the product. Tracks running completely through the box make it possible to feed the goods in at one end of the box and remove them from the other end. In this way a steady stream of wet materials is fed to the drying chambers, maintaining a reasonably uniform air-vapor mixture.

The temperature of each one of the fourteen drying boxes is controlled by a thermostat which regulates the steam supply, and upon each box is mounted an air compressor of such capacity as to remove the vapors as generated. This arrangement of independent units permits any dry-box not in use to be cut out of the system, so as to deliver to the recovery equipment at all times an air-vapor mixture uniform in composition and of a constant temperature.

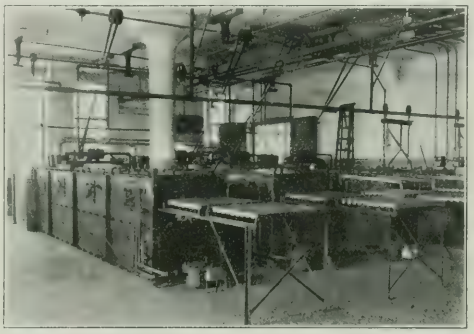


Fig. II

Bank of four drying chambers showing delivery end. Individual compressors, temperature regulators and steam supply for each chamber are in plain view, also tracks and wheeled carriages for transporting the product

As delivered by the compressor to the recovery plant the mixture of vapors shows about the following:

Volume about	450 cu. ft. per M.
Pressure	1 lb. per sq. in.
Concentration	4 per cent solvents (by vol.)
Temperature	80° C.

After the solvents are removed from the air-vapor mixture, the air, which is discharged to the atmosphere, shows about the following:

Vapor concentration	0.9 per cent solvents (by vol.)
Temperature	14° C.

It will be seen from these figures that approximately 80 per cent of the vapors passing through the plant are recovered and these figures are confirmed by the actual output.

The plant consists of a large surface condenser used as a pre-cooler; a group of scrubbing towers,

in which the vapors are scrubbed; receiving vessels in which the liquors from the towers are caught and kept cold by means of brine coils; pumps for re-circulating this liquor until it attains a concentration suitable for distillation; an ice machine; and a column still.

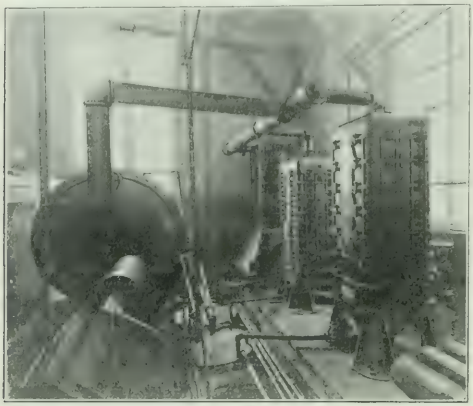


FIG. III

Pre-cooler, towers, and catch basins as arranged in solvent recovery plant

As the vapors enter the recovery plant they pass through the tubes of a surface condenser where they are lowered from 80° C. to nearly the temperature of the washed waste gases (about 10° C.). They then pass into a header and are distributed to a group of "bell-and-seal" scrubbing towers where they bubble through water of a temperature of 5° C. Here the vapors are removed from the mixture, and the air, lowered to a temperature of about 6° to 7° C. from its contact with the refrigerated wash solutions, passes out of the tower and back to the surface condenser where it serves to cool the vapors just entering the plant. After passing through the pre-cooler, the air, deprived of its vapors and warmed up by the heat absorbed from the entering vapors, is discharged to the atmosphere. Of course, any solvents left in this air are completely lost and it is quite possible that in some industrial operations it would pay to return this air to the drying chambers for re-use.

The washing of the gases in the towers is carried out by means of cold water which is re-circulated by pumps. From the towers the water returns to catch basins containing brine coils for keeping it at a low temperature, the pumps taking their suction from the catch basins. The re-circulation continues for some hours until the solution reaches a concentration of about 12 per cent solvents, when it is pumped to the storage tank and held until required by the still. After passing through the still, where the solvents are driven off, these waters are permitted to cool and are then returned to the scrubbing system. In this way small losses in the tail-liquors are avoided.

Each tower, like each drying chamber, is a complete unit, with its individual pump and catch basin, and can be operated regardless of the other units.

The still is a copper, fractionating column, composed of a steam-heating section, 36 in. in diameter, 3 distilling sections, 24 in. in diameter, and 7 distilling sections, 18 in. in diameter, divided into 20 distilling chambers. The 18-in. sections are provided with internal cooling coils, connected in series and regulated by a throttle valve. The vapors from the 24-in. sections are by-passed through a tubular condenser, preheating the feed liquors, then back into the 18-in. sections, and from there through the condenser. The steam is supplied by a closed coil and controlled by a differential steam pressure regulator. The still produces a 97 to 99 per cent product, according to the varying percentages of acetone, ethyl and methyl alcohols in the vapor mixture being worked.

The camphor remains in the sections of the still where the temperature ranges between 95° C. and 75° C. Periodically, these trays are drained through a header to a copper condenser, consisting of a series of trays, where the liquor is cooled and some of the camphor separates out on the trays. The remaining camphor passes on to a sump where it is precipitated and filtered. The camphor press cake is preserved for further purification, and the filtrate is combined with the still liquors and used over again in the scrubbing towers.

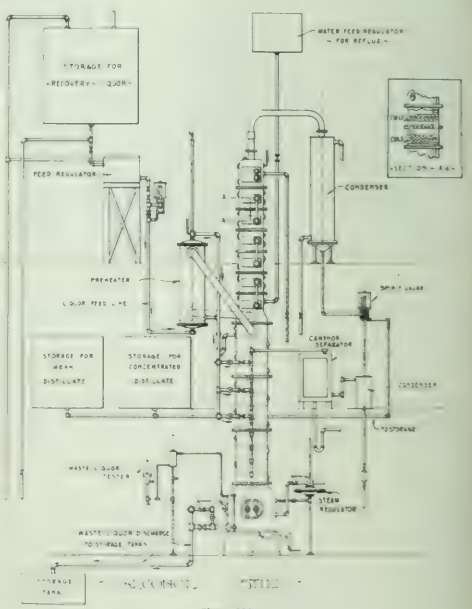


FIG. IV

Elevation of still showing arrangement of all elements required in its operation

The cost of operation per 8¾-hr. day, with a production of from 65 to 75 gal. of solvents, runs approximately as follows:

Direct labor—one man at 35 cts. per hr.	$ 3.07
Indirect labor and supervision	0.50
Expense and repairs	0.60
Steam (pumps and still)	5.20
Fixed charges	8.75
Product—70 gals.	$18.12

Total cost per gal.—$0.26 (making no allowance for camphor)

The accompanying cuts give a good idea of the general layout of the plant, also of the appearance of drying chambers, scrubbing towers, and distilling column.

WELSBACH COMPANY
GLOUCESTER CITY, NEW JERSEY

DETERMINING THE COMPARATIVE MELTING POINTS OF GLUES AS A MEASURE OF THE JELLY STRENGTH

By C. FRANK SAMMET

Received March 22, 1918

Methods for testing the comparative jelly strengths of glues have never been entirely satisfactory. Criticisms of the various methods are extensively written into the literature of glue testing, and it would seem that a simple, rapid, and yet accurate method is desirable, as the jelly strength is an important factor in the quality of glue for paper making and other purposes.

These features are involved in the following method, which is a comparison of the melting points of either the ground glues or their jellies. The melting points may be taken as a measure of the jelly strength as the two bear a close relation to each other.

The dried glues are brought to a ground condition in a hand mill and sieved between 20 and 40 mesh screens, and that portion remaining on the 40 mesh sieve is retained for the test. Although in many cases glues are mixtures of several qualities, with different melting points, yet the mixture of ground particles has never caused inaccuracies in the comparative melting-point tests. The grades determined by the melting-point test have corresponded exactly with grades determined by testing the actual jelly strength by other methods. About 1 g. samples of the glues, so prepared, are placed in small beakers and each stirred with 10 cc. to 15 cc. of cold water, not above 10° C. They are allowed to soak one minute, then a portion of each glue is withdrawn by a spatula and placed on a thin, smooth surface of metal. This metal should be preferably of brass, having an approximate length of 6 in., a width of 1.5 in., and a thickness of $^1/_{64}$ in. The long edges may be turned over to give the strip rigidity. The glue particles should be placed about 3 in. from the end of the strip, and then a portion, about the area of five pin heads, is separated with the spatula and pushed to within 2 in. of the end, thereby draining off a certain excess of water which adheres to the surface of the metal.

The little heaps of glue particles are now aligned equally distant from the end of the strip, which is then dipped to a depth of $^1/_2$ in. in a beaker half full of water at 40° C. The heating should be fairly slow, that the initial sign of melting of the glue particles may be noticed, as this is the determining factor.

Glues that are a grade apart in jelly strength show a very marked difference in their initial melting points. The poorer grades even slide rapidly down the metal surface, while the better grades melt considerably before a sliding effect occurs.

This same procedure may be followed, using the jellies of definite concentrations which have been chilled for at least 12 hrs. Sometimes it is preferable in the case of jellies to squash them flat on the metal strip with pieces of thin copper, each about $^1/_4$ in. square, leaving a layer of jelly about $^1/_{32}$ in. The copper adds weight, and slides quickly at the first indication of the jelly melting.

In these comparisons, it is essential for accurate results to keep the operations on each glue identical, and conditions uniform as to time, temperature, concentration, etc. The method has proved most satisfactory when conducted with due care. It has the advantage of ease of manipulation, rapidity of determination with ground glues at least, and only small samples need be used. It is more positive in its accuracy of the determination of jelly strength than other methods.

In furthering the value of this method for testing jelly strength of glues, it is possible to utilize other standards than known grades of glue. Mixtures of petrolatum with paraffin wax having definite initial melting points can be established for glues of higher jelly strength, while mixtures of petrolatum and paraffin oil can be used in the case of lower grade glues.

With these mixtures having definite initial melting points, the grades of glue could be more exactly defined as far as their jelly strengths are concerned, and conditions and concentrations standardized for testing, so that results from any analyst would have the same significance.

This work should be conducted with enthusiastic coöperation by glue chemists, for the good of all concerned.

CRANE AND COMPANY
DALTON, MASSACHUSETTS

ON THE INFLUENCE OF THE TEMPERATURE OF BURNING ON THE RATE OF HYDRATION OF MAGNESIUM OXIDE

[SECOND PAPER]

By EDWARD DE MILLE CAMPBELL

Received April 9, 1918

In the first paper under the above title[1] a series of experiments was described giving the method of burning, at different temperatures between 500° C. and 1450° C., a sample of pure magnesite and of determining the degree of hydration of the resulting magnesium oxide after treatment with water for periods ranging from 1 day to 18 mos. The magnesium oxide resulting from the burning of magnesite had the following composition: Silica, 2.53 per cent; alumina and ferric oxide, 2.70 per cent; calcium oxide, 3.96 per cent; magnesium oxide, 90.78 per cent. This burned magnesium oxide required an average of 44.59 per cent of its own weight of water to com-

[1] THIS JOURNAL, 1 (1909), 665–68.

pletely hydrate the magnesium oxide and the basic silicates, aluminates, and ferrites derived from the combinations of the basic and acidic oxides.

The results reported in the first paper were summarized as follows:

1—That magnesite is not completely dissociated at 500° C. in 1 hr. under the conditions used in the experiments.

2—That dissociation of the magnesium carbonate is complete at 600° C., while that of calcium carbonate is not.

3—That the hydration of magnesium oxide burned at 600°, 700°, or 800° C. is practically complete in 3 days.

4—That between 800° and 900° C. the calcium carbonate is dissociated, and that combination takes place between basic and acidic oxides, resulting in the formation of silicates or aluminates. The silicates or aluminates so formed combined with more water than would be required for the complete hydration of the basic oxides alone.

5—That a change in the constitution of the magnesium oxide sets in between 1000° and 1100° C., resulting in a marked decrease in the rate of hydration, and that this change becomes more marked with rise of temperature of burning, until at 1450° C., or nearly the temperature required for burning Portland cement, the magnesium oxide after 18 mos. immersion in water has combined with only 61.4 per cent of the water required for complete hydration.

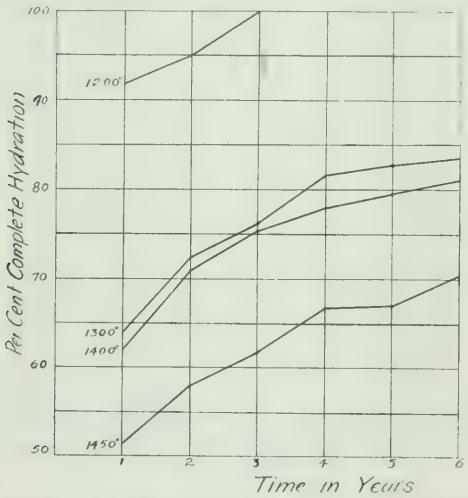


FIG. I—CURVES SHOWING THE INFLUENCE OF BURNING AT TEMPERATURES ABOVE 1000° C. ON THE RATE OF HYDRATION OF MgO

The object of this second paper is to record the results obtained after continuing the hydration of the samples described in the first paper up to a period of 6 yrs.

A study of the data reported in the first paper shows that all samples burned at temperatures not exceeding 1100° C. were completely hydrated within 3 mos., very slow hydration taking place only in the case of samples burned at 1200° C. or above. During the first 4 yrs. the desiccator, in which were placed the crucibles with the samples just covered with water, was partially filled with distilled water, but it was noted at the end of the 4 yrs. that there had been a slight, but steady, increase in weight of the samples, due to absorption of carbon dioxide. This increase in weight amounted in the course of 4 yrs. to about 3 per cent in the cases of all those samples which had been completely hydrated. Further increase in weight due to absorption of carbon dioxide after 4 yrs. was prevented by replacing the distilled water in the desiccator with a dilute solution of potassium hydroxide.

The total percentage gain of weight of the samples burned at 900° C. or above at the end of each year between 1 and 6 yrs. is given in Table I.

TABLE I—PERCENTAGE GAIN OF WEIGHT

Time of Hydration Years	Temperature of Burning 900°	1000°	1100°	1200°	1300°	1400°	1450°
1	44.88	44.92	45.33	41.34	28.99	28.12	23.31
2	45.25	45.18	46.20	42.75	32.75	32.05	26.31
3	46.27	46.27	47.25	45.13	34.43	34.08	27.97
4	47.88	47.45	47.90	47.33	36.90	35.26	30.25
5	47.50	47.49	47.77	47.61	37.36	35.94	30.99
6	47.33	47.54	47.77	47.67	37.71	36.58	31.82

Since all samples burned at or below 1100° C. were completely hydrated within 3 mos., the percentage of complete hydration after long time periods has been computed only for those samples burned at or above 1200° C. In computing the percentages of complete hydration of these latter samples, correction has been made for the increase in weight due to the slight absorption of carbon dioxide. The percentages of complete hydration of these latter samples computed in this way are given in Table II.

TABLE II—PERCENTAGE OF COMPLETE HYDRATION

Temperature of Burning Degrees	Time of Hydration in Years 1	2	3	4	5	6
1200	91.8	94.9	100.0	...	...	...
1300	64.0	72.4	76.2	81.7	82.7	83.5
1400	62.0	70.8	75.3	78.0	79.5	81.0
1450	51.2	58.0	61.7	66.8	66.9	70.3

The results given in Table II are shown graphically in Fig. I, in which the ordinates give the percentage of total hydration and the abscissae the length of time the samples were kept in water. These results show clearly why materials containing free magnesium oxide, if burned at temperatures approaching that used for the production of Portland cement, will not become completely hydrated, even when continuously immersed in water, until the lapse of probably 20 yrs. or more.

CHEMICAL LABORATORY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICH.

THE DETERMINATION OF PHTHALIC ANHYDRIDE IN CRUDE PHTHALIC ACID

By CHARLES R. DOWNS AND CHARLES G. STUPP

Received February 28, 1918

In connection with the control of a plant producing phthalic anhydride it became necessary to develop a method whereby the crude phthalic acid, containing mineral impurities, sulfur compounds, and other organic acids, might be assayed for the amount of phthalic anhydride present.

A search of the literature was made, but the methods described, with the exception of that given by Boswell (noted below), were not applicable to the crude acid resulting from the manufacture of phthalic acid.

Several attempts were made to sublime a mixture of pure phthalic acid and anhydride, in such ordinary laboratory subliming apparatus as is used in investigating other materials. The apparatus was made up of heated dishes, inverted funnels, etc., with the object of weighing the sublimate, thus obtaining quantitative results. In most of these trials a current of air was passed over the subliming surface, heated to a temperature of 200° to 220° C. Various types of condensing chambers were used.

In all cases it was found that either the sublimed crystals, built up on the condensing surface, fell back from their own weight onto a hot portion of the apparatus and remelted, or else they were carried through into the collecting chamber in the form of a fine suspended dust, which was hard to collect quantitatively.

A detachable tube apparatus was then made up as shown in Fig. I.

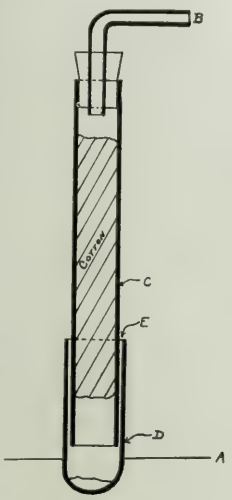


FIG. I

A weighed amount of the phthalic acid to be tested was placed in the weighed glass capsule D and the tube C was inserted, as per sketch, after it came to constant weight in a steam oven. Air was drawn through the tube C by connecting to a suction pump at the point B, the air entering the apparatus through the annular space E. The apparatus was then immersed to the point A in a low-melting metallic bath kept at a temperature from 200° to 220° C. Any vapors formed during sublimation were drawn through the cotton and held there instead of escaping through the annular space E.

Using this apparatus it was expected that the weight of the residue could be obtained, that this residue would be in a convenient form for testing for the presence of unsublimed phthalic left behind, and that after drying the cotton tube to constant weight, *i. e.*, when the water of decomposition had been evaporated, the weight of the sublimed material or phthalic anhydride would be given.

RESULTS OBTAINED ON A SAMPLE OF CRUDE PHTHALIC

No.	Temperature of Bath ° C.	Time Immersion Hours	Weight of Sample Gram	Per cent of Sublimate	Per cent of Residue
1.....	200–220	1/2	0.2574	72.9	10.4
2.....	200–220	1 1/2	0.2453	72.0	10.2

The difference of 0.2 per cent in the weight of the residue represents an actual weight in the case of only 0.0005 g., which shows that practically all of the sublimable material was off after 1/2 hr. immersion. The speed of the air drawn through was approximately 3 bubbles per sec. from a 1/4 in. glass tube through a 3-in. layer of water in a Woulff bottle. This rate of air was found to be satisfactory. A higher rate tended to carry some phthalic through the cotton plug.

In connection with weighing the sublimate in the cotton tube, the following tests were made on pure "commercial" anhydride.

Weighed portions of the anhydride were placed on watch glasses, moistened with water, and placed in an oven.

Temperature of Oven ° C.	Time of Heating Hours	Weight Taken Gram	Loss Per cent
88	15	0.2500	97
88	18	0.2500	96
100	3	0.2500	24

From these results it was evident that a direct determination by weighing the sublimate, after reaching constant weight in a steam oven, could not be used as a method of analysis.

Colorimetric tests were attempted on the residue, using phenol or resorcinol with a dehydrating agent, but dark green solutions were obtained that did not at all resemble the colors of phenolphthalein or fluorescein. In fact they were so dark that small amounts of phthalic could not be detected. Attempts were also made to determine phthalic anhydride present in the crude phthalic acid by colorimetric tests, but this method was found to be inapplicable. Attention was then turned to the titration method described by C. Boswell[1] and this method was used with the substitution of the detachable tube described above.

The details of the method finally adopted by us are given as follows:

0.250 g. of the sample to be analyzed shall be weighed into the glass capsule, and 1.5 g. of the prepared cotton boiled in 10 per cent NaOH and then washed and dried, shall be packed not too tightly in the inner tube. The length of this tube shall be about 5 1/2 in. and the column of cotton shall extend to within 3/4 in. of the bottom. The tube itself shall be inserted into the capsule to within 1/2 in. of the bottom of the latter. Suction is then applied to the top of the inner tube and air drawn through as described before, so that it bubbles through a 1/4 in. glass tube in a suction bottle at the rate of three bubbles per second. This apparatus shall be then transferred to the heating bath of melted Rose metal and adjusted so that the capsule is immersed to a depth of about 1/4 in. It is important that the apparatus should be assembled and the air be passing through it, and that the bath temperature be regulated to 200° to 220° C. before the immersion occurs. Only in this way can accuracy of results be assured. The heating shall then be continued 45 min., during which time the phthalic acid is completely decomposed and the sublimed anhydride collected in the cotton tower. The tube is then removed from the bath, the outside of the capsule cleaned of adhering metal and the weight of residue determined. The cotton plug containing the sublimate is pushed out into a beaker containing 45 cc. of standard *N*/10 NaOH. About 50 cc. of water are added and the solution boiled 1/2 hr. In case some anhydride adheres to the glass tube, the latter may be left in the caustic solution during the boiling. After 1/2 hr. the anhydride is completely dissolved in the alkali, and a small amount of solid phenolphthalein (alcoholic solution of phenolphthalein cannot be used) shall then be added for an indicator and a known excess of standard acid added. This excess must be at least 5 cc. Boiling shall then be continued 15 min. longer and the titration completed by adding alkali in the hot until the end-point is reached. The

[1] *J. Am. Chem. Soc.*, **29** (1907), 235.

phthalic anhydride titer of an exactly $N/10$ NaOH solution is 0.0074.

It will be found that the cotton plugs can be used again and again provided they be washed carefully with neutralized water after each run. Occasional titrations must be made on the cotton blanks to be sure of their uniformity and their acid equivalent. New cotton must be thoroughly boiled with $N/10$ caustic soda and washed well with neutral water.

Where there are a number of determinations to be run daily it will be found that this method using the detachable tube considerably simplifies the method as described by Boswell and in addition the weight of the unsublimable residue is obtained. This is an important feature in connection with plant control.

It is important to note that when a crude phthalic is obtained containing sulfuric and sulfurous acids it must be washed free of these compounds before testing. The presence of sulfuric acid in the crude is generally indicated by a charring of the cotton and, if this happens, the test must be repeated.

This method has been thoroughly checked by analyses of pure phthalic anhydride.

A further proof that this method is correct, when applied to crude phthalic acid, is that the actual sublimation in the plant, where there are small known losses, has given, at the lowest, 95 per cent of the analytical figure for phthalic anhydride as determined by the above method.

RESEARCH DEPARTMENT
THE BARRETT COMPANY, 17 BATTERY PLACE
NEW YORK CITY

AN IMPROVED DISTILLATION METHOD FOR THE DETERMINATION OF WATER IN SOAP

By RALPH HART

Received May 20, 1918

Water in soap is usually calculated after determining all the other ingredients. In many instances, however, it is found directly by drying the soap to constant weight in an oven at 105° C. This procedure, of course, takes considerable time and the result indicates not only water but also any other volatile constituents that may be present. A quicker method is to heat the sample over a free flame until a watch glass held over it for a moment shows no condensation of vapor, or until the odor of acrolein is just noted. This method, evidently, depends a good deal upon the personal equation.

A method occasionally employed and originally suggested by Marcusson[1] is to distill with xylene. The distillate containing the water is received in a special flask having a graduated leg in which the water settles, and the reading of the lower layer is taken as the water content of the sample. In the case of soaps containing alcohol or ammonia, these are found partly in the water layer; corrections are made by taking the specific gravity in the case of alcohol, or by titrating with standard acid in the case of ammonia.

The distillation method has been employed quite successfully for the determination of moisture in such materials as foods, oils, tars,[1] creosoted wood,[2] etc. A comparison of this method with that of drying to constant weight is given in the following table taken from S. S. Sadtler:[3]

Analyses	Distillation Tests Per cent I	Distillation Tests Per cent II	Oven Tests at 100° C. Per cent I	Oven Tests at 100° C. Per cent II
Egg Albumen	15.90	15.35	15.70	
Cheese	29.75	29.90	29.25	29.51
Butter	11.48	11.88	12.25	13.22
Linseed Meal A	5.90	5.90	5.83	5.72
Linseed Meal B	12.00	11.80	9.85	
Sawdust	17.20		16.50	

In the case of soaps, however, the distillation method gives considerable trouble on account of excessive foaming during the heating. The operation becomes tedious and slow, and considerable care is necessary to prevent the foam from entering the condenser tube. Another objection to this method is the very viscous condition of the xylene-soap solution towards the end of the distillation, thereby hindering the free escape of the vapor. The solution at the end of the distillation usually gelatinizes on cooling.

These obstacles, the writer found, are very satisfactorily overcome by the addition of red oil or oleic acid before distilling. The foaming is entirely eliminated and the solution remains very fluid even at low temperatures. The addition of red oil presents another advantage in that the xylene-red oil mixture is a much better solvent for soap than xylene alone; under like conditions it takes considerably less time to dissolve a sample of soap in the mixture than in pure xylene.

The quantity of red oil required is about the same as the weight of the soap taken for analysis. In that case, the soap is quickly and completely dissolved by the xylene, and the foaming is entirely eliminated, allowing the distillation to be carried out at any desired rate. The results compare favorably with the oven method for soap as recommended by the U. S. Bureau of Standards.[4] The two methods are compared in the following table:

	Distillation Test with Red Oil Per cent	Oven Test at 105° C Per cent
Soft Soap	42.5	42.7
Degumming Soap	69.5	70.6
Fulling Soap	16.2	17.1
3 cc. 0.5 N NaOH	96.4	98.0(*a*)

(*a*) Theoretical

Michel[5] finds it necessary in the determination of water in foods to apply a correction of 0.125 cc. to the water reading to allow for the shape of the meniscus. This correction is not necessary in soap analysis as the meniscus is very nearly flat, probably due to traces of soap mechanically carried over; for it was noticed that the meniscus between fresh water and xylene became flat on adding a few drops of a liquid soap. However, a correction of 0.05 cc. may be allowed for moisture left in the condenser, since the results in the table are uniformly lower than by the oven test.

[1] *Mitt. k. Materialprüfungsamt*, **23** (1905), 58.

[1] *J. Am. Chem. Soc.*, **25** (1903), 814.

[2] U. S. Dept. Agr., Forest Service, *Circ.* **134** (1908).

[3] THIS JOURNAL, **2** (1910), 66.

[4] *Circular* **62** (1916), 21.

[5] *J. Soc. Chem. Ind.*, **32** (1913), 445.

In this connection, it may be of interest to note that on shaking the water and xylene layers in the receiver after the distillation, the water formed a permanent emulsion with some of the xylene, but on adding sufficient red oil, the emulsion was destroyed and the layers separated completely in a short time. No emulsion, however, was formed on shaking pure water with fresh xylene. This emulsion is probably also due to traces of soap. Those familiar with the manufacture of soluble mineral oils, which consist mostly of mineral oil, red oil, and soap, or other emulsifiers, are probably aware with what care the red oil must be incorporated; only a slight excess of the latter to the compounded oil is sufficient to destroy its property of emulsifying in water.

The method, as carried out in our laboratory, is to weigh into a 500 cc. Erlenmeyer flask enough of the soap to yield about 3 cc. of water. An equal quantity of red oil and 150 cc. of water-saturated xylene are added and the contents distilled at the rate of 1 to 2 drops per second. The receiver at the start is filled with 5 cc. of the water-saturated xylene and the distillation is stopped when about 85 cc. are collected. The inside of the condenser tube is finally rinsed out with the xylene and the washings added to the distillate; this rinsing is best accomplished by distilling rather vigorously 15 cc. more of xylene. The receiver[1] consists of a cylinder holding about 120 cc. and is constricted at the bottom to a tube which is about 4 cm. long, graduated in tenths of a cc., and holds about 4 cc. of water.

The reading may be taken at room temperature or brought to any desired temperature in a water bath. Any drops of water adhering to the glass of the vessel may be dislodged by means of a very thin wire twisted at one end into a circle. The xylene layer is usually somewhat emulsified. On standing over night, however, the layers get clear, but the reading is practically no different than if taken a half hour after distillation.

The addition of oleic acid or red oil to the xylene in the distillation method for the determination of moisture in soap, as recommended, increases the accuracy by keeping the soap-xylene liquid more fluid and shortens the time of the distillation by hastening the solution of the soap in the xylene, and by eliminating foaming.

LABORATORY, L. SONNEBORN SONS, INC.
NEW YORK CITY

THE USE OF SODIUM SULFATE IN THE KJELDAHL-GUNNING METHOD

By C. T. DOWELL AND W. G. FRIEDEMAN

Received February 2, 1918

W. G. Latshaw gave in THIS JOURNAL, **8** (1916), 586, the results of some analyses which showed very conclusively that sodium sulfate could be substituted for potassium sulfate in nitrogen determinations by the Gunning modifications of the Kjeldahl method. One of the writers found on coming to this laboratory that sodium sulfate had been substituted for potassium sulfate since the appearance of Latshaw's article, but instead of using 7 to 8 g. of the anhydrous salt as was done by Latshaw, 10 g. of the hydrated salt were being used. This is equivalent to 4.4 g. of the anhydrous salt. It was thought that it should be determined whether or not the addition of water (as the water of crystallization of the sodium sulfate) would affect the result and the time required for the completion of the digestion following the Kjeldahl-Gunning method.

[1] Graefe's Oil Cylinder, Eimer & Amend Catalogue for 1913, No. 4784.

TABLE I

MATERIAL USED	Clear after Hours	PER CENT NITROGEN 4.076 g. Na_2SO_4	9.25 g. $Na_2SO_4.10H_2O$ (equivalent to 4.076 of Na_2SO_4)
Cottonseed feed	1¼	3.032	3.054
Cottonseed meal	1¼	5.896	5.896
Standard wheat shorts	1½	3.020	3.001
Wheat white shorts	1¼	2.606	2.603
Molasses feed	1½	1.707	1.702
Standard wheat shorts	1½	2.918	2.918
Standard wheat shorts	1½	2.841	2.824

Table I shows the results of analyses made to decide this point. There was little or no difference in the time required for digestion, about 10 min. longer time being required where the hydrated salt was used. It should be noted that 4.07 g. of the anhydrous salt were used and not 4.4 g. This was because we wished to compare the results obtained when 5 g. of potassium sulfate were used with the results when its molecular equivalent of sodium sulfate was used. Table II shows the results of analyses made for this comparison.

TABLE II

MATERIAL USED	Clear after Hours	Number of Analyses	PER CENT NITROGEN K_2SO_4 5 g.	Na_2SO_4 4.076 g.
Poultry mash	..	2	3.163	3.230
Mill run bran	..	2	2.760	2.760
Rice bran	..	2	1.891	1.986
Standard wheat shorts	..	2	2.858	2.851
Mill run bran	1¼	2	2.491	2.485
Mill run bran	1¼	2	2.690	2.715
Mill run bran	1¼	2	2.595	2.616

The sulfuric acid cleared up in about the same time using the above salts.

The time of digestion was independent of the salt used.

It should be noted that in our comparisons we used 5 g. of potassium sulfate instead of 10 g. as called for in the official method.

It might be said that this would give wrong results and that the time of digestion would be different from that obtained and the time required when 10 g. are used. Table III shows the results of four analyses made to answer this question.

TABLE III

MATERIAL USED	Number of Analyses	PER CENT NITROGEN K_2SO_4 5 g.	K_2SO_4 10 g.
Oat feed	2	0.787	0.792
Cottonseed meal	2	6.072	5.909
Dried blood	2	14.032	13.880
Mill run bran	2	2.943	2.896

The time required to clear was the same, about 60 min., in each analysis. It should be pointed out that a slightly higher per cent of nitrogen was obtained in each analysis where 5 g. of potassium sulfate were used instead of 10. This might be due to a slight oxidation of the ammonia by the great amount of

sulfur trioxide present when 10 g. were used, but no conclusion can be drawn from so few analyses, and in fact the results obtained by Fieldner and Taylor[1] show apparently that the per cent of nitrogen is independent of the amount of potassium sulfate, provided the ratio of grams of potassium sulfate to cubic centimeters of sulfuric acid is not greater than 0.5.

Thirty cubic centimeters of acid were used in all of the analyses reported in this paper. Mercury equivalent to 0.7 g. of mercuric oxide was added and permanganate was added at the end of the digestion.

It is shown by our analyses that either the anhydrous or the hydrated sodium sulfate may be used in the Kjeldahl-Gunning method, that the time of clearing is not affected appreciably by the water of crystallization of the sodium sulfate, and that as little as 5 g. of potassium sulfate is sufficient in the analysis of substances such as we used. No analyses were made with greater amounts of sodium sulfate than 4.07, since that amount gave the same result as 5 g. of potassium sulfate, and 5 g. of the potassium sulfate gave the same result as 10 g., which is the amount used in the official method. It is realized that our reasoning is not quite conclusive because of the lack of a sufficient number of analyses to compare the results when 5 g. of potassium sulfate are used with these when 10 g. are used, but the analyses of Fieldner and Taylor[2] seem to leave no question on this point.

OKLAHOMA EXPERIMENT STATION
STILLWATER, OKLAHOMA

THE STRUCTURE OF SCARLET S3R (B) AND PONCEAU 3R(By)

By H. W. STIEGLER

Received May 21, 1918

Scarlet S3R (B. A. S. F.) is one of the more important of the unclassified azo dyestuffs (U. S. Dyestuff Census), some 80,000 lbs. being imported in 1913. It was thought that a determination of its structure would be of interest.

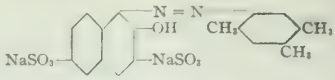
The sample of Scarlet S3R was decomposed by means of $SnCl_2$-HCl solution and the cleavage products separated and purified.

The azo component was identified as amido R-salt (1 : 2-amido-naphthol-3 : 6 di-sodium-sulfonate).

Steam distillation of the alkaline reduction liquid yielded a brownish oil of no definite boiling point. On standing for some time (cold), traces of crystallization were noted. Separation by further cooling yielded a white crystalline solid, identified as pseudo-cumidine (1 : 2 : 4-trimethyl-5-amido-benzene; melting point, 63° C.).

The presence of an oil with the pseudo-cumidine crystals probably indicates the use of crude cumidine, which contains a considerable amount of one of its isomers, mesidine.

Scarlet S3R then, being a monazo dyestuff, has the following structural formula:



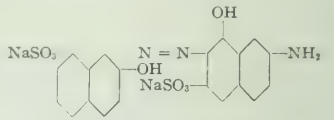
R-salt + pseudo-cumidine
Scarlet S3R

This investigation therefore classes the Badische Scarlet S3R as Ponceau 3R, No. 83 Schultz Farbstofftabellen.

In making comparative tests of the Scarlet S3R with several classified Ponceaus, slight discrepancies were noted in the case of Bayer's Ponceau 3R. This dyestuff is listed by Schultz under No. 83 as being of the same structure as that determined for Scarlet S3R.

An investigation established the interesting fact that Ponceau 3R is entirely different in structure from that given by Schultz. Both cleavage products were found to be naphtholsulfonic acid derivatives. Difficulty was encountered at this point in obtaining either product free enough of the other to proceed with their identification, as both were only slightly soluble in water, neutral sodium sulfite, etc.

Small quantities of both components were finally obtained in a pure state. Further investigation established the rather unusual use of amido Bayer acid (1 : 2-amido-naphthol-8-sulfonic acid) as the *diazo* component, and gamma acid (2 : 8-amido-naphthol-6-sulfonic acid) as the *azo* component, thus giving Bayer's Ponceau 3R the structure:



Amido Bayer acid + gamma acid
Ponceau 3R (Bayer)

This investigation indicates an error in Schultz, in that Bayer's Ponceau 3R is *not* crude cumidine + R-salt as stated there, but amido Bayer acid + gamma acid. It also classifies Scarlet S3R (Badische) as Ponceau 3R, No. 83 Schultz.

LOWELL TEXTILE ORGANIC LABORATORIES
LOWELL, MASSACHUSETTS

AMMONIA AND NITRIC NITROGEN DETERMINATIONS IN SOIL EXTRACTS AND PHYSIOLOGICAL SOLUTIONS[1]

By B. S. DAVISSON

Received January 8, 1918

INTRODUCTION

Studies in soil biology dealing with the transformations of the soil nitrogen require frequent and exact determinations of ammonia and nitric nitrogen. The unreliability of the methods in vogue among soil biologists renders necessary a study of the means by which the true value for ammonia and nitric nitrogen can be obtained. The error due to the hydrolyss of nitrogenous organic compounds is quite appreciable, and should be reduced to a minimum. The often

[1] Bureau of Mines, *Technical Paper*, **64**, 10.
[2] *Loc. cit.*

[1] An abstract of a dissertation presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Graduate School of the Ohio State University.

limited amount of material available for analysis renders it desirable to obtain both ammonia and nitric nitrogen upon the same sample. The method should be applicable for both large and small quantities of the two forms of nitrogen and the error should be of the order of magnitude of 2 per cent or less.

HISTORICAL

The determination of ammonia in urine and in other animal fluids has received the attention of many biological chemists. The aim of the proposed methods has been to obtain the true ammonia value by reducing to a minimum the error due to the hydrolysis of the nitrogenous organic matter.

The methods employed in determining ammonia in soils are more or less modifications of those used by biological chemists for determining ammonia in urine. These methods, until recently, have been adopted by soil investigators without any study having been made of their applicability to soil investigations.

In 1901[1] Folin offered objections to the Schlosing method of determining ammonia in urine because of the uncertainty of the time necessary for the transference of the ammonia to the standard acid. He proposed diluting the urine sample with 400 to 500 cc. of water, distilling the solution with MgO, collecting the ammonia in standard acid and titrating. The urine solution was then diluted back to the original volume, distilled for a second period, and the ammonia collected in a new portion of standard acid. The ammonia obtained during the second distillation represents the urea which was decomposed. The decomposition for this period is assumed to be the same as that for the first distillation and the difference between the two values represents the preformed ammonia of the urine.

Shaffer[2] made a critical study of the methods used by biological chemists for determining ammonia in urine and found that the earlier method of Schlosing (consisting in allowing the urine and the alkali to stand under a bell jar with standard acid for absorbing the ammonia) and the Boussingault method (distilling with an alkali to dryness in a vacuum at 30° to 40°) gave dependable results when the directions of the original workers were carefully followed. With certain modifications, satisfactory results were obtained. Folin's[3] method was found to be unreliable because the ammonia from the second distillation did not represent the decomposition of urea during the first distillation. More urea was decomposed during the first distillation than was represented by the ammonia recovered, consequently the second boiling gave results which were too high, thus reducing the value for the preformed ammonia.

Folin[4] outlined a second method which, with a few modifications, is now largely used for determining ammonia in urine and in other animal fluids. This method consists in the transference of the ammonia from 25 to 50 cc. of urine into standard acid by means of a rapid air current. The ammonia is liberated by 1 to 2 g. of sodium carbonate and 8 to 16 g. of sodium chloride. An air current of 600 liters per hr. for a period of 1 to $1^1/_2$ hrs. is necessary for the complete removal of the ammonia at room temperature. The author found that an appreciable amount of alkali is carried by a rapid air current and a trap, inserted between the aeration cylinder and the standard acid, is necessary to arrest this alkali. A special absorption tube was devised to insure complete absorption of the ammonia. This method was modified by Steel,[1] who used 0.5 g. of sodium hydroxide as the alkali. The hydroxide decomposes any triple phosphate present in the urine but does not decompose such nitrogenous organic compounds as urea, leucine, tyrosine, glycocoll, uric acid, hippuric acid, creatine, creatinine, and taurine.

Russell[2] investigated the Schlosing method for determining ammonia in soils by allowing the latter to stand in contact with a strong alkali. To remove the danger of re-adsorption of ammonia by the soil, he prepared a hydrochloric acid extract of the soil. Russell found that distillation with magnesium oxide and alcoholic potash gave reliable results and did not decompose the nitrogenous organic compounds. The most reliable results were obtained when the soil was distilled under reduced pressure with either of these alkalies. Only 50 to 70 per cent of the ammonia added to a soil could be recovered.

In 1915 Potter and Snyder[3] employed Folin's[4] aeration method for determining ammonia in soils. The sample of 25 g. of soil was suspended in 50 cc. of water and aerated with 2 g. of sodium carbonate for a period of 19 hrs. at a rate of 250 liters of air per hr. The apparatus is essentially the same as that used by Folin with the exception that no trap was employed to stop any entrained alkali. Remarkably concordant results were obtained and in nearly all cases the added ammonia was recovered.

The work of Potter and Snyder is a step toward obtaining more reliable methods for determining ammonia in soils. The method of attack in this laboratory differs somewhat in that we are working with solutions instead of with the soil direct. A serious objection to the method as used by Potter and Snyder is the time necessary for the removal of the ammonia. The employment of large volumes of solution and the reduction of the time of aeration present difficulties not encountered by these authors. Increasing the rate of aeration increases the error from entrained alkali and lack of absorption of the ammonia.

It has been shown in this laboratory[5] that amounts of ammonia up to 25 mg. can be recovered from 250 cc. of solution by aerating with magnesium oxide for a period of 3 hrs. at a rate of 1080 liters of air per hr. With such a rapid air current it was found that complete absorption could not be obtained without the use of a scrubbing tower to thoroughly wash the

[1] *Z. physiol. Chem.*, **32** (1901), 515.
[2] *Am. J. Physiol.*, **8** (1903), 330.
[3] *Loc. cit.*
[4] *Z. physiol. Chem.*, **37** (1902–3), 161.

[1] *J. Biol. Chem.*, **8** (1910), 365.
[2] *J. Agr. Sci.*, **3** (1910), 233.
[3] THIS JOURNAL, **7** (1915), 221.
[4] *Loc. cit.*
[5] THIS JOURNAL, **8** (1916), 896.

passing air. After aeration is complete the absorbing acid is washed from the tower into a 500 cc. Kjeldahl flask and the ammonia determined by distillation with magnesium oxide. This distillation overcomes the error from entrained alkali.

NITRIC NITROGEN

A method has been developed in this laboratory[1] for determining nitric nitrogen in soil extracts. The reduction methods were studied and the combination of the best features of the Devarda, Valmari-Devarda, and Mitscherlich-Devarda methods resulted in a method designated as the Valmari-Mitscherlich-Devarda method. The nitrates are reduced in a $N/10$ sodium hydroxide solution with 1 g. of Devarda's alloy. By using a minor modification of the Mitscherlich[2] distilling apparatus very accurate results are easily obtained. The reduction is carried on for a period of 40 min. after the solution begins boiling. It

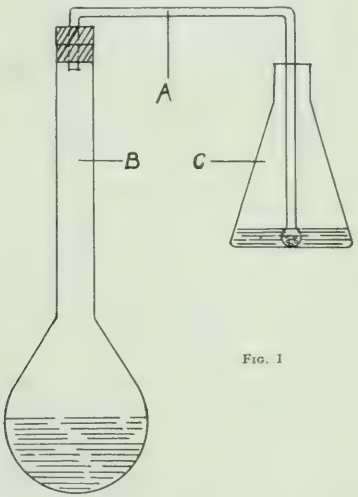


FIG. 1

has been found that the hydrogen evolved at the boiling temperature is much more effective for reducing nitric nitrogen than that evolved at a lower temperature. Solutions containing decomposable nitrogenous organic matter are boiled for 30 min. with the alkali, previous to the reduction of the nitrates. This preliminary boiling was intended to destroy such nitrogenous compounds, but it has since been found that this is not of universal application, as some of these organic compounds continue to yield ammonia for several distillations.

The methods for determining ammonia and nitric nitrogen have been developed to give reliable results under conditions admittedly extreme, that is, *large* volumes of solutions and *small* quantities of nitrogen. However, a further study, refinement, and modification of the methods seemed desirable in order that both these forms of nitrogen might be determined upon the same sample. Also, an examination of the hydrolysis of nitrogenous organic matter under varying conditions is necessary to establish the justification of such methods.

EXPERIMENTAL

AMMONIA-FREE WATER—The water used in this work was distilled over sulfuric acid and potassium dichromate and the steam scrubbed before condensation.

AMMONIA FREE REAGENTS—All the reagents were made ammonia-free before using.

INDICATOR—Methyl red, prepared by dissolving 0.02 g. of methyl red in 100 cc. of double-distilled alcohol, was used. The solutions were carbon dioxide-free when titrated.

AMMONIA SOLUTIONS—Standard ammonium sulfate solutions were made from chemically pure ammonium sulfate and standardized by distilling with magnesium oxide.

NITRATE SOLUTIONS—Standard nitrate solutions were prepared from pure sodium nitrate and standardized by the Valmari-Mitscherlich-Devarda method under ideal conditions.

STANDARD ACIDS AND ALKALIES—The standard acids were prepared from chemically pure sulfuric acid and carbon dioxide-free water. The solutions were standardized by the sodium carbonate method, which, according to Mitscherlich,[1] is the most accurate. Twenty-five cc. burettes provided with 3-way stopcocks and connected with reservoir bottles were used. These burettes are of regular 50 cc. burette length with a correspondingly smaller internal diameter and graduated to 0.05 cc. These burettes were standardized by the U. S. Bureau of Standards for 20° C. and the temperature was maintained as nearly as possible at that point. Slight deviations from this temperature were neglected as they were found to cause no appreciable change in the volume of the liquid. When portions of the solutions had stood in the burettes for 12 hrs. or more they were discarded. For small quantities of nitrogen $N/50$ acid was used, and for larger quantities $N/10$ acid.

Artificial light, having been found more satisfactory than daylight because of its being constant at all times, was used for all titrations. Large electric bulbs were used as a source of light. These bulbs were enclosed outside of the laboratory window with three panes of glass separating them from the titrating table. Thin paper was then placed over the window to shade the eyes while the full light from the bulbs fell upon the table.

DISTILLING APPARATUS—The apparatus used for distilling over magnesium oxide is shown in Fig. 1, in which A is a quartz or Pyrex glass tube, B contains the ammonia solution and C is the Erlenmeyer flask containing the standard acid. Quartz Erlenmeyer flasks and quartz tubes were first used for the distillations. Later it was found that the Pyrex glass could be substituted for the expensive quartz.

Nitrate reductions were made in the apparatus

[1] THIS JOURNAL, 7 (1915), 521.
[2] *Landw. Jahrb.*, 38 (1909), 579.
[1] *Landw. Jahrb.*, 39 (1910), 345.

shown in Fig. II. Flask A contains the nitrate solution, B a pinch of magnesium sulfate and one of magnesium oxide with a small amount of water, and C contains the standard acid.

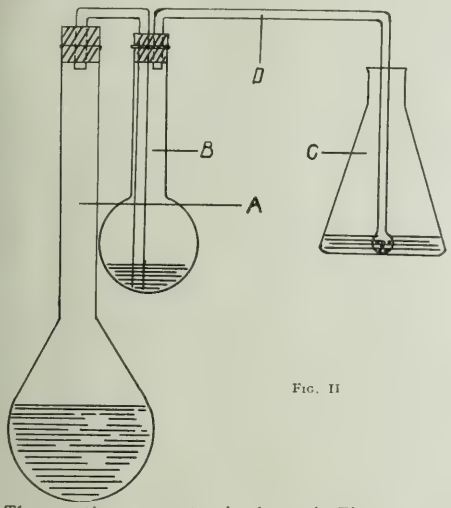


FIG. II

The aeration apparatus is shown in Fig. III. The two towers, I and J, are used as scrubbers, one containing sulfuric acid and the other sodium hydroxide, when aeration is made over magnesium oxide. If sodium carbonate is used as the alkali both towers may be filled with acid.

RATE OF AERATION—The rate of aeration was 1080 liters of air per hr. measured as previously described.[1] A Crowell pump was used for drawing air through the solutions.

SEPARATION OF AMMONIA AND ORGANIC NITROGEN

Before a positive method for separating ammonia and organic nitrogen can be developed it is necessary that we have some knowledge of the hydrolytic action of the alkalies upon some pure nitrogenous organic compounds somewhat similar to those found in the soil. The action of magnesium oxide and sodium carbonate was studied upon some pure compounds. The averages of several determinations on each substance are reported in Table I. These substances were dissolved in water and aerated with magnesium oxide and with sodium carbonate. Data are also given for boiling with magnesium oxide for a period of 20 min. Substances containing an amide group show considerable hydrolysis on boiling with magnesium oxide while the amino groups have not been appreciably attacked.

TABLE I

Substance	Wt. of Substance Used Mg	Nitrogen Obtained: Boiling with MgO Mg	Aeration with MgO Mg	Aeration with Na_2CO_3 Mg
Formamide	200.0	5.933	2.726	3.166
Acetamide	100.0	0.127	0.008	0.032
Urea	100.0	1.094	0.022	0.017
Asparagine	100.0	0.243	0.012	0.008
Aspartic acid	50.0	0.023	0.013	0.030
Tyrosine	41.7	0.027	0.034	0.039
Leucine	33.3	0.034	0.029	0.032

[1] *Loc. cit.*

Formamide has undergone decomposition on aeration with the alkalies but the other substances do not show an appreciable decomposition when one considers the large sample of substance taken. It is doubtful if as easily decomposable a substance as formamide can exist in the soil as such for any length of time. Consistent results could not be obtained by hot distillation with MgO. The results were inconsistent when the same gas burner or electric heater was used for all distillations.

A soil extract rich in organic matter after standing inoculated with *Aspergillus niger* for several days was subjected to analysis. Two hundred cc. of the extract were used. The results in Table II show the justification of aeration methods for determining ammonia nitrogen in soil extracts. Boiling with magnesium oxide has given an error of 21.8 per cent.

TABLE II

Milligrams of Nitrogen in a Soil Extract: Boiling over MgO	Aeration over MgO
1.15	0.948
1.11	0.945
..	0.948
..	0.871
Av., 1.13	Av., 0.928

The application of the methods for determining ammonia and nitric nitrogen was studied upon an extract prepared from a greenhouse soil which had been heavily manured for several years. The extract was prepared by extracting one part of soil with five parts of water. After agitation for 4 hrs. the extract was clarified with a laboratory centrifuge, some dextrose added, and, when nitrate-free, the extract was sterilized with chloroform and preserved in a closed bottle.

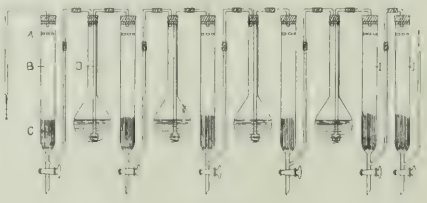


FIG. III

Soil extracts rich in organic matter offer some difficulty in determining nitrates by reduction with Devarda's alloy in an alkaline solution. The preliminary boiling in $N/10$ alkali was found not to destroy all decomposable nitrogenous compounds. The nitrate determination under such conditions has, therefore, a plus error. A volume of 250 cc. of the extract continued to give ammonia after two distillations of 30 min. each with 2 cc. of a 50 per cent sodium hydroxide solution. It was found that much of this decomposable organic matter could be removed by using 2 cc. of a saturated lead acetate solution and subsequently boiling the filtrate with 4 cc. of 50 per cent sodium hydroxide. Table III contains results on the soil extract, one with organic matter removed and the other having it present. The amounts 0.028 and 0.017 are practically negligible.

TABLE III

Distillation No.	Nitrogen Obtained: Organic Matter Present Mg.	Organic Matter Removed Mg.
1	Not determined	Not determined
2	0.109	0.028
3	0.057	0.017

After boiling 30 min. the solution is diluted back to 250 cc., and 0.9 cc. of concentrated sulfuric acid is added, leaving approximately a $N/10$ alkaline solution for reducing nitrates.

When sodium carbonate is used as the alkali it is necessary to use some substance other than lead acetate for removing the organic matter. Stutzer's[1] reagent was prepared and found very satisfactory.

At the outset of the work with the greenhouse soil, it was found that added nitric nitrogen could be recovered by reduction with Devarda's alloy, but in no case could all of the added ammonia be recovered by aeration with magnesium oxide or sodium carbonate. The amount of ammonia remaining in the solution was usually less than 0.5 mg.

This retention of the ammonia has been attributed to the formation of the difficultly soluble magnesium ammonium phosphate[2] or to the presence of a considerable number of calcium and magnesium[3] ions. Although the cause of the difficulty in this case was not exactly clear the addition of sodium oxalate overcame the difficulty, as shown in Table IV. A very heavy crystalline precipitate was obtained upon adding the sodium oxalate.

TABLE IV

Reagent Used	Wt. of Reagent Used G.	Nitrogen Taken Mg.	Nitrogen Recovered Mg.	Error
MgO	0.5	11.27	11.02	—0.05
	"	11.27	10.94	—0.33
	"	11.27	10.97	—0.30
	"	11.27	10.71	—0.56
Na_2CO_3	10	11.27	11.00	—0.27
	"	11.27	10.55	—0.72
	"	11.27	11.08	—0.19
	"	11.27	11.08	—0.19
MgO	0.5	5.57	5.24	—0.33
	"	5.57	5.29	—0.28
	"	5.57	5.38	—0.19
	"	5.57	5.16	—0.41
Na_2CO_3	10	5.57	5.53	—0.04
$Na_2C_2O_4$	2	5.57	5.56	—0.01
	"	5.57	5.60	+0.03
	"	5.57	5.53	—0.04

A number of determinations were next made using 250 cc. volumes of the extract with added ammonia and nitric nitrogen. The extract was free from ammonia and nitric nitrogen. The results of the determinations are found in Table V, and the recovery of both forms of nitrogen is complete.

TABLE V

Ammonia Nitrogen 4.73 Mg. taken: Mg. found	Error	Nitric Nitrogen 4.03 Mg. taken: Mg. found	Error
4.75	+0.02	4.00	—0.03
4.73	0.00	3.99	—0.04
4.78	+0.05	4.06	+0.03
4.70	—0.03	4.03	0.00
4.72	—0.01	4.04	+0.01
4.72	0.01	4.03	0.00
4.75	+0.02	4.01	—0.02
4.68	—0.05	4.05	+0.02
4.73	0.00	4.07	+0.03
4.76	+0.03	4.00	—0.03
Average 4.73	±0.02	4.03	±0.02
Probable error	±0.02	"	±0.02
Per cent error	0.42	"	0.49

The probable error obtained by calculation, using the method of least squares, is satisfactorily low. No determinations were made using larger quantities of the two forms of nitrogen. The order and magnitude of the error remains practically constant while the percentage error decreases with increasing amounts of the two forms of nitrogen.

DISCUSSION

The data presented in this paper show that the aeration method for determining ammonia in small volumes of urine can be successfully used for determining ammonia in large volumes of soil extracts and physiological solutions. Some modifications of the method as originally used by Folin[1] were necessary for its application to conditions encountered in soil biology studies.

The hydrolytic action of magnesium oxide and sodium carbonate upon such nitrogenous organic compounds as occur in the soil is very small when the soil extract is aerated in the cold with either of the alkalies. The organic and ammonia nitrogen of the soil extract are easily separated by aeration in the cold with sodium carbonate or magnesium oxide. Hot distillation of soils or soil extracts with magnesium oxide gives unreliable results. This procedure has been widely used and the results obtained are of questionable value. When blank and check distillations are made the results are unreliable because of the unequal hydrolysis.

The slowly decomposable protein-like substances which yield ammonia when making nitric nitrogen determinations are easily removed by using basic lead acetate or Stutzer's reagent. The subsequent boiling with $N/5$ sodium hydroxide destroys the remaining simpler substances which are likely to decompose during the reduction of the nitric nitrogen.

PROCEDURE FOR DETERMINING NITRIC AND AMMONIA NITROGEN ON THE SAME SAMPLE

In the absorbing towers are placed 25 cc. of $N/2$ sulfuric acid. Two hundred to 250 cc. of the ammonia and nitrate solutions are placed in the aeration flask, a few drops of oil, 2 g. of ammonia-free sodium oxalate, and 10 g. of pure sodium carbonate added, and the flask connected with the aerating apparatus. The solutions are then aerated for 3 hrs. at a rate of 1080 liters of air per hr.

After aeration is complete the ammonia is determined by washing the acid from the towers with 3 or 4 portions of 50 cc. each of distilled water and distilling with magnesium oxide in the apparatus shown in Fig. 1.

The aeration flasks are removed and the aerating tubes washed with distilled water. The tube is washed on the inside by forcing water into it by means of jet from a wash bottle and allowing the water to drain into the aeration flask. The sodium carbonate is destroyed by adding 5 cc. of concentrated sulfuric acid. The solution is heated to boiling and 5 cc. of the copper hydroxide suspension are added and the boiling continued for about one minute. The solution is then

[1] Bureau of Chemistry, *Bulletin* **107** (1909), 38.
[2] Steel, *J. Biol. Chem.* **8** (1910), 365.
[3] Kober, *J. Am. Chem. Soc.*, **30** (1908), 1279.
[1] *Loc. cit.*

filtered, while hot, through a coarse 15 cm. filter paper into another Kjeldahl flask. The aeration flasks are washed with hot water and the washings poured into the other flasks without filtration, since practically all the residue has been transferred to the filter paper. The residue is washed 4 or 5 times with small quantities of boiling water. A small piece of paraffin and an ebullition tube are placed in the flask to prevent frothing and bumping, 4 cc. of a 50 per cent sodium hydroxide solution added, and the solution boiled for 30 min. The solution is diluted back to 250 cc., and 0.9 cc. of concentrated sulfuric acid added to reduce the alkalinity of the solution to about $N/10$. The nitric nitrogen is then determined by reducing with 1 g. of Devarda's alloy and boiling the solution for 40 min. after bringing it to boiling in minimum time. When the solution reaches the boiling point it is advisable to reduce the flame. The reaction is quite vigorous and may result in foaming over if this precaution is not taken. As soon as the vigorous action ceases, the flames are turned up and boiling continued.

SUMMARY

The work reported in this paper justifies the following conclusions:

I—Organic and ammonia nitrogen can be separated by aerating the solutions in the cold over magnesium oxide or sodium carbonate.

II—Ammonia determinations obtained by boiling soil suspensions or soil extracts rich in organic matter with magnesium oxide are unreliable.

III—Ammonia and nitric nitrogen can be accurately determined upon the same sample by the method reported in this paper.

The author takes this opportunity to thank Dr. E. R. Allen for his helpful criticisms in this investigation.

Laboratory of Soil Biology
Ohio Agricultural Experiment Station
Wooster, Ohio

STUDIES IN SYNTHETIC DRUG ANALYSIS[1]
V—ESTIMTION OF THEOBROMINE

By W. O. Emery and G. C. Spencer

Received April 25, 1918

INTRODUCTION

Questions having quite recently arisen relative to the actual therapeutic strength of certain diuretic combinations of theobromine and theophylline, notably with sodium acetate and sodium salicylate, an investigation of such products seemed desirable. In the present paper, however, consideration will be given only to experiments involving theobromine and looking to the utilization of its periodide as a basis for evaluation. A description of very similar work on theophylline and its combinations is reserved for a future communication.

The quantitative estimation of theobromine in admixture with other agents of medicinal value, or with materials of a more or less inert nature, is complicated by the great insolubility of this compound in the more common organic reagents. A somewhat similar difficulty, encountered in developing a procedure for the estimation of acetanilide and phenacetin (acetphenetidine) in admixture, was met by the employment of glacial acetic acid. A number of preliminary trials soon demonstrated the adaptability of this solvent also for theobromine when applied to periodide formation. It was further found that the solubility is favorably affected by the presence of sodium acetate.

While it is by no means difficult to prepare several periodides of theobromine, its quantitative separation in the form of an iodine addition-product of unvarying composition, suited to the purposes of titrimetric control, is manifestly beset with difficulties naturally inherent in operations of this character, such as homogeneity, freedom from other periodides and salts, losses by decomposition, evaporation, etc. In the method presently to be described, advantage is taken of the fact that, when an acetous solution of theobromine containing sufficient iodized potassium iodide is treated with a mineral acid, a grayish black crystalline precipitate separates, which, judged by its iodine content, has the composition $C_7H_8N_4O_2.HI.I_4$. The separation of this hydriodo-tetriodide becomes quantitative if the iodine solution is reënforced with a small quantity of sodium chloride. If, therefore, the precipitation is effected in a measured volume of standard iodine and the insoluble addition-product removed by filtration, the volumetric determination of the unconsumed iodine is readily accomplished, and therefrom the quantity of theobromine involved as readily calculated by means of the appropriate factor.

EXPERIMENTAL

For purposes of identification, the above-mentioned periodide was prepared by dissolving theobromine in a few cubic centimeters of hot glacial acetic acid, transferring the clear liquid to a flask containing sufficient iodized potassium iodide, adding a little concentrated hydrochloric acid with constant agitation, and then shaking the mixture vigorously. After standing some hours, the periodide was isolated by pouring the product onto a small suction plate provided with a suitable filter, washing the mass several times with a saturated aqueous iodine solution, and exposing the crystals in the open air until apparently dry. Protracted exposure of the substance to atmospheric influences, however, is inadvisable, such treatment inducing an appreciable lightening in the color of the crystals with consequent loss of chemically combined iodine. The "exterior" iodine was determined by titration with sodium thiosulfate in alcoholic solution, and in the presence of sodium bicarbonate. Total iodine, on the other hand, was estimated by first treating the substance in acetic acid with a saturated solution of sulfur dioxide in water, followed by precipitation with silver nitrate.

Calcd. for $C_7H_8N_4O_2.HI.I_4$: I_4, 62.2; I_5, 77.8.
Found: I_4, 59.9, 61.7, 62.2; I_5, 76.5, 77.0, 77.2.

Thus it appears that, even with the greatest care, the operations of washing and drying are likely to be

[1] This Journal, 6 (1914), 665.

attended with some loss in iodine, which is reflected in the above analytical findings obtained on different samples. In order to determine experimentally the conditions best suited to the iodometric estimation of theobromine in commercial samples, it was necessary to carry through several hundred analyses on controls involving this substance, both alone and in various combinations. As typical of these experiments, the following tabulated results show the percentage recovery from precipitates prepared with varying amounts of hydrochloric acid, as also with and without the addition of brine.

No	Theobromine G.	Glacial AcOH Cc	0.1 N Iodine Cc	Concd. HCl Cc	Satd. NaCl Soln. Cc	Theobromine Found G.	Theobromine Found Per cent
1	0.1000	2	50	1	None	0.0958	95.8
2	0.1000	2	50	1	None	0.0951	95.1
3	0.1000	2	50	3	None	0.0982	98.2
4	0.1000	2	50	5	None	0.0978	97.8
5	0.1000	2	50	5	None	0.0981	98.1
6	0.1000	2	50	5	None	0.0987	98.7
7	0.1000	2	50	2	None	0.0977	97.7
8	0.1000	2	50	2	None	0.0976	97.6
9	0.1000	2	50	2	10	0.0981	98.1
10	0.1000	2	50	2	10	0.0986	98.6
11	0.1000	2	50	2	20	0.0995	99.5
12	0.1000	2	50	2	20	0.0996	99.6
13	0.1000	2	50	2	20	0.0999	99.9
14	0.1000	2	50	2	20	0.0997	99.7

The influence of other factors like sodium acetate, sodium salicylate, sodium benzoate, and sodium formate on the estimation of theobromine is shown in the following series, this substance and the component salt being applied in molecular proportions:

No.	Theobromine G	Glacial AcOH Cc	0.1 N Iodine Cc	Concd HCl Cc	Satd. NaCl Soln. Cc	Org. Salt	Theobromine Found G.	Theobromine Found Per cent
1	0.1000	2	50	2	20	NaAc	0.0981	98.1
2	0.1000	2	50	2	20	NaAc	0.0990	99.0
3	0.1000	2	50	2	20	NaAc	0.0993	99.3
4	0.1000	2	50	2	20	NaAc	0.0995	99.5
5	0.1000	2	50	2	20	NaAc	0.0994	99.4
6	0.1000	2	50	2	20	Na Sal.	0.1002	100.2
7	0.1000	2	50	2	20	Na Sal.	0.1004	100.4
8	0.1000	2	50	2	20	Na Sal.	0.0997	99.7
9	0.1000	2	50	2	20	Na Sal.	0.0998	99.8
10	0.1000	2	50	2	4	Na Sal.	0.0974	97.4
11	0.1000	2	50	2	8	Na Sal.	0.0990	99.0
12	0.1000	2	50	2	15	Na Sal.	0.0998	99.8
13	0.1000	2	50	2	20	Na Sal.	0.0994	99.4
14	0.1000	2	50	2	20	Na Sal.	0.0996	99.6
15	0.1000	2	50	2	20	Na Form.	0.1078	107.8
16	0.1000	2	50	2	20	Na Form.	0.1064	106.4
17	0.1000	2	50	2	5	Na Form.	0.1054	105.4
18	0.1000	2	50	2	5	Na Form.	0.1064	106.4
19	0.1000	2	50	2	20	Na Benz.	0.0997	99.7
20	0.1111	2	50	2	20	Na Benz.	0.1105	99.5
21	0.0555	2	50	2	20	Na Benz.	0.0554	99.9

From these experiments it is evident that the periodide method may be safely applied in the quantitative estimation of theobromine, both alone and in admixture with sodium acetate, sodium salicylate, and sodium benzoate. The abnormal results obtained in the presence of sodium formate, however, for which no satisfactory explanation based upon experimental data is as yet available, clearly indicate that some special treatment would be necessary in combinations of that character.

METHOD

In a small 50 cc. lipped Erlenmeyer flask dissolve 0.1 g. of the sample (with about the molecular equivalent of sodium acetate, in the case of theobromine alone) in 2 cc. glacial acetic acid by gentle heat on a wire gauze. Dilute with 3 to 5 cc. hot water. Transfer the perfectly *clear* solution to a 100 cc. graduated glass-stoppered flask containing 50 cc. standard 0.1 *N* iodine, using warm water for rinsing. Next add 20 cc. saturated sodium chloride solution, and finally 2 cc. concentrated hydrochloric acid while rotating the flask. Stopper the latter and allow to stand at room temperature over night. Make up to the mark with water and mix thoroughly. Pass the liquid through a small (5.5 cm.) filter previously fitted to funnel by wetting and drying, reject the first 15 cc. and collect 50 cc. in a graduated 50 cc. flask. Transfer this aliquot by pouring and rinsing to an Erlenmeyer flask of about 250 cc. capacity, and titrate the excess of iodine with standard 0.1 *N* sodium thiosulfate. The quantity of theobromine involved in the sample under examination is thereupon readily calculated from the expression:

Theobromine = I (0.0045026 × normality of thiosulfate used), in which I represents the number of cubic centimeters of thiosulfate equivalent to the iodine expended in periodide formation.

The foregoing method has been successfully applied to several commercial mixtures or combinations of theobromine, or its sodium salt, with sodium acetate and sodium salicylate. Thus, in the case of a well-known brand alleged to consist of theobromine and sodium acetate, with a calculated theobromine content of 63.9 per cent, the following values were obtained: 57.4, 58.6, 58.7 and 59.0 per cent. Another brand of a similar mixture gave 32.19 and 31.87 per cent. A sample alleged to be the double salt of sodium salicylate and sodium theobromine was found to contain 49.78 and 49.73 per cent (calculated 49.73 per cent theobromine).

SUMMARY

A method has been developed for estimating theobromine, both alone and in combination with sodium acetate and sodium salicylate, based on the formation of its periodide, $C_7H_8N_4O_2.HI.I_4$.

SYNTHETIC PRODUCTS LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

STUDIES IN SYNTHETIC DRUG ANALYSIS. VI—EVALUATION OF HEXAMETHYLENETETRAMINE TABLETS

By W. O. EMERY AND C. D. WRIGHT

Received May 15, 1918

INTRODUCTION

The present study had its inception in certain preliminary experiments connected with coöperative work on synthetic drugs, and instituted with a view to adapt a known or devise a new procedure for the estimation of hexamethylenetetramine as it ordinarily occurs in tablet preparations. A series of tests looking to its quantitative isolation by the use of immiscible solvents early demonstrated the futility of attempting a solution of the problem in this way. In operations with like volumes of water and chloroform, for example, only about 3 to 4 per cent of the substance are taken up by the latter solvent in one extraction. Attempts to utilize the condensation product of hexamethylenetetramine with antipyrine as a basis for the quantitative determination met with scarcely better success. After several other equally fruitless trials, recourse was finally had to a procedure substantially identical with a method proposed by Stuewe,[1] primarily for formaldehyde and formalin, but quite as applicable to hexamethylenetetramine.

[1] *Arch. Pharm.*, **252** (1914), 430; *Pharm. Ztg.*, **59** (1914), 218

Stuewe's method, however, while essentially a reversal of the procedure first employed by Rupp[1] in the evaluation of mercuric chloride tablets, was unfortunately so formulated as to leave the operator very much in the dark respecting the influence of certain, presumably determining, factors like time, temperature, and concentration on the quantitative outcome.

In the original, as also in the amplified and amended procedure presently to be described, advantage is taken of the fact that, when an aqueous solution of formaldehyde is treated with alkalized potassium mercuric iodide, the former is converted into a formate with a corresponding separation of slaty gray colloidal mercury, in accordance with the equation:

$$CH_2O + K_2HgI_4 + 3KOH = Hg + HCO_2K + 4KI + 2H_2O$$

If now the acidified mixture is treated with standard iodine, solution of the precipitated mercury results, and by subsequent titration with thiosulfate the quantity of iodine thus entering into combination with the mercury is easily ascertained. The procedure, therefore, resolves itself into five principal operations, namely:

1—Hydrolysis of hexamethylenetetramine to formaldehyde and ammonia.

2—Interaction of formaldehyde with potassium mercuric iodide.

3—Acidification with acetic acid.

4—Solution of the precipitated mercury in standard iodine.

5—Titration of the unexpended iodine with sodium thiosulfate. From the data thus gained, the quantity of hexamethylenetetramine is readily calculated.

EXPERIMENTAL

In the preliminary survey, the findings obtained with apparently pure samples were in part so contradictory as to indicate that a more detailed study of the method was indispensable to its successful operation. Accordingly, numerous experiments were carried out on controls with a view to ascertain, if possible, the more predominating factors, and to eliminate any such calculated to unfavorably affect the quantitative results. Thus, it was found that, while precipitation of the mercury is practically instantaneous and hence complete after the lapse of one minute from the time the mixture has attained homogeneity, there can be no objection to allowing the product to stand for a longer period, if desired, before the addition of acetic acid.

In order to determine to what extent, if any, the final result may be influenced by varying the time during which the precipitated mercury is in actual contact with acetic acid, and as a consequence subjected to its solvent action, the following tests were made.

The data show conclusively, first, that protracted contact of the separated mercury with the acid is detrimental, invariably leading to a corresponding diminution in the quantity of substance sought, and, second, that any considerable excess of acetic acid above that required to produce distinct acidity in the reacting menstruum is likewise calculated to impair the efficiency of the method.

No.	Glacial AcOH Cc.	I added after Min.	$C_6H_{12}N_4$ found Per cent
1	4	1/4	100.1
2	4	1	99.5
3	4	2	98.9
4	4	3	98.5
5	4	4	97.9
6	4	5	97.7
7	4	10	97.3
8	4	20	96.7
9	4	30	96.3
10	3	1/4	99.8
11	4	1/4	99.9
12	3	5	98.5
13	4	5	97.9
14	5	5	97.4
15	10	5	96.1

That the presence of vehicles or diluents like starch, lactose, and acacia has no appreciable effect on the quantitative findings is clearly shown in experiments on controls involving the materials in question, whereby recoveries of 99.8, 99.9, and 100.2 per cent, respectively, of hexamethylenetetramine were effected. In the following series will be found the results obtained with the perfected method on three samples: Nos. 1 to 6, a well-known commercial brand of pure granulated hexamethylenetetramine; Nos. 7 to 12, a commercial brand of hexamethylenetetramine tablets containing about 10 per cent of a vehicle or diluent; and Nos. 13 to 18, a laboratory product consisting of a triturated mixture of equal parts of pure hexamethylenetetramine and air-dried talc.

No.	40 Per cent AcOH Cc.	I added after Min.	$C_6H_{12}N_4$ found Per cent
1	10	1/4	99.9
2	10	1/4	99.7
3	10	1/4	99.8
4	10	1/4	99.8
5	10	1/4	99.7
6	10	1/4	99.8
7	10	1/4	90.7
8	10	1/4	90.6
9	10	1/4	90.8
10	10	1/4	90.7
11	10	1/4	90.6
12	10	1/4	90.7
13	10	1/4	50.8
14	10	1/4	50.8
15	10	1/4	50.9
16	10	1/4	50.7
17	10	1/4	50.9
18	10	1/4	50.7

The entire procedure as developed on numerous controls contemplates the following:

REAGENTS

A—Modified Nessler's reagent, involving:

(*a*) Solution of 10 g. $HgCl_2$, 30 g. KI, and 5 g. acacia dissolved in 200 cc. H_2O and filtered through a pledget of cotton wool.

(*b*) Solution of 15 g. NaOH in 100 cc. H_2O.

B—Tenth normal iodine.

C—Twentieth normal thiosulfate.

PRELIMINARY TREATMENT

Ascertain the weight of 20 or more tablets, triturate in a mortar to a fine powder, and keep in a small capsule tightly closed with a cork or glass stopper. Weigh out 0.5 g. of the powdered sample on a metal scoop or watch glass, transfer with sufficient water to a round bottom flask, add additional water to a total volume of 100 cc., and finally 25 cc. of 10 per cent hydrochloric acid. Connect with a reflux condenser (preferably of the worm type) and boil gently 15 min.; then, after cooling, wash out the condenser tube with a little water,

[1] *Arch. Pharm.*, **243** (1905), 300; **244** (1906), 540.

and transfer the contents of flask quantitatively to a graduated 250 cc. flask, finally diluting to the mark with water.

METHOD

With a pipette withdraw 10 cc. (containing in the case of a pure product the elements of 0.02 g. of hexamethylenetetramine) of the solution so prepared to a 200 cc. Erlenmeyer flask containing a mixture (previously chilled in ice water if available) of 20 cc. of reagent A (*a*) and 10 cc. of A (*b*), wash down neck of container with a fine jet of water, and allow the mixture to stand at least one minute after gentle rotation of the flask. Now add 10 cc. of 40 per cent acetic acid in such manner that the inside of neck is completely washed by the reagent, mix quickly and thoroughly by gently rotating and tilting the flask, and immediately run in from a burette 20 cc. of reagent B, then titrate with reagent C (adding 5 to 10 drops of starch solution toward the end of the operation) to the disappearance of the blue coloration. The final color of the solution is a pale straw-green. If preferred, the end-point may be determined by the reformation of a faint blue coloration, induced by the addition of a drop of iodine solution.

Since the standard iodine (reagent B) employed has twice the titrimetric strength of the thiosulfate (reagent C), and 1 cc. of $N/10$ iodine is equivalent to 0.001167 g. of hexamethylenetetramine (O = 16), the quantity of this product, as represented by its elements formaldehyde and ammonia, in the aliquot under examination may be readily calculated from the expression

$$\left(H - \frac{I}{2}\right) N \times 0.001167$$

in which H = the number of cubic centimeters of reagent C equivalent to 20 cc. of reagent B, I = the number of cubic centimeters of reagent C required to offset the unexpended iodine, and N = the normality of reagent C.

SUMMARY

A procedure is described for the estimation of hexamethylenetetramine, whereby advantage is taken of the fact that, when an aqueous solution of formaldehyde is allowed to react with alkalized potassium mercuric iodide, the former by virtue of oxidation to a formate effects a corresponding separation of mercury, which latter on treatment with an excess of standard iodized potassium iodide and subsequent titration with thiosulfate affords all necessary data for calculating the hexamethylenetetramine originally involved.

SYNTHETIC PRODUCTS LABORATORY
BUREAU OF CHEMISTRY
WASHINGTON, D. C.

AN IMPROVED METHOD FOR DETERMINING CITRAL A MODIFICATION OF THE HILTNER METHOD

By C. E. PARKER AND R. S. HILTNER

Received November 27, 1917

In the determination of citral by the Hiltner colorimetric method[1] with metaphenylenediamine hydrochloride, it not infrequently occurs that lemon and orange oils and extracts produce blue or green colors instead of yellow. This abnormal behavior has somewhat restricted the applicability of the method.

An investigation having for its object the study and removal of this difficulty proceeded upon the theory that an oxidation phenomenon is involved therein. In cases where the blue color develops slowly it appears to spread downward from the surface of the mixture. The metaphenylenediamine hydrochloride reagent acquires a blue color by the action of hydrogen dioxide solution, and the formation of peroxide compounds by the action of air and moisture upon terpenes is noted in the literature.[1] Nevertheless, observations of Mory,[2] Hilts[3] and the writers that it is not a matter of indifference whether fullers' earth, or animal charcoal, or nothing whatever be used for decolorizing the reagent, suggested that oxidation of the citrus oil might not be the sole cause of the phenomenon. It has even been stated that by omitting the use of fullers' earth the difficulty may be avoided. This is not always the case.

INFLUENCE OF DECOLORIZING AGENTS

Experiments, unnecessary to detail here, with fullers' earth, animal charcoal, talcum, pumice, zinc powder, platinized asbestos, eponite and kaolin, led to the conclusion that besides their obvious decolorizing action upon the reagent, such substances affect it in a more obscure way, rendering it more responsive to the action of a citrus oil which has the property of producing the blue color. It was possible, by washing the powdered metaphenylenediamine hydrochloride with small amounts of 94 per cent alcohol, to prepare a reagent which had less tendency to produce the blue color than a reagent made with the unpurified metaphenylenediamine hydrochloride. The purified reagent had a lighter color, but it is not supposed that the substance producing dark reagent solutions is identical with that causing the blue color.

THE CONSTITUENTS OF CITRUS OILS GIVING RISE TO THE BLUE COLOR

A decided blue coloration was obtained with a sample of *d*-limonene (carven) from Kahlbaum, with one marked "Limonene, pure, Schimmel and Co." which was quite yellow and sirupy, and with several samples of commercial oil of turpentine "for technical use." No blue color was obtained with available samples of citral.

Orange oil which failed to give the blue coloration was exposed to the air by standing over night in a shallow receptacle, and also by bubbling air through it for one-half to four hours, after which it gave a blue color with the reagent in a short time.

These experiments are considered to favor the presumption that oxidation of the terpene is in part responsible for production of the blue color.

EFFECT OF REDUCING AGENTS

Stannous chloride was found to prevent the formation of the blue color, whether added in the solid form

[1] U. S. Dept. Agr., Bureau of Chemistry, *Bull.* **122**, 34; **132**, 102; **137**, 70.

[1] Engler and Weissberg, *Ber.*, **31** (1898), 3046; Roscoe and Schorlemmer, *Chemistry*, **1** (1905), 257; Kingzett, *J. Soc. Chem. Ind.*, **1898**, 691; Thorpe, *Dict. Appl. Chem.*, **3** (1912), 68.

[2] U. S. Dept. Agr., Bureau of Chemistry, *Bull.* **132**, 107.

[3] *Ibid.*, **122**, 32.

or in aqueous or alcoholic solution. It was hoped that the use of an absolute alcohol solution of this salt, which remains limpid for some days, would meet the requirements, but the necessary presence of at least a small percentage of water in the solutions to be compared and the turbidity resulting from precipitation of basic tin compounds were complications leading to its rejection. Hiltner recommended 50 per cent alcohol as the solvent for making the reagent. It was found impracticable to make a 1 per cent solution with 94 per cent alcohol, and 80 per cent was finally adopted as the concentration of the solvent, but even using this reagent stannous chloride produced a turbidity.

Sulfurous acid and metaphenylenediamine sulfite were tried, but with them citral produced no yellow color or one which was rather transient according to circumstances. The metaphenylenediamine base likewise produced no yellow color with citral. Metaphenylenediamine oxalate, citrate and tartrate gave a yellow color with citral, but produced no blue color with citrus oils. The solubilities of these compounds, compared with the solubility of the hydrochloride, are such that a more dilute alcohol is required to make a 1 per cent solution.

The addition of a proper amount of oxalic acid to the original Hiltner reagent was found to accomplish the desired object in the most simple and convenient way, and was finally adopted for the proposed method.

The procedure detailed has been tried upon a number of lemon and orange oils and extracts with entirely satisfactory results, the only color aberration so far observed being a slightly brownish tinge developed in some cases. If the various samples to be compared are mixed with the reagent at the same time, as many as a dozen can be compared with a single standard within an hour without any substantial error, so far as our experience indicates. In order to do this it appears advantageous to employ always a fixed amount of the citral standard, instead of adjusting this amount as in the original method. The comparisons are then made by adjusting the dilution of the unknown samples. In this manner the operator will always work toward approximately the same shade as an end-point. Each operator may choose a concentration or amount of the citral standard appropriate to the conditions of his work, the shade of yellow to which his vision appears most sensitive, the colorimeter used, etc.

So far as known, the presence of extraneous coloring substances would not introduce sufficient disturbance to affect materially the determinations. This possibility may well be considered, however, especially in connection with orange extract, of which a larger amount must be used in making the dilutions.

DETAILS OF THE METHOD

REAGENTS—*Alcohol*—Practically colorless 94 to 95 per cent alcohol may be employed. It need not be aldehyde-free.

Citral Standard Solutions—Weigh into a 50 cc. graduated flask 0.5 g. citral. Make up to the mark with 94 per cent alcohol at room temperature, stopper and mix well. Pipette 10 cc. of this "1 per cent solution" into a 100 cc. graduated flask, make up to the mark with 94 per cent alcohol, stopper and mix. Each cc. of this contains 0.001 g. of citral. These solutions may be kept in the refrigerator but should be measured at room temperature.

Metaphenylenediamine Hydrochloride-Oxalic Acid Solution—Dissolve 1 g. of metaphenylenediamine hydrochloride and 1 g. of crystallized oxalic acid each in about 45 cc. of 80 per cent alcohol. Mix in a stoppered 100 cc. graduated flask or cylinder and make up to the mark with 80 per cent alcohol. Add 2 or 3 g. of fullers' earth, shake well, allow to settle nearly clear and decant upon a double filter. When most of the liquid has run through add the turbid residue to the liquid in the filter.

APPARATUS—Any convenient form of colorimeter may be used. (The conditions given herein are based upon the use of the Campbell-Hurley instrument.)

MANIPULATION—The operations may be carried out at room temperature. Weigh into a 50 cc. graduated flask about 0.5 g. of a normal lemon oil, or about 4 g. of orange oil, or 10 g. of lemon extract, or 50 cc. of orange extract (*i. e.*, with orange extracts, the original extract is used as a first dilution), respectively, make up to the mark with 94 per cent alcohol, stopper and thoroughly mix the contents. Pipette an exactly measured amount (say 5 cc.) of these respective first dilutions into 50 cc. graduated flasks. Pipette also 4 cc. of the standard "0.1 per cent" citral solution into a 100 cc. graduated flask. As nearly as possible at the same time add, from a small graduated cylinder, to the 50 cc. flasks 10 cc., and to the 100 cc. flask 20 cc. of the metaphenylenediamine hydrochloride-oxalic acid reagent, make all up to the mark with 94 per cent alcohol, stopper the flasks and mix well. Empty the 100 cc. flask of citral dilution into the plunger tube of the colorimeter and a 50 cc. flask of the unknown dilution into a comparison tube. Both comparison tubes are graduated in millimeters. Adjust the plunger until both halves of the field have the same intensity of color, and note the heights of the columns compared. Calculate the average of 5 or more observations. From these preliminary results compute the amount of the first dilution of the unknown which should be used in making the second dilution to produce the same color as the standard in the same height of column of liquid. Repeat the determination preparing at the same time fresh dilutions of the standard and unknown until columns of liquid of equal intensity of color differ in length not more than 5 or 10 per cent.

In cases where the quantity of material available is scanty, it may be better to reverse this procedure by varying the dilution of the standard instead of the sample in developing comparable colors.

CALCULATION—Let a = grams of citral (0.002) in 50 cc. (not 100 cc.) of diluted standard used for comparison.

b = grams of oil or extract weighed.

c = volume in cc. (50) of 1st dilution of unknown.

d = volume in cc. of same used for 2nd dilution.

e = height of column (mm.) of standard used for comparison.

f = height of column (mm.) of unknown used for comparison.

Then $\frac{a \times c \times e \times 100}{b \times d \times f}$ = per cent citral in oil or extract.

EXAMPLE—Lemon oil weighed 0.5384 g.

Preliminary d = 5 cc., e = 86 mm., f = 77 mm.

$\frac{0.002 \times 50 \times 86 \times 100}{0.5384 \times 5 \times 77}$ = 4.25 per cent, and

$5 \text{ cc.} \times \frac{77}{86}$ = 4.47 cc. approximate amount of 1st dilution to be used in final determination.

Final d = 4.5 cc., e = 79 mm., f = 77 mm.

$\frac{0.002 \times 50 \times 79 \times 100}{0.5384 \times 4.5 \times 77}$ = 4.23+ per cent.

U. S. FOOD AND DRUG INSPECTION LABORATORY
DENVER, COLORADO

THE IDENTIFICATION AND DETERMINATION OF POTASSIUM GUAIACOL SULFONATE

By SAMUEL PALKIN

Received June 1, 1918

The sulfonic acid salt of guaiacol has been used in medicine for a number of years. When so employed it is practically never used by itself but in conjunction with gums, resins, alkaloids, and other medicinal agents to counteract various symptoms. This renders its identification and determination much more difficult than if the substance were used alone. Many well-known qualitative tests for common elements are thus rendered almost useless by the presence of ordinary resins and other complicating substances that are generally present in medicinal preparations.

The potassium guaiacol sulfonate[1] used in medicine is apparently the metasulfonic acid[2] salt of guaiacol. It is a colorless salt, very soluble in water, only slightly soluble in alcohol and insoluble in ether, benzene, and chloroform.

Two samples of potassium guaiacol sulfonate from different manufacturers were obtained in the open market. These samples are designated A and B in the paper.

EXPERIMENTAL

As stated in the patent of Fabrik-Heyden,[3] no insoluble salts of the sulfonate were obtained with the heavy metals, with the exception of lead subacetate in the neutral or alkaline solution. As the compound is most generally accompanied by resins and other substances precipitable by lead subacetate, this reagent could have but little value in this connection. Organic bases gave no insoluble compounds. No good solvent was found which would extract guaiacol sulfonic acid. Amyl alcohol does so to some extent, but has not been found of value.

Taking advantage of the phenolic properties of this compound, the action of chlorine and bromine was tried. Very little action occurs in the concentrations of the compound generally used, but in higher concentrations the dibrom guaiacol sulfonate[1] is formed. This compound is extremely soluble in water and quite insoluble in most organic solvents. As it has no definite melting point or other easily identifiable physical or chemical property, the formation of this compound was not found to be of any use for the purpose in hand.

In the presence of strong hydrochloric acid and with heat, a rather unexpected reaction takes place. Instead of mere formation of a chlor- or brom-compound, hydrolysis takes place, sulfuric acid being split off almost completely and but a very small amount of chlor- or brom-compound is precipitated, and that apparently of guaiacol itself. That guaiacol is an intermediate compound is made apparent by the fact that it can readily be detected by its odor during the process of heating. This is especially true when a dilute chlorine solution is used. The amount of halogen compound formed is very small and is furthermore contaminated by other by-products, thus making it useless for purposes of identification. So effective, however, is the halogen (bromine in particular) in its hydrolytic action on the sulfonate that nearly 97 per cent of the theoretical amount of sulfuric acid is thus obtainable. In fact, this procedure with some modification is actually made use of subsequently in the quantitative determination of this compound.

Another and rather useful reaction depending on the phenolic properties was found in the coupling of this compound with diazotized amines. Among those tried were aniline, toluidine, xylidine, tolidine, *o*- and *p*-nitro aniline, *p*-amido phenol and naphthylamine, and an azo dye was formed in practically every case; but in nearly all cases, a dirty brown precipitate, exceedingly voluminous and not particularly characteristic, resulted, with the exception of that obtained with *p*-nitro aniline. The diazotized *p*-nitro aniline gave, with the alkali guaiacol sulfonic acid, a dark red, water-soluble dye, which behaved as an indicator. A small quantity of the dye used as an indicator changes very sharply from red in the alkaline solution to yellow in the acid solution. The dye is only slightly soluble in chloroform and ether but very readily soluble in amyl alcohol. In the presence of various contaminating substances as mentioned above, this dye can be extracted from the water (acid) solution with amyl alcohol and with alkali re-extracted from the amyl alcohol, thus rendering it free from obscuring impurities and observing clearly the color changes. It is necessary to eliminate or establish the absence of phenols, or guaiacol itself, which also give red dyes when applied as coupling agents to diazotized *p*-nitro aniline. Since guaiacol sulfonic acid is nonvolatile with steam and cannot ordinarily be shaken out by organic solvents, preliminary treatment to insure the absence of other interfering phenols can readily be resorted to before applying the reaction.

HYDROLYSIS—As pointed out in the discussion of the action of halogen on this compound, instead of the

[1] D. R. P. 109,789, Friedlander, V (1900), 738. D. R. P. 188,506, Friedlander, VIII (1907), 936.

[2] L. Paul, *Ber.*, **39** (1906), 2773, 4093; A. Rising, *Ibid.*, **39** (1906), 3685

[3] *Loc. cit.* (2).

[1] Krauss and Krede, *J. Am. Chem. Soc.*, **39** (1917), 1432.

expected halogenation, there results the hydrolytic action yielding sulfuric acid.

The usual procedure of heating with hydrochloric acid in a sealed tube was resorted to. About 100 mg. substance was heated with concentrated HCl in a sealed tube to 200° C. for several hours. Some charring took place but most of the sulfuric acid was split off and some of the guaiacol was further attacked to form pyrocatechol as indicated by a number of corroborative tests. A quantitative determination showed that about 88 per cent of the guaiacol sulfonate was converted. The use of the sealed tube is, of course, attended with some difficulty and quite inapplicable to preparations that generally contain guaiacol sulfonate. The experiment was made merely to note approximate extent of hydrolysis and products formed.

A procedure involving the same principles, *viz.*, high temperature, strong acid, and at the same time presence of moisture, was found in the use of high boiling liquids as well as salt solutions. These accomplished the same results much more readily. Best results were obtained with phosphoric acid (containing some NaCl) and with a concentrated $ZnCl_2$ and HCl solution which ultimately boils at about 200° C. The characteristic odor of guaiacol is given off during the boiling, if interfering substances are not present, and the volatile phenol can be distilled over and tested for in the usual manner. A color change to wine-red and then to brown or charring is observed in the latter stages of the boiling. Attempt was made to utilize either phosphoric acid or zinc chloride for the quantitative conversion of the sulfonic acid to sulfate. Nearly quantitative results were obtained with $ZnCl_2$, but the results were nearly always somewhat low, owing, apparently, to the reduction of some of the sulfuric acid during charring. Oxidation with a few drops of nitric acid during boiling was tried but was found to cause formation of nitro compounds (apparently picric acid), which precipitated along with the barium sulfate and invariably gave high results on ignition. Owing to the tendency of phosphates to be dragged down with the precipitates in the determination of sulfates, the results, using phosphoric acid as the hydrolytic agent, were always high. This procedure, while useful for qualitative purposes, was, therefore, deemed undesirable for quantitative determinations.

A table follows which shows results obtained by the various procedures described above.

The two samples of potassium guaiacol sulfonate used were previously analyzed by the bomb ignition methods as follows: A weighed amount of sample not exceeding 150 mg. mixed with an equal amount of sulfur-free benzoic acid was inserted in a Parr calorimeter bomb, about 5 g. C. P. sodium peroxide added, the whole mixed and ignited, and the sulfates determined in the usual manner, with the following results:

	Per cent SO_3
Sample A	(*a*) 30.8, (*b*) 30.5, (*c*) 30.7
Sample B	(*a*) 31.6, (*b*) 31.2, (*c*) 31.4

TABLE OF RESULTS

Sample	Weight Mg.	Reagent used	Sugar syrup added	SO_3 found G.	SO_3 by bomb method G.
B	100	HNO_3 Conc.	None	0.0308	0.0316(*a*), 0.0312(*b*), 0.0314(*c*)
	100	(No bromine)	None		
	100	(No bromine)	None	0.0304	0.0314[1]
	100	(No bromine)	None	0.0302	0.0314
	100	(No bromine)	None	0.0303	0.0314
	100	(No bromine)	None	0.0311	0.0314
	100	(No bromine)	None	0.0308	0.0314
	100	$ZnCl_2$	None	0.0291	0.0314
	100	$ZnCl_2$	None	0.0280	0.0314
	100	$ZnCl_2$	None	0.0300	0.0314
	100	$ZnCl_2$	None	0.0301	0.0314
	100	$ZnCl_2$	None	0.0294	0.0314
	100	$ZnCl_2$	None	0.0284	0.0314
	100	$ZnCl_2$ + drops of HNO_3	None	0.0324	0.0314
	100	$ZnCl_2$ + drops of HNO_3	None	0.0336	0.0314
	100	(Br + HNO_3 + Br) Proposed method	None	0.0314	0.0314
	100	Proposed method	None	0.0315	0.0314
	100	Proposed method	None	0.0318	0.0314
	100	Proposed method	None	0.0315	0.0314
	100	Proposed method	None	0.0319	0.0314
	100	Proposed method	5 cc. Conc. Syrup	0.0316	0.0314
	100	Proposed method	5 cc. Conc. Syrup	0.0315	0.0314
	100	Proposed method	5 cc. Conc. Syrup	0.0318	0.0314
	100	Proposed method	5 cc. Conc. Syrup	0.0315	0.0314
	200	Proposed method	5 cc. Conc. Syrup	0.0622	0.0628[2]
	250	Proposed method	5 cc. Conc. Syrup	0.07855	0.0785[2]
	200	Proposed method	5 cc. Conc. Syrup	0.0631	0.0628[2]
A	100	Proposed method	5 cc. Conc. Syrup	0.03074	0.0307[3]
	100	Proposed method	5 cc. Conc. Syrup	0.0306	0.0307[3]
	225	Proposed method	5 cc. Conc. Syrup	0.0692	0.0691[4]

[1] Average of 3 determinations of B.
[2] Calculated from average of B.
[3] Average of 3 determinations of A.
[4] Calculated from (3).

The following method for the qualitative testing and quantitative determination of potassium guaiacol sulfonate is recommended, with the view to its adaptation to the medicinal preparations in which it is most likely to occur.

It must be borne in mind that other sulfur-bearing compounds such as sulfonal, trional, saccharine, etc., must either be proven to be absent or, if present, previously removed by extraction before applying the method described. The author knows of no other sulfonic acids employed in medicine except ichthyol and the rarely used phenol sulfonates. The quantitative procedure herein described will not be accurate in the presence of those compounds. The qualitative tests are not interfered with by ichthyol, as nearly all of the ichthyol is precipitated on acidification with hydrochloric acid as directed in the method, the free sulfonic acid of that compound being very difficultly soluble in water. The phenol sulfonates are readily converted into the insoluble tribrom phenol by the action of bromine.

QUALITATIVE—(*a*) Some of the sample containing potassium guaiacol sulfonate is diluted with water and acidified with hydrochloric acid. If a resinous or other precipitate comes down, it is filtered. A portion of the filtrate is tested for sulfate. Another portion of the filtrate is made more strongly acid with HCl after the addition of a few grams of sodium peroxide. The solution is boiled and chlorine is generated in limited quantities which attacks the guaiacol sulfonic acid. In the presence of this compound, the characteristic odor of guaiacol becomes perceptible. If, after boil-

ing for about 15 to 20 min., a precipitate is formed, this is filtered off and the filtrate nearly neutralized with sodium hydroxide and tested for sulfates. Commercial hydrogen peroxide contains sulfates and naturally cannot be used for that test. In the absence of sulfate in the original sample, and subsequent formation of sulfate by the action of the chlorine, a good indication is had of the presence of sulfonic acid-guaiacol. In the presence of sulfate in the original, determination of sulfates before and after have to be resorted to in order to note increase due to sulfonic acid.

(*b*) Some of the filtrate is made alkaline and to it is added drop by drop a cold solution of diazotized *p*-nitro aniline. (The diazo salt is prepared by dissolving 140 mg. *p*-nitro aniline in 8 cc. H_2O and 1 or 2 cc. concentrated HCl, cooling and adding 75 mg. sodium nitrite dissolved in a few cc. of H_2O.) In the presence of guaiacol sulfonate the solution will be colored deep red. If substances are present which obscure the color, the solution is made acid with HCl, extracted in a separatory funnel with amyl alcohol, the lower aqueous layer is tapped off, and the alcohol layer re-extracted with NaOH solution, when the azo dye will color the aqueous layer deep red. On acidification, the solution changes very sharply to yellow, the azo dye behaving like an indicator in that respect. If guaiacol or other phenols are present in the original solution, they should be removed beforehand by steam distillation or extraction with organic solvent as the case may require. The guaiacol sulfonic acid will remain behind and can subsequently be tested for as indicated above.

(*c*) In the absence of much organic material or possible removal of the same the following procedure may be used. To a concentrated solution of the sample (a few cc.) in a hard glass test tube are added about 5 cc. syrupy phosphoric acid containing a little NaCl, and the mixture is boiled or preferably distilled over. Distillate, which may be less than 1 cc., may then be tested for the presence of guaiacol and pyrocatechol, as both are generally formed. A few drops of a very dilute ferric chloride solution will give with the distillate (in the absence of much HCl) a green coloration which changes to yellowish and on addition of ammonia changes to violet-blue. The neutral, or better, ammoniacal solution causes marked reduction of silver nitrate.

QUANTITATIVE DETERMINATION—(*a*) In the absence of much contaminating material, a known amount of the sample, which should not contain much more than 200 mg. of potassium guaiacol sulfonate, is diluted somewhat with water in a 150 to 200 cc. Erlenmeyer flask and 10 to 20 cc. concentrated HCl are added and then a few cc. liquid bromine. The solution is boiled gently and bromine added several times. It is then evaporated down to a small volume on the steam bath, using air blast, 10 cc. concentrated HNO_3 added, and some more bromine and boiled. This is done to convert the last traces of sulfonic acid guaiacol. The process is repeated twice and the whole evaporated to dryness on the steam bath. It is then diluted with water and sulfates determined in the usual manner.

(*b*) In the presence of much organic material, which is most often the case, a weighed quantity of the sample in a 150 cc. Erlenmeyer flask is treated repeatedly with concentrated HNO_3, preferably fuming HNO_3, heating gently at first until nearly all of the organic material has been oxidized. The same process is then repeated, using bromine and concentrated HNO_3, several times. The whole solution is then evaporated to dryness on the steam bath and the sulfates determined as above.

Factor for conversion of $BaSO_4$ to SO_3 = 0.3428; factor for conversion of $BaSO_4$ to potassium guaiacol sulfonate = 1.0376.

BUREAU OF CHEMISTRY
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE OCCURRENCE OF CAROTIN IN OILS AND VEGETABLES

By AUGUSTUS H. GILL
Received April 5, 1918

In a previous paper[1] it was shown that the peculiar bluish reaction of palm oil was due to carotin, and that palm oil could not be detected in oleomargarine by this test, because the animal fats also contained carotin. At that time, the subject was being further studied, as to what other fats and oils might contain it.

As the carotin is undoubtedly dissolved out from the seeds by the oils they contain, and as it is present in them in extremely small amounts, it was deemed best to extract it from the seeds, rather than from the oils themselves.

The substances investigated were:

(*a*) Seeds: Yellow corn, flax, mustard, black sesame, rape, and white sunflower.

(*b*) Yellow colored vegetables or products: Carrots, squash, turnip, orange peel, safflower, cottonseed meal, turmeric, and neat's-foot and linseed oils.

The procedure used in isolating carotin from various oils and vegetables consisted in extracting the finely divided dried vegetable with carbon bisulfide at a return flow condenser, evaporating off the solvent, and saponifying the residue or oil with alcoholic sodium or potassium hydroxide, leaving a slight excess of alkali; to ensure the absence of free oil, the alcohol was evaporated, keeping the temperature below 70° C. as much as possible, and the residual soap was then dissolved in water. The solution was shaken out with carbon bisulfide, which, in the presence of carotin, assumed a yellow or orange color, depending upon the amount of carbon bisulfide used. The carbon bisulfide was evaporated off, and the residue again treated with an excess of sodium hydroxide to ensure the complete removal of any oil which might possibly have escaped saponification. The resulting soap solution was extracted with carbon bisulfide, as before, with similar results. Those vegetables that were free from oils, such as carrots, were extracted directly with carbon bisulfide, after first drying the finely divided sample at a low temperature.

[1] THIS JOURNAL, 9 (1917), 136

The carbon bisulfide solution, after the extraction from sunflower seeds, was colorless, showing at once the absence of carotin.

Turnip gave a pink solution, safflower, neat's-foot oil, and cottonseed meal a yellow one, while turmeric gave a yellow solution with a greenish fluorescence. All the other solutions were blood-orange in color.

To prove the presence of carotin in these different substances, advantage was taken of various chemical and physical properties which carotin exhibits, being the same tests as employed by Palmer and Eckles[1] in their work.

These properties of carotin are:

(1) It absorbs bromine.

(2) It is not extracted from its petroleum ether solution by 80 to 90 per cent alcohol.

(3) It gives a deep red or blood-orange color in carbon bisulfide solution.

(4) It is not adsorbed by precipitated chalk.

(5) It gives characteristic absorption bands when tested in the spectroscope.

(6) It gives a blue color with the Crampton-Simons test.

Test 6 was carried out by adding the carbon bisulfide solution of the carotin to cottonseed oil—proved free from carotin—evaporating the solvent and applying the Crampton-Simons test to the oily solution in the usual way.

The results of the tests, except the spectral analysis, are tabulated in Table I; the analysis follows in Tables II and III.

TABLE I—SHOWING THE TESTS FOR CAROTIN IN EXTRACTS FROM VARIOUS SUBSTANCES

SEED OR VEGETABLE	(1) Bromine	(2) Alcohol Extraction	(3) Color of CS_2 Soln.	(4) $CaCO_3$ Adsorpn.	(6) Crampton-Simons Color Test	Relative Amts. of Carotin
Yellow Corn	Absorbs	None	Blood-Orange	Large	Blue	Small
Flaxseed	Absorbs	None	Blood-Orange	None	Blue	Small
Mustard	Absorbs	None	Blood-Orange	Large	Blue	Small
Black Sesame	Absorbs	None	Blood-Orange	None	Blue	Small
Rapeseed[1]	Absorbs	Extracted	Blood-Orange	Some	None	None
White Sunflower	None	.....	Colorless	....	....	None
Squash	Absorbs	None	Blood-Orange	Some	Blue	Some
Turnip[1]	Absorbs	Trace	Pink	Some	Brown	None
Orange Peel	Absorbs	None	Blood-Orange	Large	Blue	Small
Safflower[1]	Absorbs	.....	Yellow	....	None	None
Cottonseed Meal[1]	....	.....	Yellow	....	None	None
Turmeric[1]	....	.....	Yellow	Large	....	None
Neat's-foot Oil	?	.....	Yellow	....	None	Trace
Linseed Oil	Absorbs	None	Blood-Orange	None	Blue	Trace

[1] Shows no evidence of carotin.

The fifth test, the spectroscopic test, is probably the most reliable test for carotin. It depends upon the fact that carotin cuts off the violet end of the spectrum sharply, as if a card had been placed between the instrument and the test tube containing the solution. The instrument used in this investigation was a Krüss single-prism spectroscope and the solutions were tested according to the method of Formanek.[2] Carotin from carrots was used as a standard. The carbon bisulfide solution from this material was run through $CaCO_3$ and then extracted with 80 to 90 per cent alcohol in order to remove other pigments, although if xanthophylls were present they probably would not interfere with the readings, as the bands of this substance are shifted further toward the blue end of the spectrum from the corresponding bands of carotin.

[1] *J. Biol. Chem.*, **17** (1914), 190–249.

[2] Spectral-analytischer Nachweis künstlicher organischer Farbstoffe.

Phytosterol which might have been extracted along with carotin gives no absorption spectrum.[1] The spectroscope was equipped with an arbitrary scale. By setting this scale at a constant point, before taking any measurements, it was possible to standardize the absorption bands from carotin so that the bands of an unknown pigment could be compared with them. The solvents used were carbon bisulfide and ethyl alcohol. The colors of all unknown solutions were brought to the same tint as the solution by means of the Lovibond tintometer. This was the only means available of standardizing the strength of the solutions, which is an important factor. This was not so pronounced in the case of the carbon bisulfide solutions, being mostly a question of clearness of reading, but in the case of the alcoholic solutions a marked effect was noted. The more the solutions were diluted the greater was the shifting of the absorption bands toward the blue end of the spectrum. So, in order to get comparative results, it was necessary to have all solutions as nearly as possible at the same concentration. Palmer and Eckles, as well as other investigators, noted and read three absorption bands for carotin. In this investigation, an attempt was made to read only the extremity of one band, the end of the band toward the red, between the E and F lines. This line was particularly clear and distinct. The readings obtained are given in the following table:

TABLE II—CAROTIN ABSORPTION SPECTRA—CS_2 SOLVENT

Carrots	13.64	Rape Seed	14.02
Palm Oil	13.64	Turnip[1]	13.09, 14.89, 16.10
Corn (yellow)	13.46	Grass	13.88
Squash	13.65	Safflower[1]	15.29
Flax Seed	13.87	Turmeric[1]	15.10
Orange Peel	13.51	Linseed Oil	13.84
Mustard Seed	13.66	Sesame Oil	13.60

[1] Shows no evidence of carotin.

Neat's-foot oil and cottonseed meal were too weak to give readings, although both were colored yellow. Neat's-foot oil responded to none of the other tests, the color being so dilute. The amount of cottonseed meal obtainable was so small that the failure to obtain a reading of this substance cannot be taken seriously. Turnip was interesting in the fact that it gave three distinct absorption bands, none of which corresponded to the carotin reading. Black sesame seed gave considerable trouble as the carbon bisulfide solution dissolved resinous material which interfered with the readings. By evaporating off the carbon bisulfide and treating with alcohol the resins precipitated, and on filtering it was possible to get readings both in carbon bisulfide and alcohol. Safflower, rape seed, and turmeric gave readings considerably further toward the blue end of the spectrum than carotin. All readings given in the tables are mean readings of a series of nine observations.

TABLE III—CAROTIN ABSORPTION SPECTRA—C_2H_5OH SOLVENT

Carrots	15.38	Sesame Seed	15.24
Palm Oil	15.38	Rape Seed	15.99
Corn (yellow)	15.32	Turnip	14.80
Squash	15.38	Grass	15.47
Flax Seed	15.46	Mustard Seed	15.49
Orange Peel	15.36		

Neat's-foot oil, cottonseed meal, and linseed oil were too weak to give readings, although a reading could be obtained with the carbon bisulfide solution

[1] Gill, *Loc. cit.*

from linseed oil where the absorption was more distinct. No reading was obtained with safflower, as on the addition of alcohol to the coloring matter, a white precipitate formed and the solution which remained after filtering was too weak to read. It is quite evident from this, its behavior towards bromine and its high reading in carbon bisulfide solution, that the coloring matter in this substance is not carotin. Rape seed and turnip gave high and low readings, respectively, which is not surprising in view of their behavior in the previous tests.

SUMMARY

From this work it would seem that carotin is contained in corn, squash, orange peel, flaxseed, mustard seed, and black sesame seed. Palmer and Eckles showed its presence in butter fat and beef tallow, Gill in palm oil, and it has long been known to be in carrots and grass. It does not seem to be present in rape seed, white sunflower, turnip, safflower, cottonseed, or turmeric.

In conclusion the writer wishes here to acknowledge his indebtedness to Messrs. James F. Maguire, Jr., and In-shing Wan, by whom the experimental work was performed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

DETERMINATION OF LOOSELY BOUND NITROGEN AS AMMONIA IN EGGS[1]

By N. HENDRICKSON AND G. C. SWAN

Received February 18, 1918

The chemical methods for the detection of incipient decomposition in foods must be selected in accordance with the character of the substance under examination. As is well known, ammonia is one of the decomposition products of proteins, and the determination of loosely bound nitrogen as ammonia has proved to be one of the best chemical methods in general laboratory use for the grading of eggs.[2,3]

The principle is that of Folin,[4] namely, of aerating an alkaline fluid until all the loosely bound nitrogen is driven off as ammonia. This is caught in a known amount of standard acid for titration, or merely in an excess of acid for a colorimetric determination. The size of sample and the time in which it must be run are the determining factors in the selection of the method.

The apparatus used for this purpose has been changed from time to time as improvements were devised until it is now most satisfactory and may be of interest to those who have to deal with the determination of loosely bound nitrogen in biological material. Of the two optional methods of aeration (suction or blowing), the latter is preferable, for it is easier to keep the conditions of aeration constant, and this is important in determining the length of time necessary for complete removal of the ammonia, as other experimenters have shown[1] and as has been our experience.

The titration method is preferred wherever possible, but in case a large number of samples are to be run in a short time, the colorimetric method can be substituted. In the latter case the amounts of ammonia to be determined are so small that great care must be exercised to keep the apparatus free from ammonium salts.

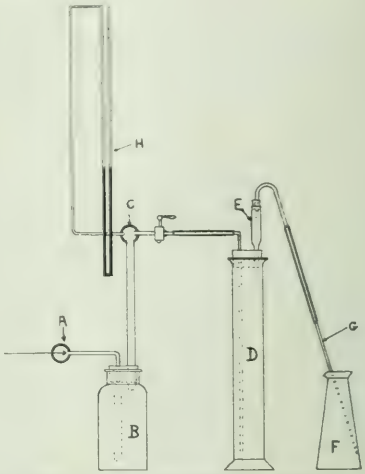


FIG. I—APPARATUS FOR TITRATION METHOD

A—Pipe from air pump.

B—Wash bottle containing 35 per cent sulfuric acid.

C—Pipe to which aeration cylinders are connected.

D—Aeration cylinder (14½ in. high × 1½ in. inside diameter) containing sample. The glass tube for aeration extends to within ½ in. of the bottom and is open at the end.

E—Trap.

F—Flask in which ammonia is caught, containing 10 cc. of *N*/50 sulfuric acid plus 2 drops of 0.2 per cent methyl red (dissolved in alcohol), and 75 cc. of water.

G—Dispersion tube made according to method of Folin and Farmer [*J. Biol. Chem.*, **11** (1912), 493] to insure complete absorption.

NOTE—It has been found by test that the ammonia is always completely absorbed in the one flask by this method.

H—Water gauge for keeping air pressure constant and thus ensuring the passage of an equal volume of air through the cylinders in a given time.

DIRECTIONS FOR TITRATION METHOD

Mix samples well (preferably with one of the electric mixers in common use at soda fountains) and weigh out 25 g. Pour the bulk of the egg into the aeration cylinder D and transfer the remainder by means of four 25 cc. portions of distilled water, stirring each time with a rubber-tipped glass rod to remove the egg adhering to the sides of the weighing vessel. Add 75 cc. of alcohol, mix well, and let stand 15 min. Now add about one gram of sodium fluoride, 2 cc. of 50 per cent potassium carbonate and 1 cc. of kerosene. Connect the apparatus, blow air through until no more ammonia comes over, and titrate solu-

[1] Published by permission of the Secretary of Agriculture.

[2] M. E. Pennington and A. D. Greenlee, "An Application of the Folin Method to the Determination of the Ammoniacal Nitrogen in Meat," *J. Am. Chem. Soc.*, **32** (1911), 861.

[3] H. W. Houghton and F. C. Weber, "Methods Adapted for the Determination of Decomposition in Eggs and in Other Protein Food Products," *Biochem. Bull.*, **1914**, 447.

[4] *Z. phys. Chem.*, **37** (1902), 161.

[1] P. A. Kober and S. S. Graves, "Quantitative Ammonia Distillation by Aeration, for Kjeldahl Urea and Other Nitrogen Estimations," *J. Am. Chem. Soc.*, **35** (1913), 1594.

tion in flask F with $N/50$ sodium hydroxide to ascertain how much of the 10 cc. of $N/50$ sulfuric acid, with which the experiment started, has been neutralized. The per cent of nitrogen is then calculated from $\frac{0.00028 \times \text{cc. of } N/50\ H_2SO_4 \text{ neutralized} \times 100}{25} = \text{Per cent Nitrogen}$.

Tests on standard ammonium sulfate solutions and on egg, at 25° C. (the usual temperature of the laboratory) and under 14 cm. water pressure, showed that the ammonia was all driven over in 4 hrs. If the pressure under which air is forced through is altered to any extent, it is necessary to alter the aeration time to correspond.

The air is passed through 35 per cent sulfuric acid in wash bottles as a precaution, although it has been found that the amount of ammonia present is not great enough to interfere. 35 per cent sulfuric acid are used, because at this strength the volume of the liquid is nearest constant under the conditions of humidity ordinarily prevailing in Philadelphia, and no attention is therefore required except to see that the acid is not neutralized. While, of course, the volume will increase or decrease somewhat, depending upon a high or low humidity, the change is not great.

By the use of a small concentration of potassium carbonate any perceptible hydrolysis of the egg protein is avoided.

At the end of 4 hrs.' aeration all loosely bound nitrogen originally present has been freed, and the quantity given off on aerating for 2 hrs. more is so small that it cannot be determined by titration. The potassium carbonate may be added in solid form, but for convenience it is preferable to add 2 cc. of a 50 per cent solution, using a 10 cc. graduated bacteriological pipette for measuring. Sodium carbonate may be used in place of potassium carbonate, but as it is much less soluble, it is not quite so convenient to use as the latter.

Eggs cannot be aerated satisfactorily without the addition of something to prevent foaming, and alcohol has been found to be most effective. Kerosene must be added also, as most of the alcohol evaporates after 2 hrs.' aeration. Kerosene carried over into the collecting flask does not interfere with the titration. The directions for adding 100 cc. of water to the egg before addition of the alcohol should be carefully followed; if the alcohol is added first, the egg is coagulated in a coarse, stringy condition, instead of finely divided, and is therefore not as efficiently aerated.

It has not been found advisable to correct for a blank. The following table shows the reason, namely, that in many cases no blank at all is obtained; where there is one, it is too small to be of practical importance.

TABLE I—12 BLANKS COMPOSED OF 1 G. Na_2CO_3, 1 G. Na_2F_2, 75 CC ALCOHOL AND 125 CC. OF WATER. AERATED 1½ HRS. THROUGH 5 CC $N/50$ ACID AND THEN TITRATED AGAINST $N/50$ NaOH

$N/50$ NaOH used—cc.	4.95	5.00	5.04	4.96	4.95	5.02
Blank—cc	0.05 −	0.00	0.04 +	0.04	0.05	0.02 +
$N/50$ NaOH used—cc.	4.95	4.95	4.95	5.00	4.90	4.95
Blank—cc	0.05 −	0.05 −	0.05 −	0.00	0.10	0.05

Sodium hydroxide cannot be used as the alkaline agent because continuous hydrolysis takes place with the liberation of ammonia, and no definite stopping place is reached. This holds even in the presence of sodium chloride to decrease the ionization, and is well shown in the following table.

TABLE II—COMPARISON OF NaOH AND Na_2CO_3 IN THE PRESENCE OF Na_2F_2 AND NaCl. SAMPLE RUN IN TRIPLICATE

1 G. Na_2CO_3 and 1 G. Na_2F_2	0.8 G. NaOH and 1 G. Na_2F_2	1 G. NaOH and 15 G. NaCl	3 G. NaOH and 15 G. NaCl
Per cent N (*a*)	Per cent N	Per cent N	Per cent N
0.0032	0.0059	0.0054	0.0104
0.0029	0.0052	0.0056	0.0112
0.0032	0.0041	0.0050	0.0112

(*a*) It should be mentioned at this point that all percentages given in this paper are on the wet basis; that is, on the weight of egg fresh from the shell, or in the case of frozen egg, immediately after thawing.

The action of magnesium oxide as compared with potassium carbonate is shown in the following table. The sample was run as usual, in triplicate for each, the only variation being in the substitution of magnesium oxide for potassium carbonate.

TABLE III

A Run as Usual		A Repeated after Standing 18½ Hours	
1 g. K_2CO_3 Per cent N	1 g. MgO Per cent N	K_2CO_3 Sample Per cent N	MgO Sample Per cent N
0.0031	0.0030	0.0007	0.0018
0.0030	0.0031	0.0005	0.0014
0.0030	0.0032	0.0004	0.0014

It is seen that the differences on the first run are within the limit of error, but after having allowed both portions to stand over night (18½ hrs.), then adding 75 cc. alcohol and 25 cc. water, and again aerating 4 hrs., more ammonia was given off by the magnesium oxide sample, indicating that in this particular case the magnesium oxide is more active than the potassium carbonate.

Table IV shows the result of using sodium hydroxide and sodium carbonate in place of potassium carbonate. One gram of each was used and the sample run in triplicate, otherwise as usual.

TABLE IV

K_2CO_3 Per cent N	Na_2CO_3 Per cent N	NaOH Per cent N
0.0029	0.0030	0.0044
0.0029	0.0029	0.0048
0.0029	0.0029	0.0044

It will be noted that potassium carbonate and sodium carbonate give the same results, whereas the results obtained by the use of sodium hydroxide are much higher. There is no definite end-point with sodium hydroxide; ammonia is given off continuously for a long time.

To illustrate the practical application of this method, the following tables and explanations are given.

Table V includes results obtained on whites, yolks, and whole eggs, fresh, and after 10 mos. in cold storage. They were so-called "April Firsts," the best grade for storage. The figures show clearly that no change takes place as regards the loosely bound nitrogen of the white, the increase for the amount in whole egg being referable solely to the rise of loosely bound nitrogen in the yolk. It also shows how close are the results on individual eggs of the same grade computed on the moist basis.[1]

[1] It might be stated here that determination of ammonia in dried egg is of little value, for it has been shown that ammonia is driven off during commercial drying. See U. S. Dept. of Agriculture, *Bulletin* **51**, "A Bacteriological and Chemical Study of Commercial Eggs in the Producing District of the Central West," M. E. Pennington, *et al.*

TABLE V—INDIVIDUAL EGGS—"APRIL FIRSTS"

Fresh			After 10 Months in Cold Storage		
White Per cent N	Yolk Per cent N	Whole Egg Per cent N	White Per cent N	Yolk Per cent N	Whole Egg Per cent N
0.0005	0.0029	0.0013	0.0003	0.0060	0.0025
0.0004	0.0031	0.0013	0.0004	0.0056	0.0026
0.0003	0.0028	0.0011	0.0003	0.0062	0.0022
0.0004	0.0028	0.0012	0.0004	0.0065	0.0035
0.0005	0.0031	0.0014	0.0005	0.0059	0.0031
0.0003	0.0034	0.0013	0.0004	0.0062	0.0030

Table VI shows results on liquid egg held frozen for some months. No apparent increase of loosely bound nitrogen is indicated in edible eggs held hard-frozen for 9 mos. If the eggs are held in the shell for that length of time at slightly above freezing, a gradual increase does take place, however. This is well shown in Table VII.

TABLE VI—LIQUID EGG HELD FROZEN

When Put in Freezer Per cent N	Months Held Frozen	After Coming from Freezer Per cent N
0.0026	3	0.0025
0.0030	3	0.0031
0.0024	9	0.0026
0.0022	9	0.0024
0.0025	9	0.0025

TABLE VII—CASE EGGS HELD IN STORAGE—"JUNE FIRSTS"
(Eggs in each sample—2 dozen—about 1 kg.)

Months	Per cent N
0	0.0013
1	0.0011
2	0.0022
3	0.0021
4	0.0028
5	0.0032
6	0.0032
7	0.0030
8	0.0035
9	0.0040

MICROCHEMICAL METHOD

The principle of this method is the same as for the titration method, but in operating, scrupulous cleanliness is compulsory for even minute amounts of ammonium salts in apparatus or reagents will, of course, invalidate the results.

Five cubic centimeters of liquid egg are placed in a 250 cc. Erlenmeyer flask and 45 cc. of phosphotungstic acid solution (made up in the ratio of 10 cc. of 1 per cent sulfuric acid, 20 cc. of 20 per cent phosphotungstic acid, and 420 cc. of water) added. Shake well, and let stand 5 min.; then filter through an ammonia-free folded filter.[1]

Ten cubic centimeters of the phosphotungstic acid filtrate are transferred to the large test tube D, shown in Fig. II; 1 cc. of 10 per cent sodium hydroxide and 2 drops of heavy white paraffin oil are added, then the solution is aerated as fast as possible into 2.5 cc. of 1 per cent sulfuric acid for one-half hour.

The dispersion tube is rinsed into the collector with ammonia-free water, 1 cc. of Nessler-Winkler solution added, and the volume then made up to 10 cc. with water. Comparison is made with pure standard ammonium sulfate solution in a Duboscq or Schreiner colorimeter.

Directions for making pure ammonium sulfate may be found in the article by Folin and Farmer previously referred to, and for Nessler-Winkler solution in *Chem. Zentr.*, **11** (1899), 320, or "Analytical Chemistry," Treadwell-Hall, I, 46. Ammonia-free water is prepared for use by the method of J. Barnes,[1] in which the water is boiled with enough bromine to color it. Before using, test with starch-potassium iodide solution to be sure all bromine has boiled off.

A comparison of results by the colorimetric and titration methods is given in Table VIII. They show that with very minute amounts of ammonia the colorimetric figures are a little high, but when dealing with amounts of ammonia (expressed as nitrogen) ranging from 0.0020 to 0.0040 per cent (0.02 to 0.04 mg.) the agreement is good. If possible, it is well to use aliquots of the egg filtrate which will bring the amount of ammonia within these limits. When dealing with bad eggs there is often so much ammonia present that a heavy brick-red precipitate forms on adding the Nessler solution. This may be overcome by adding just enough 5 per cent acetic acid to dissolve it, diluting to about 45 cc., again nesslerizing and making up to 50 cc. Of course it is necessary to make a corresponding change in the calculation.

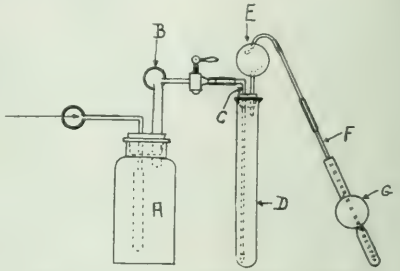


FIG. II—APPARATUS FOR MICROCHEMICAL METHOD

A—Acid wash bottles.

B—Air pipe leading from A, to which aeration tubes are attached.

C—Dispersion tube reaching to within 1/4 in. of the bottom of the large test tube D.

D—Large test tube for holding sample—10 in. high by 1 1/8 in. inside diameter.

E—Trap.

F—Dispersion tube for complete absorption. Tubes C and F are made according to the directions of Folin and Farmer referred to in the preceding method.

G—Special form of test-tube for catching ammonia without splashing liquid out of the tube. Its dimensions are—height, 6 1/2 in., inside diameter 5/8 in., diameter of bulb 1 3/4 in. A mark is placed on the constriction at the 10 cc. point.

A 1/4 h. p. motor is used to drive the air pump.

TABLE VIII—COMPARISON OF RESULTS BY COLOR AND TITRATION

White		Yolk		Whole Egg	
Per cent N by Color	Per cent N by Titration	Per cent N by Color	Per cent N by Titration	Per cent N by Color	Per cent N by Titration
0.0010	0.0005	0.0033	0.0029	0.0018	0.0013
0.0009	0.0004	0.0030	0.0031	0.0016	0.0013
0.0010	0.0003	0.0030	0.0028	0.0017	0.0011
0.0009	0.0004	0.0031	0.0031	0.0016	0.0012
0.0010	0.0005	0.0028	0.0034	0.0016	0.0014

Table IX shows the results obtained when sodium hydroxide, potassium carbonate and a mixture of potassium carbonate and potassium oxalate are used in the colorimetric method as reagents for making alkaline before aeration. It will be seen that there is no difference which is not within the limit of experimental error.

[1] Test filter papers by soaking a packet of them in ammonia free water. If a portion of this water shows much ammonia when nesslerized, the water is poured off and allowed to drain from the filter papers. The soaking and testing are repeated until the ammonia is removed; the papers are then dried.

[1] *J. Soc. Chem. Ind.*, **15** (1896), 254.

TABLE IX—COMPARISON OF K_2CO_3, NaOH AND A MIXTURE OF K_2CO_3 AND $K_2C_2O_4$ IN THE COLORIMETRIC METHOD

SAMPLE No.	1 Cc. of 10 Per cent NaOH	4 Drops of (8 Per cent K_2CO_3 + 12 Per cent $K_2C_2O_4$ in Equal Parts)	3 Drops of 5 Per cent K_2CO_3
1	0.0024	0.0022	0.0025
2	0.0023	0.0025	0.0021
3	0.0021	0.0026	0.0018
4	0.0027	0.0025	0.0025
5	0.0026	0.0025	0.0027
6	0.0026	0.0026	0.0026

SUMMARY

I—Titration and colorimetric methods for the determination of the small amounts of loosely bound nitrogen in liquid eggs by aerating the alkaline material (according to the principle of Folin) have been presented, with descriptions of the apparatus and precautions necessary.

II—The effect of various agents used to make the material alkaline, some results on different grades of eggs, and a comparison of results obtained by both methods are shown in the tables.

FOOD RESEARCH LABORATORY
BUREAU OF CHEMISTRY
PHILADELPHIA, PA.

A METHOD FOR THE DETECTION OF FOREIGN FATS IN BUTTER FAT

By ARMIN SEIDENBERG
Received May 22, 1918

The methods at present available for the detection of foreign fats in butter fat are such that in many cases considerable difficulty is experienced in definitely ascertaining the addition of limited quantities. The constant which has been found to be of most significance in the analysis of butter fat is the Reichert-Meissl number. This constant is dependent upon the soluble volatile acids which are particularly characteristic of butter fat. While the other constants which are usually depended upon in determining the purity of fats and oils, such as the specific gravity, refractive index, melting point, saponification number, iodine number, etc., have in the case of butter fat well-defined limits, sufficiently distinct to permit the identification of an unadulterated butter fat, they nevertheless in many instances lie so close to those of other fats that considerable quantities of these can be added to a butter fat without thereby transgressing the limits for a known pure sample.

THE REICHERT-MEISSL NUMBER

Among the more commonly known edible fats and oils none has a Reichert-Meissl number that approaches the minimum and maximum limits of this constant for butter fat. These range according to the numerous authorities cited by Lewkowitsch[1]* from 17 to 36.3. According to Sherman[2] the usual variations in the Reichert-Meissl value for butter fat are between 24 and 34; cocoanut oil, with a Reichert-Meissl number of 6 to 8, has the next highest value among the more widely used edible fats and oils, while the other edible fats and oils usually have numbers below 1. According to Lewkowitsch[3] the lowest Reichert-Meissl value adopted by analysts in various countries, although not officially, lies between 23 and 25. He states that values need not fall below this in a legitimate sample of butter fat if proper precautions in feeding, etc., are taken. In view of the fact, however, that a large number of undoubtedly pure samples of butter fat have been observed with Reichert-Meissl values below these, it is evident that no butter can be adjudged legally adulterated unless its constants are all decidedly below the lowest observed limits of a pure sample.

The wide variation of the Reichert-Meissl number makes it feasible to add considerable quantities of foreign fats to a butter with a high value without thereby causing it to fall below the lower limit. The problem is further complicated according to Lewkowitsch[4] by the fact that glycerides or ethers of the volatile fatty acids such as tributyrin or amyl acetate may be added to an adulterated butter fat in order to raise its Reichert-Meissl value. He states that even without counteracting the effects of sophistication by this means it is not possible to detect in every case the presence of 10 or even 20 per cent of a foreign fat in butter fat by means of the Reichert-Meissl value. Indeed, it is quite evident that on a butter having a Reichert-Meissl value of 33 or above, adulteration to the extent of 25 and 30 per cent may be practiced without lowering the value below the lowest observed limits. Thus the writer found on adding 30 per cent of tallow to a butter fat having a Reichert-Meissl number of 33.9 that the value was decreased to only 24.7. The refractive index of the sample containing the 30 per cent added tallow was 1.4588, which is still within the limits that have been observed for a pure sample. None of the other constants usually determined would be affected to a greater extent. Methods depending upon determining the amount of stearic acid present are likely to prove uncertain, particularly in view of the varying amounts of this acid found in butter fat by different observers.

COMPOSITION OF BUTTER FAT

The constants of any fat or oil are of course dependent upon the glycerides which it contains and upon the fatty acids which constitute these glycerides. The fatty acids generally considered to be present in butter fat are butyric, caproic, caprylic, capric, lauric, myristic, palmitic, and stearic. The comparatively large amount of the lower soluble volatile fatty acids are peculiarly characteristic of butter fat and it is upon these that the Reichert-Meissl number depends. Their amount in proportion to the other fatty acids is, however, not very large. According to Browne the total amount of butyric and caproic acids present in butter fat is 7.54 per cent. Duclaux[6] found butter fat to contain 2 to 2.26 per cent caproic acid and 3.37 to 3.65 per cent butyric acid. Browne states the amount of oleic acid to be 32.50 per cent, of palmitic acid 38.61 per cent, and of stearic acid 1.83 per cent. According to a large number of butters of varied composition examined by Siegfeld[7] the volatile soluble acids range from 5.60 to 7.09 per cent, the volatile insoluble acids from 0.95 to 3.28 per cent, the saturated nonvolatile acids from 40.65

* Numbers refer to corresponding numbers in "References," p. 621.

to 52.01 per cent, and the unsaturated acid from 32.19 to 46.07 per cent. In a former investigation he had found the oleic acid to vary between 23.53 and 53.28 per cent. Hehner and Mitchell[8] using an alcohol saturated at 0° C. with stearic acid came to the conclusion that butter did not contain any or only very small amounts of stearic acid. However, Holland, Reed, and Buckley[9] secured considerable amounts of stearic acid from butter fat, namely, from 7 to 22 per cent of the insoluble fatty acids present. There are not many references in the literature with respect to the glycerides formed by these acids. In only a few instances have any attempts been made to isolate them. Amberger[10] succeeded in isolating tristearin and palmito-distearin from butter fat although in such slight amounts that he was not capable of forming any conclusions as to the actual quantities of these glycerides present. However, in view of the comparatively small amount of stearic acids found to be present in butter fat by other investigators, the quantity of these glycerides must be comparatively slight.

GENERAL DISCUSSION

From these facts the assumption seems fairly well justified that butter fat does not contain any considerable amount of glycerides consisting entirely of the higher saturated and less soluble fatty acids. The absence of any very large amount of tripalmitin is indicated by the conclusion arrived at by many investigators such as Bell[11] and others that the largest part of the glycerides in butter fat consists mainly of mixed glycerides. It is evident that the comparatively small amount of insoluble glycerides which seems to be present in butter fat may be sufficiently characteristic to form the basis of a method for detecting the addition of other fats and oils containing larger proportions of the insoluble glycerides. With this idea in mind Amberger[12] undertook to develop a method for detecting lard and tallow in butter fat. The method consisted in dissolving 20 g. of sample in ether to 65 cc. and allowing to stand at 15° to 18° C. for 24 hrs. In this way he found that from pure butters, crystals weighing 0.009 to 0.4 g. separated out while butters containing 15 per cent tallow gave residues between 0.63 and 1.45 g. and those containing 15 per cent lard gave residues between 0.11 and 0.40 g. In a later paper[13] he added to 31 g. of sample, ether to a combined volume of 100 cc. and allowed it to stand for 1 hr. and then shook the solution. After another hour the solution was again shaken and if it contained no deposit or only a trace the sample was shown to be pure butter or to contain less than 12 per cent of tallow. If a deposit is formed it is filtered off and weighed. The addition of 15 per cent tallow to butter fat can be definitely detected by this method. Hydrogenated fats can also be detected when the iodine number has been reduced to less than one-half.

DISCUSSION OF PROPOSED METHOD

In a previous paper[14] the writer outlined a method for fractionating fats and oils. The method consists essentially in dissolving the fat or oil in two or more solvents, one or more of which has the greater solvent action upon one or more groups of glycerides and is at the same time more volatile. This more volatile solvent is then removed by aspirating air through the solution, the removal of the solvent being accompanied by a very slow and finely graded lowering of temperature and by a very thorough agitation of the solution. In this way a progressive condition of insolubility is attained with the greatest possible refinement, making it possible to distinguish to some extent between the nearly placed points of comparative insolubility of the more nearly related glycerides. It is possible to accomplish by this method a separation of the glycerides into fairly well defined groups. The writer pointed out in this paper how this method might be applied to detect the addition to butter fat of a foreign fat containing larger amounts of the less soluble glycerides. In view of the previous experience it was evident that the absolute quantitative isolation of the pure glycerides of the higher saturated fatty acids could only be accomplished after making numerous fractionations. It was therefore determined to undertake to secure a series of empirical constants, developed under well defined conditions and which would serve to distinguish between a pure and an adulterated butter.

As on the previous occasion, it was found that a mixture of alcohol and ether offered the most favorable medium in which to dissolve the fat. The ether has great solvent action on all the possible glycerides of butter fat, this action decreasing, however, particularly with respect to the stearates and palmitates, with decreasing temperature, and the alcohol is readily miscible with ether and also has slight but at the same time selective solvent action on the glycerides of butter fat. The solvent action of alcohol on most fats and oils according to Vandervelde[15] amounts to only 2 per cent. It is, however, greatest on those containing the glycerides of the lower fatty acids or of the unsaturated fatty acids.

In the course of the experimental work it developed that in order to get significant results the conditions of operating the method would need to be exactly defined and standardized. It was found that the conditions which were most important were the quantity of sample, quantity and proportion of solvents, speed of suction, and temperature of suction. In order to determine in what way these conditions could be combined to give the most satisfactory results, considerable preliminary work was necessary. All the results obtained refer to 10 g. of sample dissolved in ether-alcohol to a total volume of 96 cc. While other amounts were tried these seemed to give the most favorable results and further experimental work was confined to these quantities. The suctions were carried on in a 150 cc. graduated cylinder. The temperature was in each case controlled so as not to fall below the points indicated. In the preliminary series of determinations no time observations were taken and no attempt made to keep the speed of the suction at a uniform rate. To this may be ascribed a lack of uni-

formity observed between some of the results. It was therefore deemed necessary so to conduct the process as to proceed within a specified time limit. It will be noticed that by observing this condition quite satisfactory agreements were secured.

From a consideration of the preliminary results it was seen that the proportion of 90 parts ether to 10 parts absolute alcohol with the temperature regulated between 10° and 15° C. seemed most favorable, both because it indicated most sharply the addition of fats, such as lard and tallow, containing the more insoluble glycerides, and also because it indicated the presence of oleomargarine containing in this case a lesser proportion than butter fat of the more insoluble glycerides. Oleomargarine is usually made from a fat such as tallow deprived of most of its content of glycerides of the higher fatty acids. It therefore consists mainly of the more soluble oleates and has a larger proportion of these than butter fat. For this reason a butter fat containing oleomargarine comes down at a lower point than when pure; of course this depends largely upon the type of oleomargarine used.

OUTLINE OF PROPOSED METHOD

In order to get comparable results it is necessary to adhere with the utmost precision to the method as adopted. For the suction a 150 cc. graduated cylinder 27.0 cm. high and 3.1 cm. in diameter is used. This should be attached to a firm ringstand so that its bottom is about 15 cm. above the table upon which the stand rests. The cylinder (see illustration) is securely closed with a rubber stopper through which pass a thermometer 0.6 cm. in diameter and two pieces of glass tubing each approximately 0.5 cm. in diameter. The one glass tubing that enters the liquid should almost reach the bottom of the cylinder while the bottom of the thermometer should reach some point below 45 cc. Ten grams of the sample are weighed out into a beaker and carefully washed into the cylinder with a mixture made up by adding to 90 cc. ethyl ether an amount of absolute alcohol to bring the total volume up to 100 cc. The solution of fat in this ether-alcohol mixture is brought to a total volume of 96 cc. When the thermometer and glass tubing are immersed in this solution it should reach a point between the 100 and 102 cc. marks on the cylinder, the level of the solution being adjusted by raising or lowering the thermometer. The suction is so conducted that the air first passes through some 95 per cent alcohol in another flask. The speed of suction should be so regulated that it will take about 10 min., not more than 12 and not less than 8 min., to reduce the level of the liquid to the 60 cc. mark on the cylinder. The temperature of the solution should be controlled, after it has been lowered to 15° C. in the course of the suction, so that it is maintained as near as possible to 12.5° C. throughout the process. It should after this never fall below 10° C. or rise above 15° C. This temperature control is accomplished by raising and lowering a beaker containing water at 40° to 50° C. so as to immerse the lower part of the cylinder.

The designation "turbid" may be defined when applied to the present method as that point at which the liquid becomes opaque to the extent of making it impossible to view through it a pencil or other

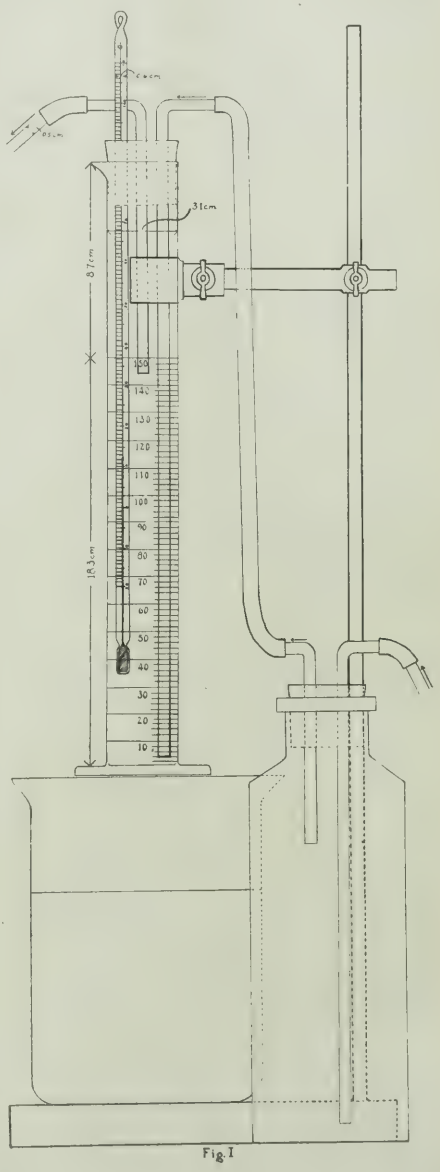


Fig. 1

object held upon the opposite side of the cylinder. The liquid usually begins to become slightly turbid 3 to 4 cc. before this point is gradually reached. The suction is continued until the liquid becomes turbid,

and the point noted. If this is above 60 cc. the suction is carried on until the level of the liquid is reduced to 60 cc. and the liquid then filtered through a perforated Gooch 2.5 cm. in diameter, using a circular piece of filter paper. This paper should be moistened with a little alcohol and fit securely into the Gooch so that none of the precipitate can pass through. The filtration should be rapid and the filtrate clear. When all the liquid possible has been drawn off from the residue the paper is removed and the residue carefully detached from it with a keen-edged spatula, care being taken not to include any fibers from the paper. The amount of this residue is then determined after the solvent still adhering to it has been evaporated off in an oven.

It may be well again to emphasize at this point the necessity of maintaining with the greatest exactness the conditions outlined above in order to get concordant results. Another precaution which it is desired to point out here is the importance of mixing the sample well before using. On numerous occasions the writer has made the observation that the higher melting point of glycerides, on solidifying first, settle to the bottom. On again warming, these glycerides liquefy so that seemingly the sample has become completely homogeneous. Another factor that may well lead to error are the changes produced in butter fat due to heating it at too high a temperature. Butter fats that have been affected in this way, indicated usually by a slight darkening, become turbid at an abnormally high point, caused probably by the oxidation of the oleates.

SUMMARY OF RESULTS

In order to determine the limits of variation for a pure butter fat by this method, constants were secured from 100 samples of butter of known purity. The results are given in Table I. Nos. 1 to 10, inclusive, were butters secured from a particularly pure source and which there is every reason to believe were unadulterated. Their Reichert-Meissl numbers were determined and found to be normal in every case. Nos. 11 to 16, inclusive, were derived from creams also secured from a very satisfactory source and which there was every reason to assume were unadulterated. Nos. 17 to 100, inclusive, were derived from cream samples brought to this laboratory by inspectors of the department for the ordinary routine determination of fat content. The constants for turbidity secured from all of these samples show a very satisfactory concordance, which may be taken as an additional confirmation of the purity of the samples. In Table II these results are summarized. This shows that the great majority of the turbidity values, namely 94 out of a total of 100, range between 50 and 60 cc. inclusive. The extreme limits observed were 64 cc. and 48 cc. Some additional allowance may be made at each of these points to constitute a doubtful zone and the maximum and minimum turbidity limits for a pure butter placed at 44 cc. and 68 cc., respectively. In only 4 cases did a turbidity occur above 60 cc. The maximum residue secured was 0.449 g.

TABLE I—CONSTANTS OF PURE BUTTER FAT (100 PER CENT)

No.	Tur. Point	No.	Tur. Point	No.	Tur. Point	No.	Tur. Point	No.	Tur. Point
1(*a*)	62	21	54	41	56	61	57	81	58
2	...	22	57	42	59	62	57	82	60
3	54	23	51	43	54	63	55	83	60
4	56	24	53	44(*d*)	62	64	57	84	58
5	57	25	58	45	60	65	58	85	56
6	57	26	55	46	60	66	56	86	58
7	55	27	60	47	59	67	54	87	52
8	54	28	58	48	55	68	53	88	58
9	58	29	54	49	53	69	58	89	60
10	58	30	54	50	55	70	59	90	59
11	60	31	58	51	56	71	59	91	58
12	56	32	54	52	56	72	60	92	60
13	54	33	48	53	57	73	58	93	57
14	48	34	54	54	57	74	60	94	57
15	58	35	51	55	57	75	59	95	55
16	50	36	55	56	57	76	60	96	54
17	57	37(*c*)	64	57	56	77	56	97	55
18(*b*)	62	38	54	58	57	78	56	98	52
19	57	39	56	59	54	79	57	99	55
20	58	40	58	60	57	80	60	100	54
								101	56

(*a*) Residue = 0.311 g. (*b*) Residue = 0.248 g.
(*c*) Residue = 0.449 g. (*d*) Residue = 0.150 g.

TABLE II—SUMMARY OF RESULTS OF TABLE I

Turbidity Point	Number of Samples	
48	2	
50	1	
51	2	
52	2	
53	3	
54	14	
55	9	94
56	12	
57	17	
58	16	
59	6	
60	12	
62	3	
64	1	

Table III shows the effect of the addition to butter fat of varying amounts of tallow, lard, oleomargarine, and hydrogenated fat. While for tallow, oleomargarine, and the same hydrogenated fat, and also to a lesser extent for lard, there is a fair conformity between the turbidity points and the per cent of added fat, such is not the case with respect to the residues. These show very considerable variations even within the same percentage of any given added fat, particularly, however, for lard. The cause for this does not seem clear to the writer. However, the same effect can be noted in Amberger's[16] results and indicates the advantage of using the turbidity points instead of the amount of residue as a standard. In a number of cases the melting points of the residues were determined and found to vary between 50° and 55° C. No distinction could be noted in the melting points of the residues secured from samples containing different foreign fats. However, the quantity of the residue may be determined as a confirmatory test. If it should amount to above 0.5 g., it would serve in connection with a high turbidity point (above 68 cc.) to show the addition of a foreign fat such as ether tallow or highly hydrogenated fat.

From the table it will be seen that 10 per cent or above of added tallow can be detected in every case by this method. The results for lard vary considerably. The addition of 25 and 30 per cent of this can be detected with certainty in every instance investigated; the detection of 10, 15, and 20 per cent additions is, however, in some cases doubtful. The results for the oleomargarine given in the table show that the addition of 20 per cent did not influence the turbidity point sufficiently to assure its detection. It was,

TABLE III—SHOWING THE EFFECT OF ADDED FOREIGN FATS

Sample No.	1		2		3		4		5		6		7		8		9		10	
Foreign Fat, %	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc	Res. G	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.
Tallow																				
5	73	0.454	66	0.485	64	0.150	64	0.374	64	0.198	62	0.325	64	0.489	62	0.434	64	0.558	73	0.584
10	..	...	..	...	70	0.456	70	0.541	69	0.467	73	0.586	71	0.859	71	0.663	71	0.780	..	...
15	76	1.025	75	0.746	..	...	..	...	..	...	..	...	..	...	..	...	..	...	77	0.568
20	..	...	..	...	..	...	..	...	..	...	81	0.846	80	0.774	79	0.696	80	1.065	..	...
25	80	0.917	82	0.885	..	...	..	...	..	...	..	...	..	...	..	...	..	...	82	0.951
30	..	...	..	...	79	0.906	85	0.914	82	0.993	..	...	..	...	..	...	..	...	..	...
Lard No. 1																				
10	..	...	..	...	..	...	..	...	..	...	72	0.358	64	0.439	65	0.470	66	0.629	..	...
15	70	0.719	66	0.377	..	...	..	...	..	...	72	0.507	65	0.199	68	0.375	65	0.482	70	..*
20	..	...	..	...	65	0.360	70	0.433	70	0.193	..	...	..	...	..	...	..	...	..	...
25	71	0.748	72	0.335	..	...	..	...	..	...	68	0.560	67	0.636	73	0.552	72	0.530	..	...
30	72	0.541	71	0.407	73	0.395	74	0.400	71	0.190	70	0.280	72	0.497	70	0.493	70	...*	76	0.571
Lard No. 2																				
30	..	...	..	...	..	...	71	0.280	72	0.497	70	0.497	70	0.426	..	...	..	...	..	...
Oleo. 56																				
20	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...	54	...
25	..	...	..	...	42	...	41	...	44	...	44	...	..	...	..	...	..	...	..	...
30	42	...	42	...	43	...	40	...	42	...	40	...	42	...	40	...	42	...	43	...
35	..	...	..	...	..	...	..	...	42	...	..	...	..	...	..	...	..	...	..	...
40	..	...	..	...	40	...	..	...	..	...	..	...	..	...	..	...	..	...	..	...

Sample No.	18		19		17		17		20		21		21	22
Foreign Fat, % Hyd. Fat No. 2	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Foreign Fat, % Hyd. Fat No. 1	Tur. Cc.	Res. G.	Tur. Cc.	Res. G.	Tur. Cc.	Res. G,	Foreign Fat, % Hyd. Fat No. 3	Tur. Cc.	Foreign Fat, % Coconut Oil Stearin	Tur. Cc.	Tur. Cc.
5	66	0.350	..	...	5	73	1.220	75	1.280	..	...	20	59	20	..	..
10	77	0.630	73	0.674	10	..	...	..	...	78	1.469	25	..	25	45	..
10	..	...	..	...	10	82	1.374	..	...	..	...	30	50	30	40	..
15	..	...	79	0.766	15	..	...	..	...	86	2.228	30	..	..	..	40
25	82	1.860	..	...	25	..	...	..	...	91	3.530	..	..	..	..	..

100 per cent	Tur. Cc.	Res. G.
Oleo	34	...
Lard	84	0.782
Tallow	83	2.060
Hyd. Fat No. 1	73	...
Hyd. Fat No. 2	86	3.289
*Hyd. Fat No. 3	..	...
Coconut Oil Stearin	28	...

however, possible to notice the addition of this fat in quantities of 25 and 30 per cent and above with certainty. Oleomargarine, as has already been pointed out, may be of varying constitution dependent upon the source from which it is derived. The results are influenced accordingly. It was for this reason not possible to detect the addition of another sample of oleomargarine evidently containing larger proportions of the less soluble glycerides even in quantities of 25 and 30 per cent. It will be noticed that the results for the different hydrogenated fats vary considerably. The iodine numbers of these fats were determined and found to be as follows: No. 1, 73.4; No. 2, 34.5; and No. 3, 3.4. In No. 1, having a higher iodine number, the amount of unsaturated oleates is high, while the amount of the saturated and less soluble glycerides is comparatively small, so that these latter do not raise the turbidity point of butter fat sufficiently to serve for their detection. The effect of the saturated glycerides produced by the hydrogenation is also seen in a comparison of the results between hydrogenated fats No. 2 and 3 given in the table. In the case of No. 3, having an iodine number of 3.4, the addition of even 5 per cent can be detected with certainty, while No. 2, which has an iodine number of 34.5, can be detected in quantities of 10 per cent or above. Where the iodine number of a hydrogenated fat is high, as in the case of No. 1, so that its addition cannot be detected by the suction method, the determination of this value in a suspected sample of butter fat would in many cases give evidence of the presence of the added fat.

The table also shows the effect of the addition of a sample of coconut oil stearin to butter fat. The effect of this fat also may vary with the constitution of different samples. The results for 100 per cent of the various fats used illustrate to what extent the effect produced is due to their insoluble glycerides.

REFERENCES

1—"Oils, Fats, and Waxes," 5th Ed., Vol. II, p. 823.
2—"Organic Analysis," Rev. Ed., p. 191.
3—"Oils, Fats and Waxes," 5th Ed., Vol. II, p. 825.
4—*Ibid.*, p. 816.
5—*J. Am. Chem. Soc.*, 21 (1899), 823.
6—*Compt. rend.*, 102 (1886), 1022.
7—*Z. Nahr. Genussm.*, 24 (1912), 457.
8—*J. Am. Chem. Soc.*, 29 (1907), 32.
9—*J. Agr. Res.*, 6 (1916), No. 3, 101.
10—*Z. Nahr. Genussm.*, 26 (1914), 2, 65.
11—"The Chemistry of Foods," Vol. II, 14.
12—*Ibid.*
13—*Chem. Abs.*, 11 (1917), 1695.
14—THIS JOURNAL, 9 (1917), 855.
15—*Bull. soc. chim. belg.*, 25 (1911), 210.
16—*Ibid.*

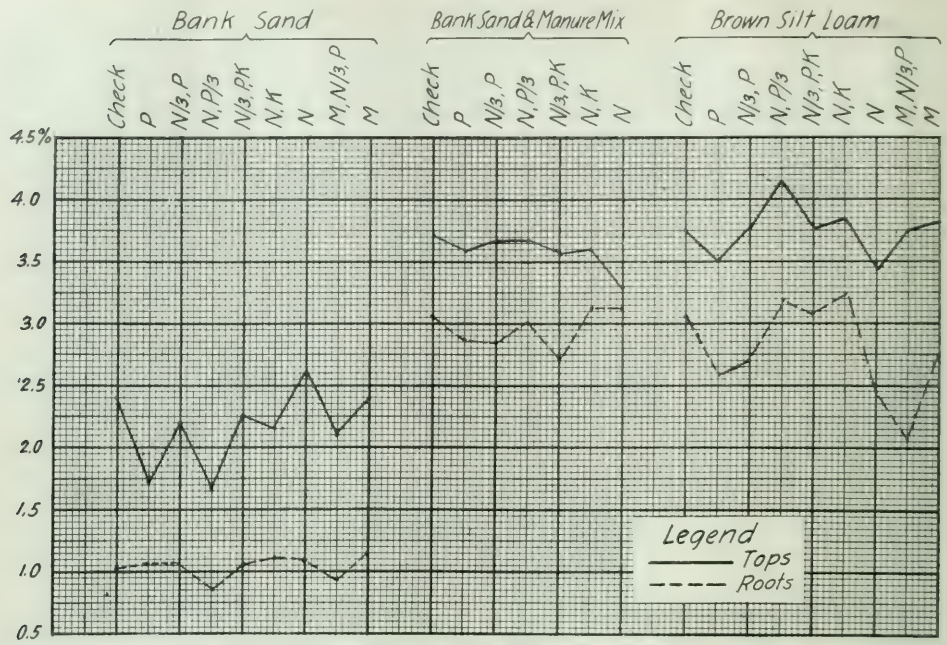
CHEMICAL LABORATORY
DEPARTMENT OF HEALTH
CITY OF NEW YORK

COMPARISON OF PERCENTAGES OF NITROGEN IN TOPS AND ROOTS OF HEAD LETTUCE PLANTS

By H. A. Noyes

Received March 27, 1918

In the investigations of the growth of head lettuce in the greenhouse being conducted by the horticultural department of the Purdue University Agricultural Experiment Station, it has been found that the plants grown on different soils and on the same soil with different fertilizer treatments vary considerably in their nitrogen content. The reports of analyses of the same species of plants show that the analyses of a species are not constant but the variations found



GRAPH 1—NITROGEN CONTENT OF TOPS AND ROOTS OF HEAD LETTUCE PLANT

in the preliminary investigation here reported were so large that we are endeavoring at present to ascertain the optimum analysis for the head lettuce plant.

SOILS USED AND FERTILIZER TREATMENTS GIVEN

1—Bank sand containing very little available plant food.

2—A mixture of bank sand and partially rotted horse manure at the rate of 3 bu. of sand to 2 bu. of manure.

3—A brown silt loam which produces good crops in the field.

The fertilizer materials used were partially rotted horse manure, nitrate of soda ($NaNO_3$), acid phosphate, and muriate of potash (KCl).

The following table gives the specific treatments given the individual plots:

TABLE I

ABBREVIATION	TREATMENT
Check	Nothing
P	Acid phosphate at rate of 400 lbs. per acre
N/3, P	Sodium nitrate at rate of 133 lbs. and acid phosphate at rate of 400 lbs. per acre
N, P/3	Sodium nitrate at rate of 400 lbs. and acid phosphate at rate of 133 lbs. per acre
N/3, P, K	Sodium nitrate at rate of 133 lbs., acid phosphate at rate of 400 lbs. and muriate of potash at rate of 200 lbs. per acre
N, K	Sodium nitrate at rate of 400 lbs. and muriate of potash at rate of 200 lbs. per acre
N	Sodium nitrate at rate of 400 lbs. per acre
M, N/3, P	Manure at rate of 20 tons, nitrate of soda at rate of 133 lbs., and acid phosphate at rate of 400 lbs. per acre
M	Manure at rate of 20 tons per acre

The treatments given in the table were run on all three soils, the only exception being that no manure plots were run on the sand and manure mixture.

VARIETY OF LETTUCE USED AND PERIOD OF GROWTH

The variety of lettuce grown was May King. The plants were started in flats and transferred to the greenhouse plots when about 3 in. in diameter. The plots were harvested 10 weeks after setting in the greenhouse when it appeared that they had matured as much as they would under the treatments given.

SELECTION OF PLANTS FOR ANALYSIS AND THEIR PREPARATION FOR ANALYSIS

Each plant was cut and weighed individually. Those two plants which weighed nearest the average weight for all the plants of each plot were selected for the moisture and nitrogen determinations. The roots of these two average plants were taken out, washed, dried, and prepared for analysis.

The plants and roots were dried in bags hung just over, but not touching, steam radiators. The air-dry samples were ground to pass a sieve having holes 0.75 mm. in diameter.

The nitrogen determinations were made according to the regular Kjeldahl method. The ammonia was collected in $N/5$ acid and titrated with $N/10$ sodium hydroxide and methyl red as an indicator.

Table II gives the crop and nitrogen results, and Graph 1 shows the nitrogen content of the roots and tops by soils and fertilizer treatments.

Table II brings out the following:

(A) IN CONNECTION WITH THE AVERAGE WEIGHT OF THE PLANTS GROWN ON THE DIFFERENT PLOTS 1.—The brown silt loam grew the largest plants.

2—The different fertilizer treatments gave effects varying with the soil.

(B) IN CONNECTION WITH THE MOISTURE CONTENT OF THE PLANTS 1.—The greatest variation in moisture obtained was between 93.1 per cent on the brown silt loam with the manure treatment and 89.4 per cent on the bank sand with nitrogen and potassium treatment.

2—The extreme variation in moisture on the bank sand series was approximately three times that in the silt loam series which in turn was one-half that in the sand and manure series.

TABLE II—CROP AND NITROGEN RESULTS

Treatment	Average green wt. per plant Tops Grams	Water in plants Tops Per cent	Nitrogen in air-dry plants Tops Per cent	Nitrogen in air-dry plants Roots Per cent	Ratio of per cent N in roots to per cent N in tops
Bank Sand					
Check	56	89.5	2.40	1.02	100 to 235
P	58	89.5	1.72	1.05	100 to 164
N/3, P	64	90.6	2.17	1.05	100 to 207
N, P/3	59	90.3	1.65	0.84	100 to 196
N/3, P, K	59	90.3	2.25	1.06	100 to 212
N, K	63	89.4	2.17	1.12	100 to 194
N	74	90.6	2.60	1.10	100 to 236
M, N/3, P	87	92.4	2.09	0.94	100 to 222
M	84	91.8	2.39	1.18	100 to 203
Average	67	90.5	2.16	1.04	100 to 208
Variation	31	3.0	0.95	0.34	72
Bank Sand and Manure Mixture					
Check	75	89.7	3.68	3.05	100 to 121
P	112	90.9	3.59	2.87	100 to 125
N/3, P	111	91.9	3.65	2.86	100 to 127
P, N/3	75	91.4	3.66	3.00	100 to 122
N/3, P, K	71	91.1	3.58	2.72	100 to 132
N, K	75	90.8	3.61	3.13	100 to 115
N	58	90.7	3.27	3.13	100 to 105
Average	82	90.9	3.58	2.97	100 to 121
Variation	54	2.2	0.41	0.41	27
Brown Silt Loam					
Check	129	92.4	3.73	3.05	100 to 122
P	108	92.0	3.50	2.61	100 to 134
N/3, P	114	92.2	3.77	2.70	100 to 139
N, P/3	112	92.5	4.12	3.21	100 to 128
N/3, P, K	114	92.6	3.78	3.11	100 to 122
N, K	118	92.5	3.83	3.22	100 to 119
N	130	92.6	3.46	2.46	100 to 141
M, N/3, P	153	92.8	3.75	2.06	100 to 182
M	146	93.1	3.85	2.75	100 to 140
Average	125	92.5	3.75	2.76	100 to 136
Variation	45	1.1	0.66	1.16	63

(C) IN CONNECTION WITH THE NITROGEN CONTENT OF THE PLANT (TOP) 1.—The lowest average nitrogen content was obtained on the bank sand series, namely, 2.16 per cent, and the highest was obtained on the brown silt loam series, namely, 3.75 per cent.

2—The fertilizer treatments varied the nitrogen content most on the bank sand which was lowest in plant food content and least on the bank sand and manure mixture which was highest in plant food content.

3—Phosphorus by itself lowered the nitrogen content of the plants on all three soils.

4—Nitrogen by itself increased the nitrogen content of the plants grown in the bank sand but decreased the nitrogen content when used on the other two soils.

5—The effects of the phosphorus and nitrogen when used jointly were different for each of the three soils.

6—The soil had a greater effect on the nitrogen content of the plants (tops) than the fertilizer treatment did.

(D) IN CONNECTION WITH THE NITROGEN CONTENT OF THE ROOTS 1.—The lowest average per cent nitrogen of roots was obtained in the bank sand series, namely, 1.04 per cent, and the highest was obtained in the sand and manure mixture series, namely, 2.97 per cent.

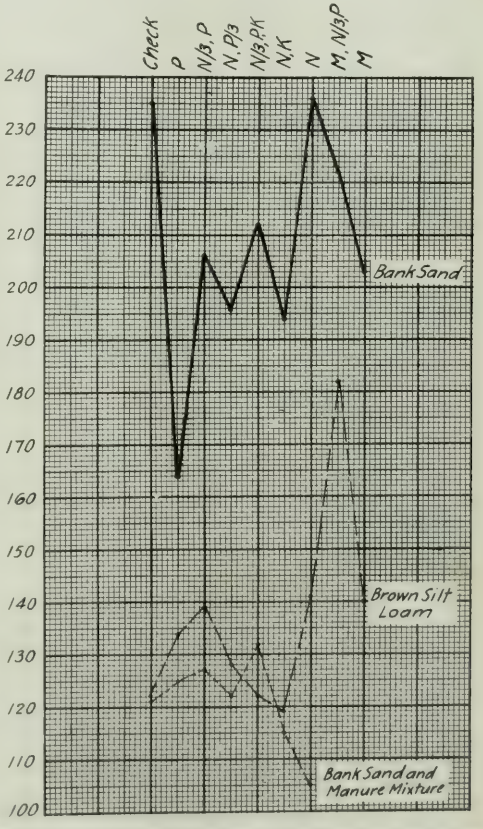
2—The fertilizer treatments varied the per cent nitrogen of the roots most in the brown silt loam series and least in the bank sand series.

3—Phosphorus by itself lowered the nitrogen content of the roots in the brown silt loam and sand and manure series but raised it slightly in the bank sand series.

4—Nitrogen alone raised the nitrogen content of the roots on the bank sand and the sand and manure series but lowered it considerably on the brown silt loam series.

5—The effects of the nitrogen and phosphorus when used jointly were different for each of the three soils.

6—The soil had a greater effect on the nitrogen content of the roots than the fertilizer treatments did.



GRAPH 2—THE NITROGEN COMPOSITION OF THE TOPS COMPARED TO THE NITROGEN CONTENT OF THE ROOTS (NITROGEN COMPOSITION OF ROOTS TAKEN AS 100)

COMPARISON OF NITROGEN IN TOPS AND ROOTS

Graph 2 gives the ratio of the nitrogen in the roots to that in the tops and shows the wide variation in the nitrogen content of the tops in relation to that in the roots.

1—In the bank sand series the nitrogen in the tops averages a little over twice that in the roots. On 6 out of the 9 plots there was over twice the per cent of nitrogen in the tops that there was in the roots. The 3 plots on which the nitrogen in the tops is far removed from the average are the check plot, phosphorus plot, and the nitrogen plot.

2—In the sand and manure series the nitrogen in the tops averages approximately $1^1/_8$ times that in the roots. The only fertilizer treatment which is widely divergent from the average is the nitrogen (alone) plot.

3—In the brown silt loam series the nitrogen in the tops averages a little over $1^1/_3$ times that in the roots. Only one plot is widely divergent from the rest, namely, the manure-nitrogen-phosphorus plot.

4—Leaving out the plots that are widely divergent, we have the following: 2.06 times the per cent nitrogen in the tops of plants grown in bank sand as there is in the roots; 1.31 times the per cent nitrogen in the tops of plants grown in brown silt loam as there is in the roots; 1.24 times the per cent nitrogen in the tops of plants grown in brown silt loam as there is in the roots.

SUMMARY

I—The nitrogen content of head lettuce plants grown in different soils varies greatly.

II—Different fertilizers affect the nitrogen content of head lettuce plants on the same soil.

III—The same fertilizer treatment affects the nitrogen content of plants grown on different soils in different ways.

IV—Between the brown silt loam, which was in a good state of fertility, and the bank sand, enriched with manure, there was less difference between the ratio of the nitrogen per cent of the roots to that in the tops.

V—In the bank sand and manure series where manure was used at the rate of 2 bu. of manure to 3 bu. of sand, fertilization varied the ratio of the per cent nitrogen in the roots to that in the tops from 100 in roots to 105 in tops, to 100 in roots to 132 in tops.

VI—The per cent nitrogen in the tops of the head lettuce plant does not tend to bear a constant relation to that in the roots.

VII—With the per cent nitrogen in the roots taken as 100, the closest ratio obtained was 100 parts in roots to 105 in the tops; the widest ratio was 100 parts in roots to 236 in the tops.

Acknowledgments are made to Mr. Lester Yoder and Mr. Ira Baldwin for assistance in the analytical work.

AGRICULTURAL EXPERIMENT STATION
PURDUE UNIVERSITY
LAFAYETTE, INDIANA

AN ANAEROBIC CULTURE VOLUMETER

By ZAE NORTHRUP

Received May 18, 1918

During the past year, in studying qualitatively and quantitatively the gas production in fruits and vegetables canned in tin and glass, several types of bacteria were isolated. It was desired not only to determine whether these organisms were gas producers and anaerobes, but also to determine with as much accuracy as possible the composition and comparative amounts of the gases evolved in pure culture for purposes of comparison with the gas in the can from which they were taken.

An apparatus was needed to fulfil these requirements which would furnish sufficient gas for analysis, simulate can conditions as nearly as possible, and enable the gas evolved to be conducted directly to the gas burette for analysis as had been done with the gas collected from the blown cans.

After several preliminary experiments the apparatus illustrated was constructed and found to work satisfactorily. One of the ideas in its construction was that such an apparatus, to be of general use to laboratories studying gas-producing organisms (in canned goods especially), should consist of stock laboratory equipment and not require the purchase of special and costly apparatus, or the use of large quantities of media. Another idea in its construction, which is mentioned above, was to imitate can conditions by fostering anaerobiosis, *i. e.*, the organisms grow in this apparatus under anaerobic conditions and produce gas, which collects under pressure as in the can, and to imitate conditions in a glass-covered glass can where pressure is not first evidenced by a bulging top as is usual with the tin can or Mason jar.

Dr. Wm. Mansfield Clark brought forth the objection to this apparatus that it did not give quantitative results since the gases evolved, being under enormous pressures, were partially dissolved in the liquid. However, this same contention would hold true in the study of gases direct from swells and as these gases must be studied under the conditions under which they are produced it seems as if Dr. Clark's argument would not hold in this case.

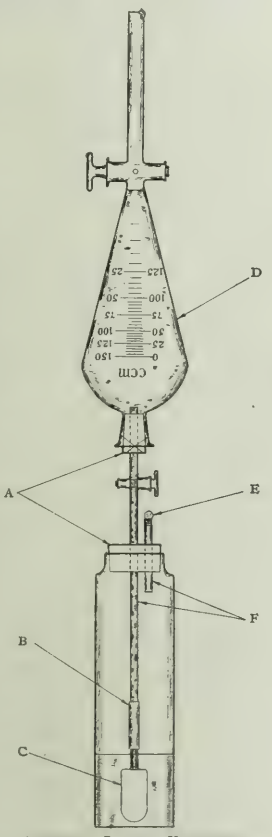
METHODS OF USE

As will be noted in the accompanying illustration, the materials necessary for the construction of the anaerobic culture volumeter are a separatory funnel with glass stopcock (Squibb's pear-shaped funnel with graduations possesses some advantages over other shapes), one-hole rubber stopper to fit, glass stopcock and tubing, tall wide-mouthed bottle of about 300 cc. capacity fitted with a two-hole rubber stopper, a short piece of rubber tubing, and a small Berkefeld filter.

The separatory funnel and connecting tubing are first filled with the desired liquid culture medium. Enough medium is also poured into the bottle so that the level of the liquid is slightly over the top of the filter. When the stopcock on the funnel is closed, the medium remains in the separatory funnel, due to atmospheric pressure.

For sterilizing the apparatus and the contained medium, a piece of cotton is placed in the tube at the top of the separatory funnel. The cock in the connecting tube is then closed and that at the top of the funnel opened.

After sterilization, the cock in the separatory funnel is closed and that in the connecting tube opened. When the apparatus has cooled sufficiently the cock in the connecting tube is closed and that at the top opened. The inoculation is now made by pipetting into the stem of the separatory funnel any inoculated liquid medium and if the medium does not then reach the stopcock, sufficient sterile medium is introduced to make the funnel culture anaerobic when the cock is closed. After this is accomplished the cotton is replaced, the top cock closed, and the lower cock opened.



ANAEROBIC CULTURE VOLUMETER

A—Cork
B—Coupling
C—Bacterial filter
D—Separatory funnel
F—Cotton
E—Glass tubing

In the experiments performed, the organisms grew in the medium in the separatory funnel and produced gas which forced the liquid medium down and out through the Berkefeld filter into the bottle; the cotton plugged vent prevents the development of pressure in the bottle. Contrary to expectations and much to the advantage of the experiment the organisms did not grow through the filter for several days thus allowing ample time for analysis of the gas formed. The separatory funnel was connected up directly with the gas burette after removing the cotton, and the upper cock was opened very carefully as the gas was under considerable pressure. Samples of gas were drawn from time to time from the apparatus and showed but little variation in composition quantitatively and qualitatively.

After the organisms grew through the filter, any gas produced escaped through the vent, so this culture could still be used for obtaining gas for analysis under practically the same conditions as before. On the whole this apparatus has proved very satisfactory for the purpose for which it was designed. I have been aided in the perfection of this apparatus by Mr. G. I. Blades, a senior horticultural student.

The suggestion has been made since that the Doremus apparatus for quantitative extraction of gases employed by Baker[1] could be used in the study of pure cultures by simply inoculating cans, sealing and incubating them, instead of utilizing the apparatus described above. Perhaps in many instances this idea can be put in practice. I employed the Doremus apparatus used by Baker, in the study of gases direct from naturally formed "swells," previous to devising the above apparatus and found it entirely satisfactory in this respect, but for pure cultures it has the following disadvantages: the large hole punctured by the Doremus apparatus renders it exceedingly difficult to reseal without introducing either solder, HCl, or foreign organisms. It was found necessary to cut a little square tin, sterilize it, and solder it over the opening when further cultivation was desired. If the Doremus apparatus was constructed to punch a smaller hole, this tube would become easily and quickly clogged with seeds, skins, pulp, etc., of the food under investigation.

Again, because of the use of pure cultures it would be very undesirable to force water into the can through the gas extraction apparatus as is suggested by Baker. Water has been found to be an undesirable liquid over which to collect gas from the cans on account of its absorptive power. Mercury has been employed in all our tests.

It is not easy to regulate the amount of gas taken from the can when tin cans and the Doremus apparatus are used, in fact, immediately as the can is punctured, all the gas escapes into the retaining bottle before it is possible to control it. It is not possible to tell whether all gas has been extracted and shut it off, until the contents of the can reach the first glass connection. This results in the contamination of the connections and perhaps of the gas apparatus itself with the organisms under study, and if these are spore-formers this is an especially serious disadvantage. The transparency of the glass is one of the biggest arguments in its favor; another argument before mentioned is that it stimulates the conditions in the all-glass can which is one of the most highly advocated for the cold pack method.

BACTERIOLOGICAL LABORATORIES
MICHIGAN STATE AGRICULTURAL COLLEGE AND EXPERIMENT STATION
EAST LANSING, MICHIGAN

[1] H. A. Baker, "Apparatus for Quantitative Extraction of the Gases in Canned Food Containers," *Eighth International Congress of Applied Chemistry*, Section on Hygiene, **18** (1912), 43–44, 3 figs.

LABORATORY AND PLANT

AN ELECTRICAL CONDUCTIVITY RECORDER FOR SALINITY MEASUREMENTS[1]

By E. E. Weibel and A. L. Thuras

Received May 3, 1918

The electrical conductivity of brines and other salt solutions varies with the degree of concentration. A recording instrument might, therefore, be of value where a continuous record of the density or concentration of a solution is desired. Recently such an instrument[2] has been designed at the Bureau of Standards for obtaining a continuous record of sea water salinity to a high degree of accuracy. A brief description of the method is given with the hope that it will be of value in its application to other solutions.

DESCRIPTION OF METHOD

The method consists in measuring the ratio of the resistance in two equal or nearly equal electrolytic cells, A and B, Fig. I. One cell, A, is sealed and contains an average sample of the solution to be measured, whose salinity or concentration is known. The other cell, B, is open and has flowing through it the solution to be measured. This ratio is obtained by a Wheatstone bridge using alternating current to eliminate polarization effects in the cells. A calibration of the apparatus can be made at any time by using solutions of known salinity in the open cell or by carefully measuring the solution flowing through the open cell by some accurate method. A record of the resistance ratio of the two cells is made by a recorder similar to those now in use for measuring temperature, but some changes will have to be made to adapt this recorder to the use of alternating current.

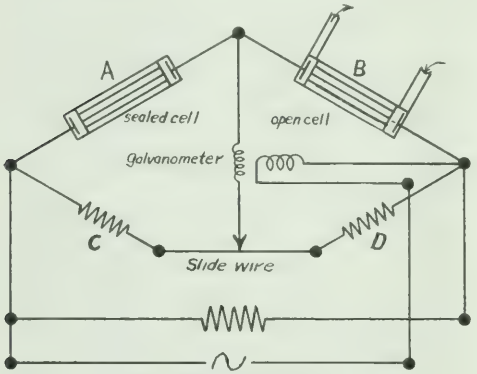


Fig. 1—Theoretical Diagram

The new and important feature of the method is the use of two cells containing liquids of nearly the same properties which make it possible to compensate almost entirely for the large temperature coefficient of the solution. The two cells are placed in a uniform temperature bath and the only error introduced is that due to the small differential temperature coefficient of the two solutions.

For very dilute solutions which may vary greatly in resistance, as for instance distilled water containing traces of salt, the replacing of resistances C and D by an open and closed cell, respectively, is recommended. Then no matter how much the resistance of the solution changes in the two open cells B and C, the current through the two branches of the bridge will be equal, and consequently if all of the cells are geometrically equal the bridge will be completely compensated for polarization. With high resistance cells and high voltages the use of direct current on such a bridge is suggested. This modification has also the advantage of doubling the sensitivity of the bridge.

MEASUREMENTS OF SEA WATER

Preliminary experiments using sea water of different concentrations showed that:

1—Good balances can be obtained with a simple Wheatstone bridge circuit containing the two electrolytic cells, using either a telephone at 500 cycles per second or an alternating current galvanometer at 60 cycles per second.

2—The temperature compensation is sufficient. For the maximum difference in salinity in the two cells, which is about 0.5 per cent, the lack of compensation did not exceed 0.03 in salinity (0.03 g. of solids per kg. of water) for a change of 10° C.

3—No appreciable change in balance due to the flow of the sea water through the open cell was obtained.

4—To obtain a continuous record of salinity an alternating current galvanometer similar to the usual direct current galvanometer is needed to operate the recorder. This galvanometer was constructed of the electromagnetic moving coil type[1] and has a sensitivity and other operating constants as good as those of the direct current galvanometers now used.

After these preliminary experiments had shown the feasibility of the method, a more careful study was made of certain sources of error in order to obtain data upon which to base the design of proper cells. These effects are:

1—Heating produced by the current in the cells.

2—Temperature lag of the sealed cell when the sea water temperature in the bath suddenly changes.

3—Time necessary for the resistance ratio to reach its true value when the sea water passing through the open cell changes in salinity.

[1] Published by permission of the Director of the Bureau of Standards. This publication is made without obtaining the consent of the senior author, who recently lost his life at the front in France. The junior author has added a paragraph of new matter relating to solutions varying greatly in resistance (Para. 4) and has suggested the application of the method to a wider range of solutions than sea water.

[2] Weibel and Thuras, *J. Wash. Acad. Sci.*, **8**, No. 6.

[1] E. E. Weibel, Bureau of Standards, *Scientific Paper*, **297** (1917), 23.

Consideration of these effects leads to the design of specially constructed cells.

MULTIPLE TUBE CELLS

Each of the two cells, Fig. II, contains 6 parallel glass tubes 14 cm. long and 1 cm. in diameter. These tubes are joined at each end to bulbs containing annular shaped platinum electrodes. Each electrode has an area of 5.3 sq. cm. and is held rigidly in place by 4 platinum pins which are welded to the electrode and sealed into the glass wall of the cell. The cells are designed so that there are no pockets in which air can collect and the sea water is admitted in such a manner as to sweep off any bubbles which might collect on the electrodes. The inlet and outlet tubes are sufficiently large to respond to the maximum change in salinity.

RECORDER

In order to secure a continuous record of salinity or concentration the Wheatstone bridge and galvanometer must be embodied in a recorder mechanism such as that developed by the Leeds and Northrup Company. The electrical connections are as shown in Fig. I. The most important changes in their present recorder are due to the use of alternating current. This current may be obtained from the usual 60-cycle supply, but if only direct current is available then the small direct current motor used for driving the recorder mechanism can be equipped with slip rings and be operated as a converter. The recorder paper should be ruled so that salinities can be read directly.

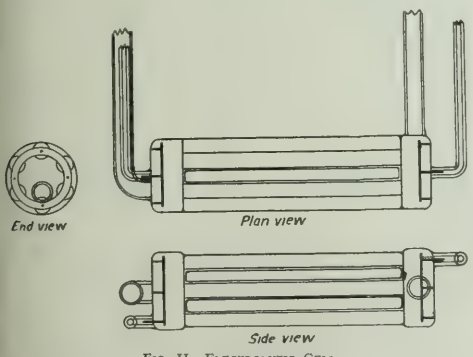


Fig. II—Electrolytic Cell

INSTALLATION AND OPERATION

The recorder should be properly mounted in some convenient place and with insulated wires leading from it to the cells. The cells, Fig. III, should be placed close together in a bath through which water direct from the solution continuously flows, or the cells may be immersed directly in the solution if convenient. This will insure a uniform temperature throughout the bath. A flow of water, also taken directly from the solution, should be maintained through the open cell. This flow must be broken as it leaves the open cell in order to eliminate the resistance error due to shunting the cell.

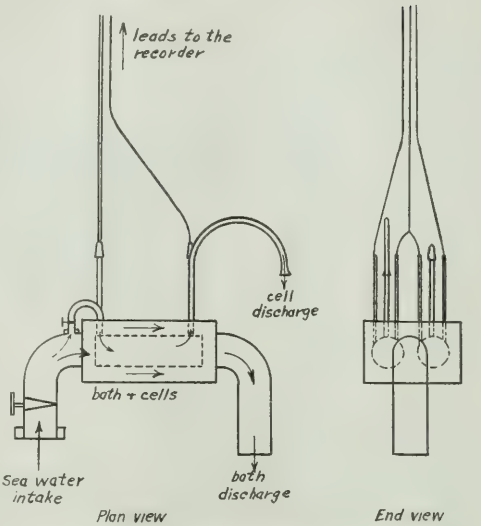


Fig. III—Connections of Bath and Cells

SUMMARY

An apparatus is described to give a continuous record of the salinity or density of a solution by the measurement of its electrical conductivity. A pair of electrolytic cells is described which, when used with a suitable alternating current galvanometer, will give satisfactory operation in connection with a recorder. The temperature compensation is obtained by placing both cells, which are in the two arms of a Wheatstone bridge, in a uniform temperature bath or directly in the solution which is to be measured. The application of this method, with such modifications in details of construction and arrangement as are necessary to meet the needs of a particular case, is suggested for the measurement of the salinity or concentration of brines and other salt solutions and also many other substances whose composition is constant throughout changes in concentration.

Bureau of Standards
Washington, D. C.

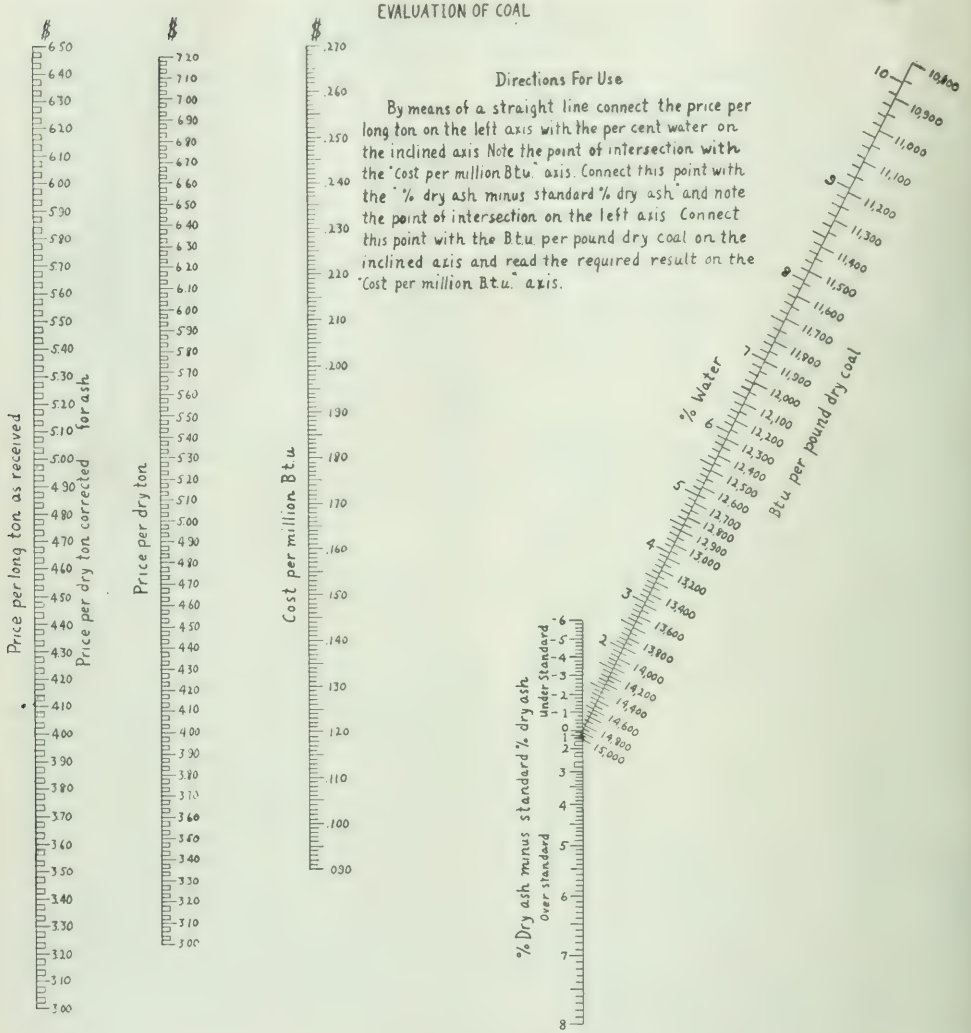
AN ALINEMENT CHART FOR THE EVALUATION OF COAL

By A. F. Blake

Received April 16, 1918

Some time ago the writer published a description of "A Graphic Chart for the Evaluation of Coal,"[1] which, to judge from the inquiries received regarding it, has proved of value to a number of chemists and engineers. As a result of a recent study of nomography it has become evident that the method of charting can be very much improved by the substitution of alinement principles for those of ordinary

[1] This Journal, 8 (1916), 1140



analytical geometry. It may be stated as a general rule that cross-section charts, though very useful for the visual presentation of the relationship of different variables, are not nearly as suitable as alinement charts for the purposes of numerical calculation. The latter are more compact and more easily read, are entirely self-interpolating, and allow less opportunity for error, since there is no necessity for projecting points first vertically and then horizontally over considerable distances.

The chart given here, like the one previously described, is designed to determine the relative values of different coals, given the price per ton and the chemical analysis, by calculating the relative costs of a million heat units in accordance with the methods established by the United States Bureau of Mines. The equations to be solved are as follows:

$$c = \frac{100\,a}{100 - b} \qquad (1)$$

$$f = c + \frac{(d - e)^2}{200} \qquad (2)$$

$$f = c - 0.02\,(e - d) \qquad (3)$$

$$x = \frac{1{,}000{,}000\,f}{2{,}240\,g} \qquad (4)$$

$$x = \left[\frac{100\,a}{100 - b} + \frac{(d - e)^2}{200}\right]\left[\frac{1{,}000{,}000}{2{,}240\,g}\right] \qquad (5)$$

$$x = \left[\frac{100\,a}{100 - b} - 0.02\,(e - d)\right]\left[\frac{1{,}000{,}000}{2{,}240\,g}\right] \quad (6)$$

a = Price per long ton (in dollars) of the coal as received.

b = Per cent water in coal as received.

c = Cost per long ton (in dollars) of the dry coal.

d = Per cent of ash on the dry basis.

e = Per cent ash selected as the standard.

f = Cost per long ton (in dollars) of the dry coal corrected for ash.

g = B. t. u. per lb. dry coal.

x = Cost per million B. t. u. (in dollars).

The theoretical considerations upon which these equations are based are all discussed in the previous paper. Equations 2 and 5 apply when the ash is greater than standard and 3 and 6 when the ash is less than standard. $\frac{(d - e)^2}{200}$ is an algebraic expression which happens to represent almost exactly the price deduction to be made for excess ash as given in the tables of the Bureau of Mines Bulletins, and accounts for the increased labor charges, diminished efficiency of combustion, etc., resulting from high ash coal. The values which the Government deducts from the price per ton to be paid we *add* to the cost per ton. When the ash is below standard a premium of 2 cents per ton for each whole per cent less is paid. This explains Equation 3. Equation 5 is a combination of 1, 2 and 4, and Equation 6 of 1, 3 and 4.

The tedious arithmetical calculations which would be required to solve these equations are all eliminated by the use of the chart shown herewith. The directions for use are given in the cut. To illustrate its use suppose it is desired to know which of two coals, A or B, is the more economical, the prices and analyses being as follows:

	A	B
Price per long ton	4.54	$5.38
Per cent water	4.30	3.50
Per cent dry ash	10.40	6.00
B. t. u. per lb. dry coal	13,550	14,350

By means of a ruler, a drawing triangle, a fine silk thread, or best of all a strip of celluloid with a straight line ruled on its under side, connect 4.54 on the left-hand axis with 4.3 on the inclined axis. The line intersects the "Price per dry ton" axis at 4.74. If 6 is taken as the standard ash, this point, 4.74, is then connected with 4.4 on the lower part of the ash axis and the line cuts the left-hand axis again at 4.84, the cost per dry ton corrected for ash. This point is connected with 13,550 on the inclined axis and the desired result, 0.1595, read at the intersection with the "Cost per million B. t. u." axis. Proceeding similarly with B, we obtain 0.1734 as the cost per million B. t. u. A is therefore the cheaper coal and the extra price of B is greater than justified by its better quality. Or, if it were desired to know what price should be charged for B to have the heat cost equal to that of A, we would start with 0.1595, the cost of a million heat units in A, and work backwards on the analysis of B obtaining $4.95. The intermediate values obtained, if not interesting, need not be noted at all, the straight line being merely pivoted over the point of intersection. The first alinement solves Equation 1, the second either 2 or 3, and the third 4.

This chart shows how even a very complicated equation, such as 5, involving several multiplications and divisions, as well as additions, subtractions, and a square can be readily and easily solved by a properly constructed alinement chart. It is impossible in this paper to go into the mathematical details governing the construction of the chart, but the reader is referred to "A Manual of Chemical Nomography" by Dr. Horace G. Deming[1] for information which should make the matter clear. The chart is, in fact, a sort of adaptation of the calculating device known as the nomon.[2]

Atlantic Sugar Refineries, Limited
St. John, N. B., Canada

NOTE ON THE USE OF THE DIPPING REFRACTOMETER

By Wyatt W. Randall

Received June 3, 1918

Experiments recently made in this laboratory seem to the writer to justify the publication of a note of warning to chemists who may have occasion to use the dipping refractometer for exact determination of the refractive properties of liquids, especially where the latter are rather volatile.

Two samples of whiskey containing an unusually low percentage of alcohol were under examination by Mr. C. O. Miller. The density of each of the alcoholic distillates having been determined with the aid of the pycnometer, the refractometer reading at 20° C. was made as a means of estimating the amount of methyl alcohol, should any be present. In order to prevent any inaccuracy of reading through evaporation of alcohol, in each case the distillate was placed by Mr. Miller in the metal cup secured by a bayonet joint to the instrument. The readings gave a percentage-of-alcohol-by-weight which differed notably from that found by the use of the pycnometer, and which indicated the presence in each distillate of about 1.25 per cent of methyl alcohol to 98.75 per cent of ethyl. Similar results were obtained by two other chemists, working independently. As the presence of methyl alcohol in any noticeable amount in these whiskeys was a matter of importance, all the distillations and determinations were carefully repeated by Mr. Miller; while the general results were the same, the figures obtained were not as close as was considered necessary in a case in which much was at stake. Accordingly, the writer obtained fresh distillates, determined their respective densities and refractometer readings, using, however, in the latter work, glass beakers instead of the metal cup, in the belief that evaporation would play a very small part in the case of a 25 per cent alcohol at 20° C. The beakers were of course corked while they hung in the bath, and the corks were withdrawn only when alcohol and refractometer prism were both unquestionably at 20° C., that is, about after half an hour's immersion in the bath. The readings gave no evidence of the presence of methyl alcohol. The original distillates were reëxamined, this time using

[1] *University Press*, Champaign, Illinois.

[2] *J. Am. Chem. Soc.*, **39** (1917), 2137.

glass beakers and, again, no evidence of the presence of methyl alcohol was obtained.

The only simple explanation of these differences is that the temperature of the liquid in the metal cup was distinctly higher than that of the bath. Accordingly, the following experiments were made: The bath was brought to, and maintained at, 20° C., according to bath thermometer A (brass-jacketed, about 10 in. long and graduated in tenths of degrees). Comparison of A with thermometer B (not jacketed, about 4 in. long and graduated in fifths of degrees), while the bulbs of both were in the bath, showed no noteworthy differences.

I—An alcohol of about 22.75 per cent by weight was put in a glass beaker and also in the metal cup. Both these vessels were then fitted with corks and placed in the bath. After about 25 min. thermometer B was inserted in each in turn, after the cork had been withdrawn and readings obtained as follows:

Temperature of alcohol in glass beaker.....	20.02° C.
Temperature of alcohol in metal cup.....	20.03° C.

II—Readings made with the refractometer dipping in the alcohol in the glass beaker were: 55.78, 55.80, 55.79, 55.79, 55.78, 55.79—Average, 55.788, which corresponds to 22.75 per cent by weight.

III—Readings made with the alcohol in the metal cup, following Zeiss filling directions, were: 55.49, 55.49, 55.47, 55.49, 55.50, 55.48—Average, 55.487, which corresponds to 22.60 per cent by weight.

IV—Readings made with the alcohol in the metal cup, the latter having been filled while off the refractometer and then clamped on, were: 55.55, 55.52, 55.56, 55.54, 55.55—Average, 55.543, which corresponds to 22.62 per cent by weight.

V—After these readings had been made, the metal cup was detached and the temperature of the alcohol contained in it quickly read.

Temperature of bath, thermometer A.....	20.0° C.
Temperature of bath, thermometer B.....	20.0° C.
Temperature of alcohol, thermometer B...	20.5° C.

VI—Readings made with water in an open beaker were: 14.65, 14.67, 14.67, 14.66, 14.67, 14.66—Average, 14.663.

VII—Readings made with water in the metal cup, filled as directed by Zeiss, were: 14.57, 14.56, 14.57, 14.58, 14.57, 14.58 Average, 14.572.

VIII—After these readings had been made, the metal cup was detached, and the temperature of the water in it quickly determined.

Temperature of water in bath.....	20.0° C.
Temperature of water in cup.....	20.6° C.

The temperature difference in V appeared to be about 0.5°, in VIII about 0.6° C. I believe these are distinctly too great. In the effort to make the reading quickly, I do not believe time enough was given for the liquid and the thermometer to come to equilibrium. Besides, the metal cup was probably somewhat warmed in detaching from the refractometer, the quantity of liquid was small, and the whole bulb of B was not immersed; I believe, therefore, that about 0.4° or 0.45° would be nearer the true difference. The effect of a 0.5° C. difference in temperature was tried.

IX—Readings of alcohol in an open beaker at 20.5° C. were: 55.40, 55.41, 55.40, 55.41, 55.41, 55.41—Average, 55.407, which corresponds to 22.55 per cent by weight.

It thus appears that the low readings obtained when the closed metal cup is used are due, at least chiefly, to a difference in temperature between the water of the bath and the liquid in the cup, and that a similar difference in temperature does not exist when a glass beaker is used instead of the metal cup.

It now became a matter of interest to learn under what conditions the data were secured upon which Leach and Lythgoe based their method for the detection and estimation of methyl alcohol in the presence of ethyl. Inquiry of Dr. Lythgoe brought word that glass beakers only had been used in their work.

The next question was, What is the cause of this difference of temperature in the contents of the metal cup, according as it is attached or not attached to the refractometer? I was informed by Dr. W. J. A. Bliss that, at the Johns Hopkins physical laboratory, Dr. Pfund had found that, in standardizing a dipping refractometer, complete accord in the readings could be secured only when the temperature of the room was close to that of the bath. This suggested that heat was conducted by the metallic parts of the instrument and of the cup to the contents of the cup. Accordingly, Dr. Bliss and I made readings of the two thermometers when the bath was only 1° to 1.5° colder than the air. No effort was made to keep the bath at a fixed temperature; B's readings in the water of the bath averaged 0.07° higher than A's. In the liquid in the metal cup, immediately after detaching it from the refractometer, B's readings averaged 0.10° higher than A's readings in the bath, which indicates that the contents of the cup were, under these conditions, only about 0.03° warmer than the surrounding water of the bath.

Later, I cooled the bath to about 15° while the room temperature was 27°. B, hanging alongside the cup, with the bottom of its bulb about a half inch above the water of the bath, read 22°. When placed side-by-side in the water of the bath, A read 15.00°, B, 14.92°. (Probably A's brass jacket was keeping its readings somewhat higher than B's.) The temperature of the bath was slowly rising: when A read 15.15°, B, placed in the alcohol in the cup just after it was detached, gave a reading of 15.65°, quickly falling to 15.50°.

These rather rough experiments seem to bear out the conclusion that heat is conducted from the air to the contents of the metal cup through the metal parts of the instrument, and that the difference in temperature between the contents of the metal cup and the water of the bath is roughly proportional to the difference between the air temperature and that of the bath.

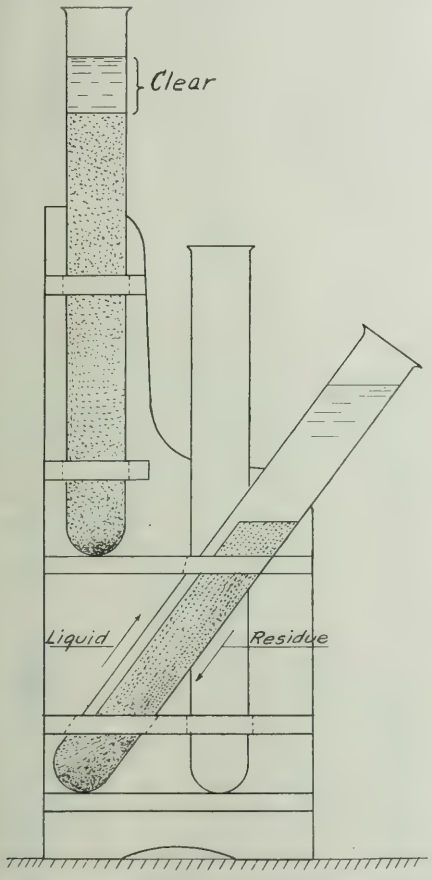
LABORATORY OF THE
STATE OF MARYLAND DEPARTMENT OF HEALTH
BALTIMORE, MARYLAND

DECANTING

By H. Tillisch

Received January 10, 1918

The decanting of liquids from residues is generally a very tedious operation. The time required for the separation can be much abbreviated without mechanical means, if the tube simply is held in an inclined position, *e. g.*, at an angle of 45°. The liquid will then form a channel in the upper part of the tube, while the residue will go along the under part to the bottom. In this way the two currents, upwards and downwards, will be separated from each other.



The decanting operation can thus be finished in one-third of the time required by the usual method of using vertical tubes. It is common practice to use narrow inclined tubes, etc., for obtaining a rapid decanting in liquids or for separating dust from air. The same principle can, as shown, be of use in the laboratory.

The common tube holders ought to be slightly modified for easy decanting in inclined tubes. The modification is suggested in the diagram.

Aarhus, Denmark

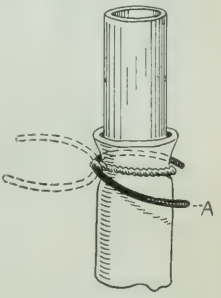
A DEVICE TO INSURE TIGHT CONNECTIONS BETWEEN GLASS AND RUBBER TUBING

By C. C. Kiplinger

Received April 17, 1918

In gas analysis trouble is experienced frequently in the attempt to make tight connections between glass and rubber tubing. Experience has shown that this is accomplished best by wrapping a single turn of wire about the joint and twisting tightly. However, there are two objections to this method. The wire tends, if twisted tightly, to cut the rubber, and if the rubber tubing is appreciably over-size, the tubing is compressed or pinched near the twisted portion of the wire, frequently making a small channel through which leakage occurs.

The device herewith described overcomes these difficulties, permits the use of over-size rubber tubing, and insures gas- and water-tight joints. It has been used throughout the year with Liebig condensers and gas apparatus and has given complete satisfaction. A is a piece of stout wire bent in U form of such size that the limbs of the U will just slip over both tubes. A loop of stout cord is tied about the connection, the wire U is slipped through this loop as shown in dotted lines, the cord now twisted, using the wire as a lever, and as soon as the joint is tight, the U is turned as shown at A. Cord is better than the usual copper wire for this purpose in that the former distributes the force more uniformly throughout its length.



A further advantage of this mode of attachment lies in the ease with which it may be dismantled, requiring as it does no pliers or other tools for this purpose.

344 Harrison Avenue
Lexington, Kentucky

A SIMPLE AND ENTIRELY ADJUSTABLE RACK FOR KJELDAHL DIGESTION FLASKS

By Frank E. Rice

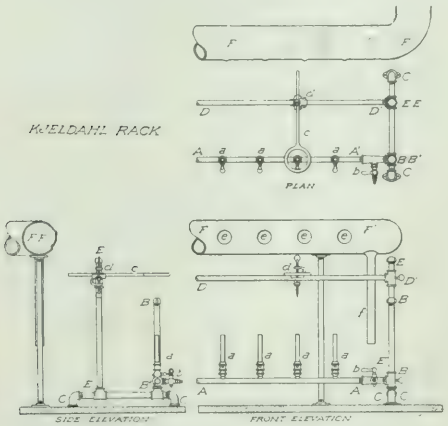
Received March 11, 1918

The apparatus here described can be made by any pipe fitter from standard pipe, and unions, and without any specially prepared parts. It will be found to cost much less than similar equipment on the market. It takes up but little space when in use, and its great flexibility in adjustment makes easily possible still further contraction when it is not being used.

A A′ is an iron pipe in which are mounted burners, *a*, each with a stopcock. At the ends of this pipe are found stopcocks, *b*, for gas intake. This line is adjustable up and down on standard B B′, which is in turn adjustable forward and back on support C C′.

An iron rod, D D′, is adjustable up and down on standard E E′, which is also in turn adjustable for-

ward and back on C C′. Set-screws are used in up and down adjustments, but are not necessary in forward and back adjustments, provided the sliding members fit the supports reasonably snug. Rings, *c*, for supporting flasks are of iron and of the straight stem type. They are attached to the rod D D′ with fasteners, *d*.



F F′ is a pipe with outlet in the rear to hood suction. Holes, *e*, are of sufficient diameter to admit the mouths of digestion flasks and act as supports for the same. This pipe should have a slight fall with an opening at the lower end and drain, *f*, for carrying off condensation acid.

Department of Chemistry
N. Y. State College of Agriculture, Cornell University
Ithaca, New York

RELATIVE VISCOSITY OF OILS AT ROOM TEMPERATURE

By C. Frank Sammet
Received April 13, 1918

Oftentimes it is desirable to arrive at a relative expression for the viscosity of oils without having recourse to the elaborate apparatus and means for determining the absolute viscosity.

A rapid procedure which has proven satisfactory for a relative determination is based on the time of absorption of an oil when dropped upon blotting paper under uniform conditions.

A piece of heavy weight blotting paper, about three inches square and having a rapid absorption,[1] is supported by a beaker so that the absorbing area is not in contact with the support, as such contact would interfere with the absorption. The oils to be compared are brought to room temperature, then 0.5 cc. of oil is withdrawn by a 1 cc. pipette, and allowed to flow onto the blotter with the end of the pipette held in the surface of the oil. The pipette is then withdrawn after a few seconds draining, with a certain amount of oil still remaining in the end by capillarity. This method of draining has given the most uniform results.

The time of absorption in seconds is noted on the stop watch from the first contact of the oil with the blotter until the complete absorption has taken place. It is plainly visible in reflected light.

which is essential that the comparison be made under like conditions.

Blotters from the same package run very uniformly if of high quality, but since the test is so easily made, several results should be averaged.

If different pipettes are used for each oil, they should have approximately the same time of delivery for a given liquid.

When oils are too viscid at the temperature of comparison, they may be reduced in viscosity with a small but definite volume of solvent, such as kerosene, or with some other low viscosity oil.

Crane & Company
Dalton, Mass.

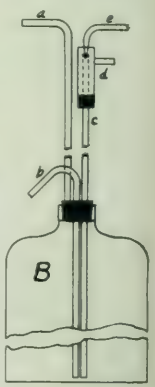
[1] Reed, This Journal, 10 (1918), 44.

AN ASPIRATOR

By J. M. Johlin
Received April 17, 1918

An aspirator which has been found convenient can be easily made from a large bottle, a few rubber stoppers, and a few pieces of glass tubing, as illustrated in the accompanying figure. Methods of operating the aspirator suggest themselves.

Through the tube *b* the bottle B can be either filled with water or emptied again. When the water cannot be forced out by pressure but must be siphoned, a rubber tube may be used as an extension. Tube *a* serves as an intake or outlet for the gas. The gas is displaced from B by allowing a capillary stream of water to flow into *c* from *e*. This arrangement operates on the principle of a constant-level water bath, the side neck *d* carrying off any overflow. The outlet of *e* should be small or the stream of water will carry air bubbles into the aspirator. The outlet of *a* should be sufficiently above *c* to prevent water from flowing through it when all gas has been displaced. The force of the stream of water flowing into *c* generates a pressure slightly greater than that of the water column in *c*.



This type of apparatus is far less clumsy and less top heavy than is the average form of aspirator; a considerably increased pressure can be developed without adding materially to the weight of the apparatus or without decreasing its stability; operating on the principle of the constant level bath, the aspirator needs no attention during operation until all the gas within the apparatus has been displaced.

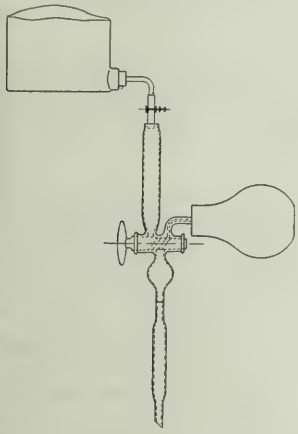
Syracuse University
Syracuse, New York

PIPETTE USED IN TITRATION OF OILS FOR ACIDITY

By J. Jacobsen
Received April 11, 1918

The use is as follows:

The rubber bulb is squeezed and the oil to be examined is sucked into the lower tube, which has a capacity of 5.5 cc., *i. e.*, 5 g. of oil. The cock is turned and the upper tube is filled with a suitable quantity,



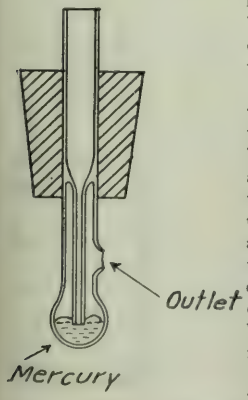
for instance, 10 cc., of a mixture of ether and methylated spirit, conveniently taken from a tubulated bottle, which is fixed just above the pipette. Then the cock is turned again and the oil, followed by the ether-alcohol mixture, is run into a flask and titrated with alkali. In that way the lower tube is cleaned out automatically and is at once ready for a new sample.

Aarhus Oliefabrik, Ltd.
Aarhus, Denmark

A SAFETY VALVE

By E. Rittenhouse
Received December 17, 1917

The safety valve shown in the sketch has been found very useful and may be of interest to other chemists. It is very easy to make and quite reliable.



The valve is intended for use in a distilling flask when determining ammonia by absorption in standard acid solution. It will prevent the acid from going up into the flask by letting air in and breaking the vacuum. The valve is made entirely of glass with a drop of mercury in the bulb. It is very effective, never sticking, always set.

The principle, namely, the pressure due to a column of mercury, can be adapted to all low-pressure work both above and below that of the atmosphere.

1822 So. Broad Street, Philadelphia

A TEST FOR WOOL

By Harry Leb. Gray
Received May 4, 1918

The detection of wool in the presence of cellulose fibers, in cases where the treatment has been such as to destroy the characteristic appearance of wool and

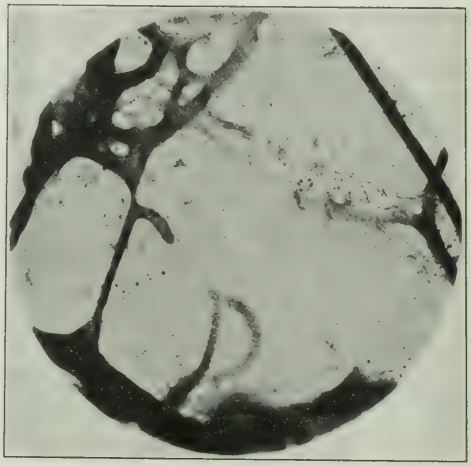


Fig. I—Characteristic Appearance of Wool Fiber after Treatment
Magnification = 100

where the fibers have been dyed in dark colors, is exceedingly difficult. In such cases the following method of procedure has been found satisfactory.



Fig. II—Wool and Cellulose Fibers after Treatment
Magnification = 100

The fibers to be examined are placed on a microscope slide and covered with two drops of a 30 per

cent sodium hydroxide solution. The slide is then gently heated over a flame until vigorous boiling just takes place, whereupon it is immediately removed and examined under the microscope.

Wool fibers become greatly swollen, in some cases partially dissolved, and present the appearance, which is characteristic, of being full of cells or bubbles. Undyed wool gives a dirty yellowish brown color.

Cotton and wood pulp fibers are unchanged except that they become somewhat clearer and slightly shrunk.

RESEARCH LABORATORY, EASTMAN KODAK COMPANY
ROCHESTER, N. Y.

ADDRESSES

GILMAN HALL: THE RESEARCH UNIT OF THE CHEMISTRY GROUP AT THE UNIVERSITY OF CALIFORNIA

By MERLE RANDALL

Received May 29, 1918

The department of chemistry at the University of California is now housed in three separate buildings—Chemistry Hall, the Freshman Laboratory, and Gilman Hall. The first is a rambling, vine-covered, red-brick structure, with a fine record of past achievement; the second, a temporary wooden structure; and the third, a massive, reënforced concrete monolith, built as a part of the permanent University along the lines of the Hearst plan.

The original building, Chemistry Hall, was built in 1890, and various additions have been made to it from time to time. The lecture rooms, museum, and the storeroom for all departments are located in this structure. The laboratories are now used by the departments of organic and analytical chemistry for both instruction and research.

In 1912 a temporary, three-story, wooden building, known as the Annex, was erected and, until the occupancy of Gilman Hall, was used exclusively for graduate research in physical chemistry. It is to be hoped that the research spirit, so well nurtured in the little annex, will continue to grow in the new quarters.

Another three-story wooden building, known as the Freshman Laboratory, was built in 1914 for the purpose of accommodating the general introductory course in inorganic chemistry and qualitative analysis. This building is unique in that it is used for the one course only. It contains storerooms, two distributing rooms, and eleven small laboratories, each of which accommodates twenty-five students working simultaneously, thus making room for a total of eleven hundred working in four different sections. The capacity of each laboratory was limited to twenty-five students in order that each instructor should become intimately acquainted with his students.

In 1916–1917 Gilman Hall, the first wing of the new chemistry

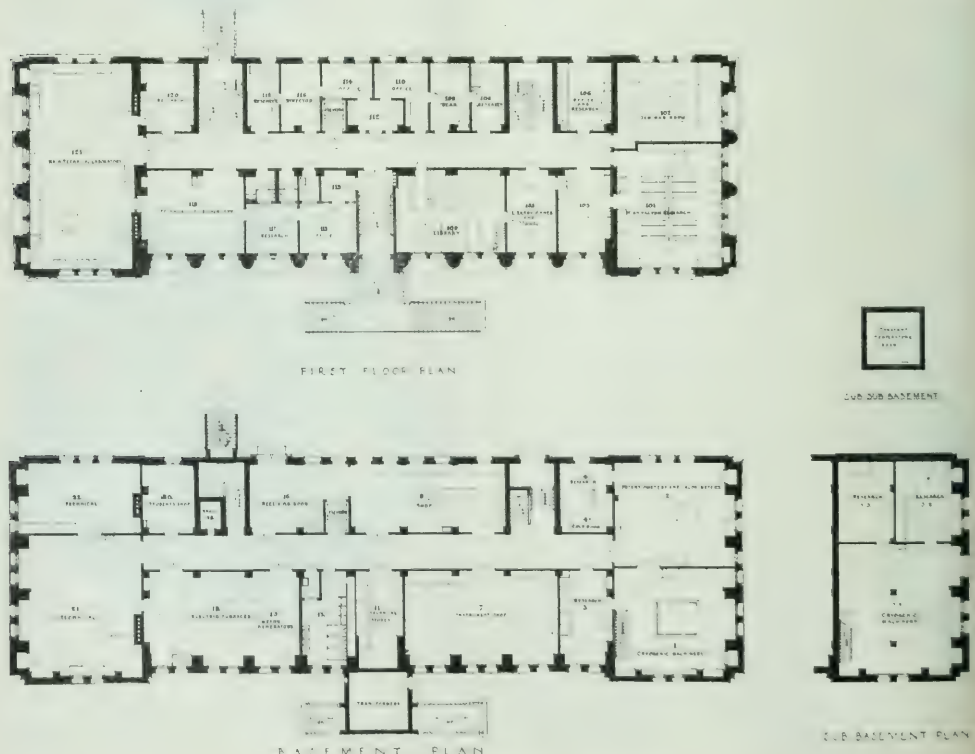


FIG. 1—FIRST AND BASEMENT FLOORS, GILMAN HALL

building, was erected. It was named in honor of Daniel Coit Gilman, president of the University, 1872–1875, later president of Johns Hopkins University, under whose administration the College of Chemistry was organized. Gilman Hall is devoted exclusively to research and instruction in physical and technical chemistry.

GENERAL DESCRIPTION

Gilman Hall, with a ground area of 189 by 57 ft., is nominally a two-story building (Figs. 1 and 2). There is an attic entirely finished which is lighted by large dormer windows. The basement is entirely above ground and under a portion of it is the sub-basement, also above ground level. And beneath the sub-basement is a small sub-sub-basement.

The walls, floors, and roof are heavy monolithic reënforced concrete. The exterior is a cement plaster, the roof covered with red tile. Much credit is due to the architect, Mr. John Galen Howard, for the manner in which he has succeeded in combining artistic composition, permanency, and chemical usefulness.

The interior presents many features unusual in a permanent building. Every square foot of floor space is utilized. Each room was planned for a specific purpose, but at the same time every effort was made to obtain a general uniformity of equipment, thus admitting of change when necessary.

The interior wood trim of Oregon pine (Fig. 14) and the cement base are arranged so as not to project beyond the plaster line. Apparatus or tables can therefore be placed directly against the wall without interference.

All piping and conduits are carried exposed on the ceilings. In order to facilitate the future installation of additional or temporary piping or equipment, metal inserts were placed in the ceilings, and pipes $^1/_2$ in. in diameter in the neutral plane of each floor beam and girder. The concrete ceilings were left unplastered and then painted. A smooth finish was obtained by oiling the forms before the concrete was poured. Several metal sleeves with covers (Fig. 14) connect each room with those above and below. Modified picture moulds (Fig. 14) permit of fastening upon the walls without marring the plaster. Removable wooden panels over the transoms and between the rooms (Fig. 10) near the ceiling provide ready communication between rooms on the same floor. A complete piping system can be installed to each room without cutting floors or walls.

Redwood panels (Fig. 11) are located in every room beneath the electric power switches. Two styles of lockers (Fig. 14) are used. The desk tops are, for the most part, sugar pine finished in aniline black stain. Members of the laboratory are permitted to fasten apparatus on any exposed woodwork, or to the bench tops.

Alberene stone tops have been used in the technical rooms and in the hoods (Fig. 16). Ventilation is by individual tile flues directly to the roof. Over some spaces hanging glass ventilating hoods (Figs. 6, 8, 10, 11) have been provided.

PIPING SYSTEM

In general, the piping systems are arranged to furnish five different supplies, namely, gas, low-pressure air, suction, oxygen, and water, available in each laboratory. The mains are in the basement and second floor corridors (Fig. 3). The following systems are installed:

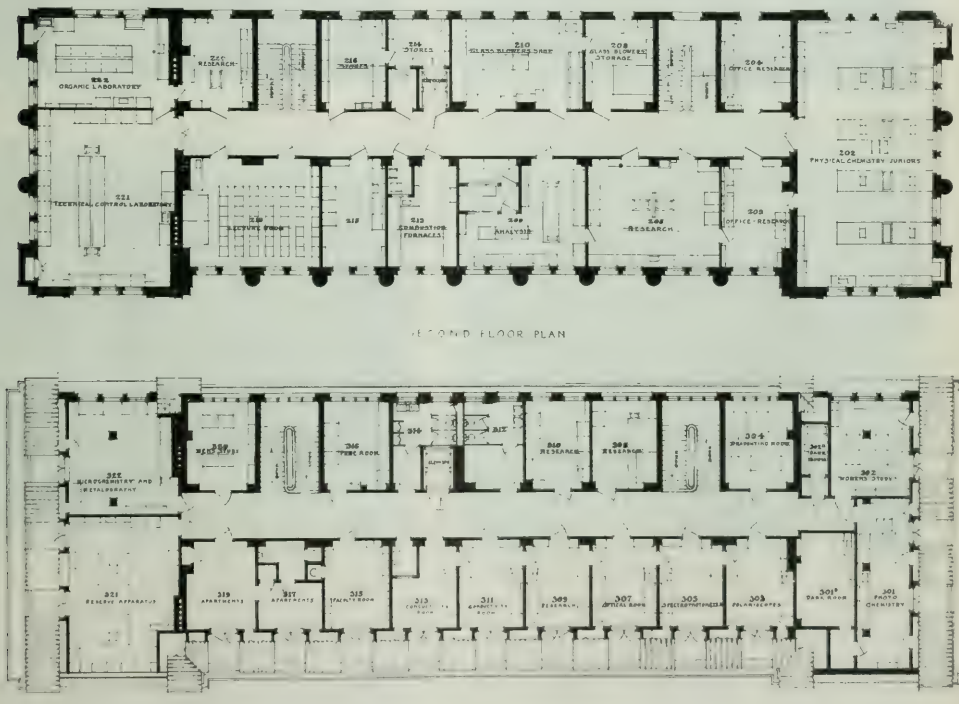


FIG. 2 — ATTIC AND SECOND FLOORS, GILMAN HALL

GAS—4 in. main from Pacific Gas and Electric Company.

WATER—4 in. main from People's Water Company; 4 in. main from University system, for fire protection, condensing water, etc.

DISTILLED WATER—Block tin line from special stills and 100 cu. ft. storage tank in Room 308 on upper floor.

HIGH-PRESSURE AIR at 85 lbs. pressure is supplied by a 7 in. by 6 in., 50 cu. ft. per min., Ingersoll Rolger, short belt, drive compressor (Fig. 7), with 3 ft. by 8 ft. storage tank. This unit is supplied with General Electric automatic control for starting and stopping the motor.

LOW-PRESSURE AIR is supplied through four reducing valves.



FIG. 3—BASEMENT CORRIDOR, SHOWING VAULT AND EXPOSED PIPING SYSTEMS



FIG. 4—CARPENTER, SHEET METAL, AND PLUMBING SHOP, ROOM 8. (PATTERN LATHE AND SCROLL SAW NOT SHOWN)



FIG. 5—INSTRUMENT SHOP, ROOM 7. (METAL SAW, DRILL PRESS, AND RIVETT LATHE NOT SHOWN)



FIG. 6—GLASSBLOWER'S SHOP, ROOM 210. (MERCURY STILL AND VACUUM BENCH NOT SHOWN)

Later a separate low-pressure blower will be installed for use when larger volumes of air are required.

SUCTION at from 20 to 25 in. vacuum is supplied from an automatically controlled, 2 cylinder Packard vacuum pump (Fig. 7).

HIGH VACUUM is supplied to Rooms 1, 101, and 103 through a lead line, by a Langmuir condensation pump, backed by a General Electric, two-stage, oil-sealed pump.

HIGH VACUUM at 0.001 mm. mercury is supplied through a lead line to the optical rooms on the attic floor, and to some of the second-floor rooms by three-stage, oil-sealed Trimount pumps. Glass vacuum cocks are used on these hihg vacuum lines.

OXYGEN is stored in tanks at high pressure and supplied to the line through reducing valves.

EXHAUST STEAM at 5 lbs. pressure is supplied for heating from the University power house. A separate vacuum return line is provided.

STEAM AT 30 LBS. pressure is also provided by the University power house for experimental purposes, and for the stills, hot closets, hot plates, etc.

STEAM AT 250 LBS. pressure is supplied to a special line from a small vertical oil-burning boiler located in the basement.

CONDENSING AND COOLING WATER, etc., is sent to the power house through the 30 lb. steam return line.

CIRCULATING BRINE is furnished by a 2 h. p. brine circulating pump from a 72 cu. ft. cooling tank.

LIQUID AMMONIA for cooling is supplied by a 4 in. by 4 in. York ammonia compressor (Fig. 7) equipped with automatic control. A special section of the high vacuum room is reserved for use of liquid ammonia from cylinders.

CRUDE FUEL OIL AND STOVE DISTILLATE lines are supplied by Fess gear pumps from 150 gal. storage tanks outside the building.

ELECTRIC SYSTEM

The electric system is centralized in the feeder board (Fig. 9). This board forms the partition between the electric furnace laboratory and the motor generator room. Not all the electric equipment is as yet installed.

4000 VOLT, 60 CYCLE, 3 PHASE, STAR CONNECTED A. C. is brought to two oil switches from the University power house.

110–220 VOLT, THREE-WIRE D. C. is also supplied to a 300 ampere breaker by the power house.

440 VOLT, 60 CYCLE, 3 PHASE, DELTA CONNECTED A. C. is supplied through an oil switch from three 40 kv. amp., 2300 volt transformers located in the transformer room. This is used for general power purposes.

220 VOLT, 3 PHASE, DELTA CONNECTED A. C. is obtained from the above transformers.

110–220 VOLT, 60 CYCLE, THREE-WIRE, SINGLE PHASE A. C. for lighting and experimental power is supplied by a 30 kv. amp., 2300 volt transformer.

220–440 VOLT, 60 CYCLE, 3 PHASE, DELTA CONNECTED OR SINGLE PHASE for furnace work will be supplied from a bank of three 100 kv. amp., 2300 volt transformers. The primaries of the transformers are connected to a double throw switch so that the bank can be thrown 3 phase, star, or in parallel on a single phase. The secondary sections are brought to the board. Another set of 220–440 volt primary transformers will be used for supplying the furnaces.

110 VOLT D. C. is generated by a 17.5 kw. motor generator set with a Tirrill regulator. This will be used for special work.

110 VOLT D. C. is also generated by a 12.5 kw. motor generator.

440 VOLT D. C. can be obtained by putting the above machines in series with the 220 volt service from the university power house.

6–12 VOLT D. C. is supplied by a 5 kw. double commutator machine with 110 volt field excitation.

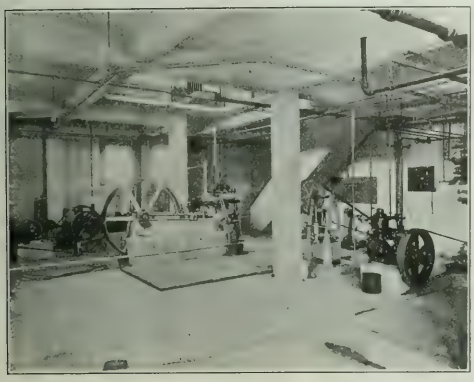


FIG. 7—CRYOGENIC LABORATORY, SUB-BASEMENT. AIR COMPRESSOR, LIQUID AIR PLANT. SUCTION PUMP, AND ICE MACHINE (NOTE FLOATING FOUNDATION)



FIG. 8—CRYOGENIC LABORATORY, UPPER PORTION, ROOMS 1 AND 3 CONTROL PANELS AND BURDETT ELECTROLYTIC OXYGEN HYDROGEN GENERATORS



FIG. 9—ELECTRIC FURNACE LABORATORY, ROOM 19. FEEDER PANEL (UNFINISHED) BEHIND WHICH ARE THE MOTOR GENERATORS AND OIL SWITCHES



FIG. 10—TECHNICAL ELECTROCHEMICAL LABORATORY, ROOM 119. MAIN DISTRIBUTION BOARD

12–24 VOLT D. C. will be supplied for furnace work by a 50 kw. double commutator machine.

A 100 CELL EDISON STORAGE BATTERY will be installed behind the left end of the feeder panel.

By means of the distributing system any voltage on the feeder board or in any part of the building is available on any other board. The fields of the generators can be controlled from any room. Only heavy currents are taken directly from the feeder panel.

The main distribution board (Fig. 10) is in Room 119 directly above the feeder board. From the fuses on this board 17 No. 6 wires run to each of the 6 distribution boards. (Right-hand portion of board, Fig. 10.) From the fuses on the distributing

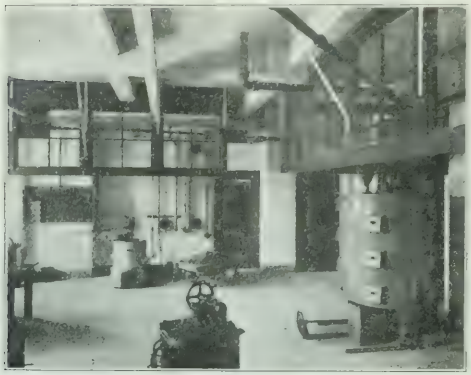


FIG. 11—FURNACE LABORATORY ROOM 19. HERRESHOFF ROASTING FURNACE ON THE RIGHT



FIG. 12—MAIN TECHNICAL LABORATORY, ROOM 121. PIPING SYSTEMS AND SUSPENDED BALCONY

board 7 No. 8 wires run to each of the room panels (Fig. 10), from which two 2-wire, 60 ampere and one 3-wire circuit can be used at the same time. Ordinary 110 volt A. C. and D. C. may be brought to the switches on the room panels by means of fuses alone, but by moving these fuses to other positions and using flexible leads, any other circuit may be connected to these switches. By paralleling the circuits 180 amperes of a single kind of current may be brought to the room panel. Means of locking the fuses and plugs on the distribution board are provided.

All machinery is individual motor-driven by 440 volt, 3 phase, A. C. motors, except the machines in the instrument and glass-blowing shops which are driven by 220 volt D. C. motors.

SHOPS

Probably the most important feature of the laboratory is the shops. Each of these is in charge of a full-time mechanic with occasional assistance. These shops exist for the primary purpose of constructing research apparatus and for aiding the research men of this department.

The CARPENTER, SHEET METAL, AND PLUMBING SHOP (Fig. 4) is equipped with a Wells pattern lathe, a Greenlee tilting saw table with boring and mortising attachments, a Porter 6 in. jointer, a Beach tilting table scroll saw, a 32 in. band saw, sheet metal working tools, and a complete line of fittings and tools for pipe as large as 2 in. in diameter.

The INSTRUMENT SHOP (Fig. 5) has an 8 in. Rivett lathe complete, an 8 in. Stark lathe, a 12 in. Seneca Falls lathe, a Robbins and Myers buffer and grinder, a Cincinnati universal tool grinder, a Browne and Sharpe 2A milling machine, a 20 in. Barnes drill, a Sigourney sensitive drill, a Canedy-Otto drill, a Grabo metal saw table, an oxyhydrogen welding equipment, a 2 ton travelling Peerless hoist, and a large number of small tools and stock. A 14 in. Hendey lathe and a 20 in. Lodge and Shipley lathe are contemplated.

The GLASS-BLOWER'S SHOP (Fig. 6) has various blow torches for glass and quartz and machines for grinding and polishing. In an adjoining room is a very complete stock of stopcocks, and about 3000 lbs. stock of soda, lead, pyrex and quartz glass tubing of all sizes.

THE STUDENTS' SHOP—Members of the laboratory do not, except in special cases with the permission of the mechanics in charge, use the above shops. They may, however, make free use of the students' shop, Room 20, which is equipped with a limited amount of machinery and hand tools.

LIBRARY, STUDIES, ETC.

The University fortunately possesses a very complete library, and a large number of the books relating to chemistry are shelved in the CHEMISTRY DEPARTMENT LIBRARY, Room 109. Books may be taken, without formality, to the library annex, Room 105,



FIG. 13—SEMINAR ROOM



FIG. 14—OFFICE AND RESEARCH LABORATORY, ROOM 105. VACUUM BENCH ON THE LEFT

where there are tables and blackboards, and where violent and heated scientific discussions may take place without disturbing the readers. A study for the men, Room 320, and one for the women, Room 302, are also provided.

The SEMINAR ROOM (Fig. 13) is arranged for small discussions or faculty meetings around the central table, but its capacity may be increased to about 60 people without losing much of the congenial atmosphere of the small seminar. Discussion is encouraged by easy access to blackboards which line the walls of the room.

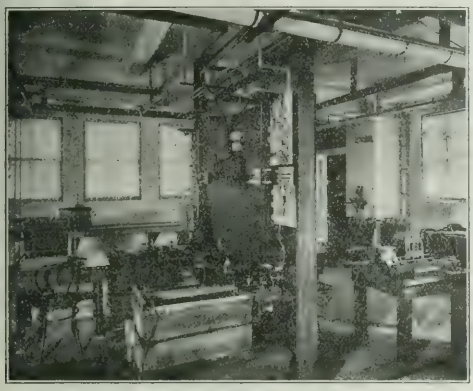


FIG. 15—POTENTIOMETER AND CALORIMETER LABORATORY, ROOM 2

A small LECTURE ROOM, Room 219, with seats for 60 people, is used for the courses in advanced physical and technical chemistry.

The DRAFTING ROOM, Room 304, is equipped with cross-section paper, drawing tables, and instruments. A glass top table illuminated from below is a special feature.

THE LABORATORIES

CONSTANT TEMPERATURE ROOM—A pit 14 ft. by 14 ft. and 10 ft. in depth is located under a portion of the sub-basement. A trap door in the ceiling and traps in the various floors above provide for a clear height of about 70 ft. for experimental purposes. The walls are heavily reënforced so that dangerous apparatus may be operated in this room. Since the room is underground and there is no access to it except through the trap in the ceiling very uniform temperatures can be maintained.

The CRYOGENIC OR LOW-TEMPERATURE LABORATORY (Figs. 7 and 8) occupies the sub-basement and Rooms 1 and 3 of the basement. The compressors and heavy moving machinery rest upon a floating foundation. This foundation consists of a 10-in. slab of reënforced concrete floating on 6 in. of dry sand and isolated from the rest of the building by a 2 in. sand joint (see foreground Fig. 7). With all the machinery in motion the laboratories are so completely free from vibration that the most sensitive galvanometers may be mounted directly on the walls (Fig. 15). The motor generator sets, Room 15, are mounted on a similar floating foundation.

The liquid air plant at present consists of a new 20 h. p., 4 stage, Norwalk compressor and Brin liquefier. A modern, high-efficiency, liquid air plant is planned for this laboratory and the present compressor will be used for the production of liquid hydrogen. A liquid helium plant is also planned. Two standard commercial units of Burdett electrolytic oxygen-hydrogen generators for the production of pure gases are installed. The liquefiers are on the floor above the compressors, which are visible through a 10 ft. by 10 ft. opening in the floor. Ample space and facilities for research at low temperatures are provided.

The POTENTIOMETER AND CALORIMETER LABORATORY (Fig. 15) adjoins the cryogenic laboratory and contains large oil thermostats and suitable high-resistance potentiometers permanently installed for the measurement of electrode potentials. A potentiometer sensitive to 0.000,000,01 volt and free from parasitic e. m. f.'s., and several 50-junction thermo-elements and twin calorimeters are in use. A second potentiometer of like characteristics is being installed.

COLD ROOM—Certain experiments cannot be carried out in the open air since the temperature in Berkeley is never below freezing. One-half of one of the small research rooms in the basement (Room 4) is therefore used as an ice box and provided with direct ammonia expansion coils. A standard laboratory desk and the usual laboratory piping and electrical service, with the exception of water, are available.

The HIGH VACUUM LABORATORY, Room 101, is provided with a series of 8 low benches, 6 ft. long, 18 in. wide and 18 in. high, at the back of which is a framework of $^1/_2$ in. steel rods upon which complicated glass apparatus may be conveniently mounted (Fig. 14). These benches are arranged end-on on each side of a central bench upon which is the usual laboratory piping and, in addition, 0.001 mm. of mercury vacuum.

The PHYSICAL CHEMICAL LABORATORY (Fig. 16) has space for 42 students. Five thermostats will be installed in this room.

A SPECIAL RESEARCH LABORATORY (Room 205) is provided for seniors doing advanced physical chemistry and researches which do not require large complicated apparatus.

A large number of small rooms are devoted to special purposes. Of these the polariscope room, No. 303, the spectrophotometer room, No. 305, the conductivity room, No. 311, and the high frequency conductivity room, No. 313, deserve special mention. A separate, well ventilated room, No. 316, is provided for work involving dangerous or unpleasant gases. Metallographic and photochemical laboratories, Rooms 322 and 301, are being equipped. There are two large dark rooms. A 60 ft. optical path is available in Rooms 303–313.



FIG. 16—PHYSICAL CHEMISTRY, ROOM 202, FOR JUNIORS. THERMOSTATS AND RELAYS ARE NOT YET INSTALLED

For the most part offices and private research laboratories have been combined. There are a large number of these, Room 103 (Fig. 14) being a typical example.

The ANALYSIS ROOM, No. 209, is equipped as a general analytical laboratory with electrolytic bench and other analytical conveniences. It is not intended for instruction, and it is probable

that a full-time analyst will be put in charge, who will do routine analysis connected with the various researches, prepare solutions, etc.

Small BALANCE ROOMS which can be kept free from moisture, carbon dioxide, etc., open off the analysis room.

The COMBUSTION LABORATORY, Room 213, adjoins the analysis room. It is equipped with organic and carbon combustion trains, multiple unit electric tube, crucible, and muffle furnaces.

The ORGANIC LABORATORY, Room 222, is fitted with a Kjeldahl rack, thermostats, and the general equipment of an organic laboratory. This laboratory is not connected with the organic department but is for the convenience of those who need to do organic synthesis, etc., incidental to theoretical and technical researches.

TECHNICAL LABORATORIES

The TECHNICAL LABORATORIES, Rooms 21, 22, 121, and 221, form in effect a four-story factory. The upper room is equipped for the analytical control of technical operations, the factory laboratory, and a part of the room is reserved for large apparatus. The main room (Fig. 12) contains a steam table, a drying closet, a large shelf dryer, 8 in. and 15 in. International basket centrifuges, a large International centrifuge, two 250-lb., 50-gal. jacketed autoclaves, two 2-gal. autoclaves, combination column still, extractor, condensers, etc., Kestner type evaporator, a 500-gal. tank, 5-gal. and 25-gal. jacketed cast iron kettles with extension pieces and covers. The kettles may be combined to make such pieces as vacuum pans, vacuum agitators, vacuum crystallizing evaporators with or without agitation, nitrators, sulfonators, etc. This equipment is being added to very rapidly.

The heavy technical rooms, Nos. 21 and 22, contain a steam boiler, a cement kiln, a suction filter, a filter press and grinding machinery.

The ELECTROCHEMICAL LABORATORY has been already partly described. Operations are worked out on a small scale in Room 119 (Fig. 10), and on a larger scale in Room 19 (Fig. 9). This room is provided with a traveling 2-ton Peerless hoist. A large stock of electrodes, refractories, and materials for furnace construction are carried in Room 11. The steel has been omitted from the floor in order to diminish eddy current losses. The furnace laboratory houses several gas and oil furnaces and a Herreshoff mechanical pyrites burner with six 24-in. hearths.

STORES

Stores are distributed from Rooms 214 and 216. Only a small number of instruments of general use are here. Most of the apparatus is stored in apparatus closets built in the laboratory in which it is most often used. A large room, No. 321, is provided for large set-ups temporarily out of use. All apparatus and stores are catalogued by the number of the room, a section letter, and shelf number. This number appears on the apparatus, and a tag giving the temporary location is left in the permanent location when the instruments, etc., are in use. It is the policy of the laboratory to keep all apparatus in use, and easily available day or night.

In this brief outline only those features which are unique in laboratory construction and equipment have been described. The accompanying photographs are designed to show certain of the rooms as they appear under actual working conditions.

UNIVERSITY OF CALIFORNIA
BERKELEY

DYEING OF KHAKI IN THE UNITED STATES[1]

HISTORICAL AND THEORETICAL

By JOHN C. HEBDEN

The khaki-dyed fabrics are used almost wholly for military purposes. The use of this color for uniforms had its origin in the Boer War. The peculiar shade of the terrain of South Africa made it possible to conceal the presence of troops from the enemy by adopting a shade for uniforms which blended with the color of the landscape. Military observers, noting the effect of the use of this kind of uniform, gave their attention to its development in other countries.

The history of the dyeing of khaki is spread through the literature, and really originates in the first patents taken out by Gatty in Great Britain in 1884. It was not, however, until 1897 that the development of this color was taken up seriously. The British dye houses then began to give particular attention to the production of this color, both on cotton and wool.

At about the year 1900 the American Government took up the use of khaki-colored fabrics for the manufacture of tents, kits, and uniforms. From that time there has been a steady development in the improvement of both the shade and quality of the fabrics. The early shades of khaki used by the American Government were comparatively light and of a greenish yellow tone. This shade was changed to a darker and more yellow brownish khaki. As the German field gray came into use, our Government adopted what is now known as the olive-drab. At the present time the three shades of khaki seem to be in use.

When the use of khaki was taken up by the American Army, our soldiers were clothed in uniforms made from woolen fabrics. Although the quality of the wool used was the best, such fabrics, in order to have strength, were of necessity heavy. Mr. T. B. Owen, between the years 1900 and 1902, while he was acting as superintendent of the Atlantic Mills in Providence, R. I., called to the attention of the Quartermaster's Department the superiority of worsted fabrics or worsted serges, particularly for the manufacture of blouses and shirts. These fabrics were tried by the Army and found to be superior to the woolen fabrics. To-day there is scarcely any woolen fabric used, except for blankets and overcoats.

Khaki is usually dyed on cotton or wool. The production of a khaki shade on silk is required so infrequently that methods for producing this color on this fiber need not be discussed.

The dyeing of khaki both on cotton and wool may be classed under the following methods:

1—Chemical or oxidation methods for both cotton and wool.
2—Mordant dyeing methods, particularly for dyeing wool.
3—After-chroming methods, or one-bath chrome methods, for wool.
4—Direct or substantive dye methods, with or without after-treatment, particularly for cotton, but also applicable to wool.
5—Sulfur color dyeing methods for cotton.
6—Vat color dyeing methods for cotton.

The chemical or oxidation method generally used for dyeing cotton cloths or yarns for khaki-colored fabrics, for use in uniforms, tents, and kits, is based upon the production in and on the fiber of a mixture of the oxides of iron and chromium. Before the shades thus produced were used for military purposes particularly, these dyes were usually designated as iron buffs. The browns produced by the use of salts of manganese, usually called manganese bister, are too deep and too red to be used as khaki shades or as the basis for khaki colors.

In the production of khaki by this method, the cloth is padded or saturated with a mixture of iron and chromium salts, and then, either with or without ageing, is passed into a solution of an alkali in order to precipitate the mixture of iron and chromium oxides in and on the fiber. An alternative method is to pad or saturate the cloth, dry at a low temperature, age in an ageing machine, and then pass into a solution of alkali in order to precipitate the oxides and produce the khaki color on the fiber. In the padding or precipitating method, when the padded or saturated goods are not dried, it is necessary to make several passages of the fabric through the solutions of the salts of iron and chromium, and through the alkaline solution. When the method in which the cloth is padded, dried, and aged before

[1] Address delivered before the New York Section, Society of Chemical Industry, May 24, 1918.

treatment with alkali is used, it is rarely necessary to make more than one passage through the different solutions. Thus it will be seen that while it is necessary to have special machinery and equipment in order to dye khaki by the short method, it is more economical and the shade of color can be more easily controlled. The first method described may rightly be termed the wet method, and the second the drying method.

The following recipe may be given as an illustration of the wet method:

75 lbs. chrome alum are dissolved in
25 gal. water. To this solution are added
5 qts. commercial nitrate of iron, 90° Tw.
5 qts. commercial pyrolignite of iron, 25° Tw.

The goods are first thoroughly boiled out, or half or full bleached, as may be required for the particular fabric. They are then padded in the above solution, so that the fabric is thoroughly saturated. After padding, the goods are passed through a boiling solution containing 6 ozs. of calcined carbonate of soda per gal. The passage through the iron and chrome salt solution, followed by the passage through the alkaline solution, may be repeated 4 or 6 times before a full shade of khaki is produced. After the depth of shade required is obtained, the goods are thoroughly washed to remove excess of alkali and to prepare them for any after-treatment required.

To produce a khaki color by the drying method, the following recipe will serve as an illustration:

10 gal. acetate of chrome, 32° Tw.
5 gals. pyroliguite of iron, 20° Tw.
10 gals. water are mixed together

The goods are padded in this solution, and dried at a low temperature. The goods may then either be passed through a boiling solution of carbonated soda or passed through an ageing machine after drying, and then through a boiling solution of carbonate of soda. One passage through the solution of chrome and iron acetates will produce a full or medium shade of khaki. It is rarely necessary to make two passages through the acetate solution.

Many modifications of the typical recipes given above have been used. These modifications have been attempted principally to modify the shade, *i. e.*, to make a color more olive in tone, and also to increase the fastness of the color produced to the chemical tests to which the fabric is subjected after dyeing. Thus, attempts have been made to add other salts than the salts of chromium and iron to the bath, with the idea of increasing the fastness to acids. None of these attempts, however, have been particularly successful, so that it is safe to say that the chemical or oxidation khaki on cotton cloth or cotton yarn is produced by the use of a mixture of iron and chromium salts. It is to be noted, however, that goods dyed with acetate of iron, or with iron salts other than the pyrolignite, are liable to become tender in storing. This is due to the gradual oxidizing and deoxidizing of the iron oxides formed in the dyeing process, this oxidizing process being accelerated apparently by the cotton fiber. When pyrolignite of iron is used, the impurities contained in this product seem to have a modifying action upon the oxidation process and less tendering is observed.

Khaki colors when dyed by either of the above methods or modifications of these methods are not particularly fast to acids, and do not meet the tests in this respect required by the military authorities. The colors, however, are very fast to light, scouring, washing, and the ordinary treatments to which the fabrics are subjected.

Many attempts to render the khaki-dyed fabrics, when dyed by the iron and chromium method, fast to acid, have been proposed. These methods consist in after-treating the dyed fabrics with various salts or acids, as, for instance, copper salts, boracic acid, tungstates, etc. None of these methods have produced a fabric which would meet the tests. The only method thus far published which will produce an iron and chromium khaki fast to acid is the one patented by Gatty, which consists in treating the steamed goods with a solution of silicate of soda.

Very fast bronze colors are produced on cotton by oxidizing on the fiber meta-phenylene or meta-tolylene diamine. A typical recipe for producing these so-called fast bisters or browns is the following:

1 lb. phenylene diamine hydrochlorate or acetate
1/2 lb. chlorate of soda
1/2 lb. yellow prussiate of soda
are dissolved in one gallon of water

Pad the well-boiled or bleached goods through this solution, dry at a low temperature, pass through the ager, wash and soap. The color may be modified by making various additions of oxidizing agents to the solution, or by adding various bases, as, for instance, alpha-naphthylamine, aniline salt, diamidodiphenylamine, sulfocyanate of ammonia, or even salts of iron and other compounds, which will produce dyes on the cotton fiber by the above oxidation method.

These colors, although remarkable for their fastness to light, scouring, and acids, have not been produced successfully in a large way, owing to the fact that the padding solution is constantly oxidizing and changing in composition. The color is thus produced in the solution before the fabric is wetted, and dried. In the case of phenylene diamine, the oxidation is so rapid that in order to obtain results it is necessary to make up the various solutions of ingredients separately, and mix these solutions together in the proper proportion as they are fed into the padding machine. This involves so much care and attention that the process does not seem to be suited to our manufacturing conditions. The author has made many attempts to overcome the oxidizing action in the solution, but thus far there seems to have been no method devised which will make it possible to make a comparatively permanent solution, as is the case in the solution used in dyeing aniline black by this same method.

We may safely say that the iron-chromium method for dyeing khaki on cotton is the only chemical or oxidation method in practical use. For the dyeing of khaki, however, on wool, both the iron-chrome method and the diamine method have been used very successfully.

The dyeing of khaki colors on wool or worsted yarn or tops, with a combination of iron, chromium, and manganese salts was worked out at the Atlantic Mills in Providence, R. I., in the years 1900 and 1902, by Mr. Herbert Fulsom, who was then chemist for the company. The details of the process were not made public. Mr. Fulsom succeeded in producing a color which was free from the harsh feel usually produced in mordanting wool with iron. This permitted the wool dyed after his method to be drawn and spun in the usual manner, and to produce yarns of excellent quality. The color was extremely fast to light, washing, and scouring, but was not remarkably fast to acid treatment. Its fastness in this respect, however, was sufficient to meet the Government test. The shade of khaki in vogue at that time was much lighter than the dark shade used at the present time. It would hardly have been possible to have produced as deep a color as is required by this method. Furthermore, it is not possible to produce the olive-drab by this method.

In 1903 and 1904, the author produced at the Peacedale Manufacturing Co., Peacedale, R. I., an oxidation khaki based on the diamine method. This color is remarkable for its fastness to light, scouring, fulling, acids, reducing agents, and rubbing. The maximum shade produced by this method is too light to match the shade of khaki now in vogue. When darker shades of color than the shade used at that time were attempted, this method failed. The process, however, can be used on tops,

yarns, or piece goods; the shades produced are remarkable in that they are level and uniform. The fiber is particularly soft, and spins practically as well as white wool. The method used is as follows:

For 450 lbs. worsted tops: Add to the dye bath the following products in the following order:

5 lbs. meta-tolylene diamine dissolved in
6 gals. acetic acid, No. 8

After the addition, enter the goods into this bath, keeping the temperature at about 120° F., and work the goods for 15 to 20 min. to allow the fiber to take up the diamine. Lift the goods, and then add the following solution:

7½ lbs. ferric chloride
18 lbs. chromium chloride or fluoride
12½ lbs. chlorate soda

Bring the bath to the boil, and work in the boiling bath until the shade is produced. The goods are then thoroughly washed, and need no subsequent treatment to prepare them for the spinning operations. The khaki thus produced is the fastest for the depth of shade of any of the dyes known to date.

Before discussing the mordant dyeing after chroming, one bath chrome, and the direct dye methods for the production of khaki shades, let us consider the relation of fastness to scouring and alkali to the chemical constitution of dyestuffs in general. From a careful study it will be seen that the fastness to scouring and alkali depends upon the chemical constitution of the dye molecule, and upon the nature or chemical reactivity of the elements or molecules substituted in the nucleus or nuclei of this molecule. The substitution of halogen, nitro groups, amido groups, sulfo groups, hydroxyl, carboxyl, and other groups, not only react as chromophoric radicals, but modify the chemical reactivity of the dye molecule. These substituted groups thus determine the dyeing properties of the compounds, the fastness of the colors produced to scouring and alkali, and also modify the shade due to their chromophoric character. From a study of these substitutions in the molecule, the dyeing properties and fastness to scouring and alkali can be predicted.

Generally speaking, a dyestuff, in order to be applied to the fiber, must be soluble in water. This solubility is generally dependent upon the substitution in the molecule of a sulfo, hydroxyl, or carboxyl group. If these groups be present and are not in the ortho position, the solubility of the dyestuff, even after being dyed upon a mordant or fixed by after-treatment, may be sufficient to render the color not fast to scouring. There is a class of colors containing an amido group in the molecule which, after the dye is fixed upon the fiber, can be diazotized and developed, as it is termed. If there are too many sulfo, carboxyl, or hydroxyl groups in the molecule, the color produced, even after developing, is not fast to scouring. The fastness to scouring and alkali is decreased in proportion to the increase in the number of these groups substituted in the dye molecule.

Colors fast to scouring and alkali cannot be produced unless those groups which are capable of dyeing upon a mordant, or being after treated after the dye is fixed upon the fiber, are present in the molecule and are in such a position one to the other, that definite compounds can be produced by combining with the mordant or by the after-treatment. The sulfo groups of a dye molecule cannot be treated by any reagent now known, which will render them fast to scouring or alkali. Neither can the hydroxyl or the carboxyl groups be treated and made insoluble unless they be in the ortho position one to the other. Thus, two hydroxyl groups, one hydroxyl and one carboxyl group, and certain hydroxy azo groups, when in the ortho position, determine the property of fastness to water and scouring when the dyestuff is either dyed upon a mordant or after-treated with a compound which will render the color insoluble.

Kostanecki showed that the property of dyeing on a mordant, possessed by certain color acids, was due to the fact that those color acids which dye on a mordant, have either two hydroxyl groups in the ortho position in the molecule, or a hydroxyl and a carboxyl group in the ortho position, or that the compound was an orthonitroso, or orthoquinone oxime. When the dyeing method now known as the after chroming method was studied and analyzed with reference to the chemical constitution of the dyestuffs, it was found that the ortho position was the determining factor. Thus, orthodihydroxy, peridihydroxy, orthohydroxycarboxy, and certain orthohydroxyazo dyes were all not only modified in color, or developed in shade by after-treating the dyed fiber with bichromate or by dyeing with chromate or chrome salts, but they all had distinct mordant dyeing properties following the Kostanecki rule.

Not all dyes, however, which meet the requirements of the Kostanecki rule, or those which may be after-treated, are fast to scouring. This lack of fastness is due to the modifying influence on the solubility of the dye, of the groups substituted in the molecule other than those which give the dye the mordant dyeing or after-chroming property. These substituted groups have sufficient influence upon the solubility of the after-treated or mordant-dyed color, to render the dye produced not fast to scouring and alkali.

To illustrate these facts, a few concrete examples may be cited in order to show the relation of dye constitution to the production of fast khaki shades.

Alizarine is an orthodihydroxy anthraquinone, the hydroxy groups being in the 1,2 positions. The Turkey red produced by the use of true alizarine is the fastest red to boiling and bleaching. The scarlet reds made from anthrapurpurine and flavopurpurine, as well as the red made from purpurine, are not as fast as true alizarine red made from alizarine. This lack of fastness is due to the presence in the molecule of a third hydroxy group. This group readily unites with any alkali, rendering the lakes formed with the mordant soluble. True alizarine, not having this third hydroxy group, is practically insoluble. Those alizarine blues which are penta- and hexa-hydroxyanthraquinones are not as fast to scouring as alizarine, because all of these dyes have a hydroxy group which can react as does the hydroxy group in anthraflavine or flavopurpurine.

Sulfo, nitro, and carboxyl groups can react in the same way as does the hydroxy group when not in the ortho position. Colors containing these groups are invariably not fast to scouring or alkali unless the sulfonic acid nitro compound, or other compound, in which the group is substituted, is of itself difficultly soluble. An increase in the number of these groups in the dyestuff molecule generally produces very soluble compounds, and therefore the colors produced therefrom are not fast to scouring and alkali.

The mordant dyeing methods require two operations: First, the mordanting proper; second, the dyeing. For the production of khaki shades there are really only two mordants which may be considered, *viz.*, the chrome and titanium mordants. Iron, nickel, cobalt, and aluminum mordants produce, when combined with the proper dyestuffs, khaki shades; but the colors produced fail either in fastness to light, scouring, alkali, or acid. The colors produced in a titanium mordant are remarkably fast in every respect, but the colors which dye on this mordant and produce khaki shades are very limited. The chrome mordant, however, permits of the use of a wide range of dyestuffs, and has this advantage, that khaki shades can be produced by the chrome mordanting method by the use either of the regular mordanting method, the after-treating method, or by the one bath chrome method. The chrome after-treating method, and the one bath chrome methods are the methods usually used. Neither of these methods are applicable to the production of khaki on cotton.

The true mordant dyeing yellows, as, for instance, the oxyketone colors represented by alizarine yellow or galloaceto-

phenone and the yellow dyestuffs derived from dye woods, tannins, and from natural sources, while they can be combined with red and blue mordant dyeing dyestuffs and produce khaki shades, are not fast to scouring and alkali because of the pre ence of a hydroxy group in the molecule, which does not unite with the mordant. These dyes follow the rule laid down for anthrapurpurine and similar dyestuffs. The strictly mordant-dyeing dyestuffs are not, therefore, used in producing khaki colors. Many, however, of the acid dyes which produce khaki shades can be dyed on a mordant; but the method is long and does not yield the fastest colors, nor is the method as practical as the after-treating or one-bath chrome method. The mordant-dyeing method has, therefore, found very little use for this purpose for the dyeing of wool. Except as a printing method it has found no use on cotton.

The dyestuffs used for the production of the yellow-orange or yellow-brown used as a basis for khaki, to be shaded to the true khaki shade with blue, black, or green, and with red or a reddish brown, are nearly all azo dyes derived from salicylic acid. The hydroxyl and the carboxyl groups in the ortho position in the salicylic acid molecules give these dyes the property of dyeing on a mordant. They follow the Kostanecki rule in this respect. At the same time, the chromogen in the color, being the azo group, and the substitutions in the molecule being acid in character, the dyes are true acid dyestuffs. They therefore can be dyed either as acid dyes or as mordant dyes, or can be after-treated. Many of these dyes, also, can be dyed by the chrome in the bath method. The fastness of the dyes to scouring and alkali varies in proportion to the numbers of those groups substituted in the molecule, which tend to render the compound soluble. The colors are uniformly fairly fast to light and acid; certain members of the series are exceptionally fast to all the tests required. The major part of the coloring entering into a khaki shade is yellow, so that the amount of blue and red required to produce a true khaki color, or an olive-drab in conjunction with the yellow or orange or yellow-brown, is very small. For this reason only those dyes, which in very light shades are fast to scouring and light, can be used for shading purposes.

As types of the dyestuffs that may be used, the following are cited:

Alizarine Yellow—Salicylic acid plus nitro anilines

Milling Yellow—Salicylic acid plus amidoazobenzol and its monosulfonic acid

Chrome Fast Yellow—Salicylic acid plus amidocresolether

Chrome Fast Green H acid plus orthoamidoparanitrophenol

Acid Alizarine Garnet—Resorcine plus orthoamidophenolparasulfonic acid

Changes may be run on these combinations by using dyes which produce the same relative amounts of yellow, red, and blue when dyed. Thus, the acid alizarine garnet may be in part or wholly replaced by a red-brown; the green by a black or a blue, which yields, when dyed, a fast gray. Again, the yellow derived from the salicylic azo compound may be replaced by the fast yellows derived from primuline, which are usually termed chloramine yellows. The khaki colors produced to-day on wool are made from combinations of dyestuffs similar to the colors enumerated above.

The khaki colors produced by the direct or substantive dye methods are in no case, even when after-treated or developed, on cotton or wool, sufficiently fast to pass the Government test. This method of dyeing is used, however, at times. The combinations of dyestuffs that may be used are almost without limit but the colors obtained are uniformly not sufficiently fast. The dyeing method is simple, involving a dyeing in a salt or soap bath for cotton, or a weak acid bath for wool. The color produced by the direct dyeing may be used as such, or may be after-treated with a mixture of bichromate, sulfate of copper, and acetic acid, or diazotized and developed on the fiber, as the case may be.

The sulfur colors form an important group of dyestuffs for the production of khaki shades and olive-drab on cotton. The dyeing method is simple and direct, and the fiber is, when properly dyed, uniformly soft and strong. The dyeing method consists in boiling the cotton in a solution of the dye made by reducing the color with sodium sulfide, and adding alkali and salt to this solution in order to fix the dye on the fiber. Dyeings made from sulfur colors should always be thoroughly washed with water, and then soaped and wrung or extracted in the centrifuge, so that some of the soap solution may be left in the fiber, and the fiber or cloth thus be rendered alkaline. This after-treatment or finishing operation is necessary in order to render the fiber soft, and to prevent the oxidation of any sulfide compound which may be left in the fiber. This subsequent oxidation of the dye on the fiber may result in tendering of the cotton. The oxidation and tendering, however, is prevented by the alkaline condition of the fiber.

Direct dyeings of sulfur colors are usually not sufficiently fast to scouring and acid to meet the Government requirements. However, if a proper selection of dyes be made, and the direct dyeings made from these be after-treated with a solution of bichrome, sulfate of copper, and acetic acid, colors which meet the ordinary Government test are obtained. The use of mineral acid in this after-treatment may produce a subsequent tendering of the fiber, even though the dyeings be after-treated or finished from soap solution. For this reason, acetic acid only should be used in this after-treatment.

The sulfur dyes are all manufactured by empirical methods. The constitution of the colors and the chemical reactions involved in their manufacture are not known. It is, therefore, necessary to select the dyes to be used, only after careful dyeing tests have been made, and these dyeing tests subjected to the required tests for determining the fastness to scouring, alkali, acid, etc. By making combinations of dyes selected from the evidence obtained from such dyeing tests, satisfactory khaki shades can be produced. The sulfur colors are not applicable to wool.

The vat dyes, so-called, because they are dyed in reduced condition in a vat, as is indigo, produce, next to the oxidation or chemical method, the fastest khaki colors. These dyestuffs, when reduced to leuco compounds by the use of hydrosulfite of soda or other reducing agents, and dissolved in alkali, have an affinity for the cotton fiber. If the cotton, either as raw stock, yarn, or in the piece, be immersed in the dye, the fiber will take up the leuco compound from the solution. This dissolving of the leuco compound in the fiber continues until the solubility of the compound in the alkaline solution and in the fiber reaches an equilibrium. The equilibrium varies for each dye. If the cotton which has taken up the reduced dye be wrung out to remove the excess solution, and subjected to the action of the air, the leuco body is oxidized, and the color is produced on the fiber.

Not all dyestuffs belonging to this class are fast. But there are several which produce the fastest shade known on cotton. From these exceedingly fast dyes, a great variety of very useful shades can be produced. The dyeing method is applicable to raw stock or yarn, and by special methods cotton piece goods may be dyed with these dyestuffs. The colors produced by the fast dyes of this class are fast to the severest scouring and boiling, fast to acids and bleaching, and exceedingly fast to light. The dyeing being performed in an alkaline bath, the cotton fiber or cloth is therefore uniformly soft and strong.

In dyeing khaki by this method, the yellow entering into the shade is again the major part of the dyestuffs used. The yellows that may be employed are those known under the trade name of ALGOL YELLOWS AND ORANGES, CIBANONE YELLOWS AND ORANGES,

HELINDONE YELLOWS AND ORANGES, and INDANTHRENE YELLOWS AND ORANGES. By the use of the proper dye methods these yellows can be shaded to produce khaki colors and olive-drab, meeting the severest tests as to fastness. For shading these yellows to produce a khaki or an olive-drab, it is necessary to use colors of the same class, giving the red or blue-gray tones necessary to produce the shade required in conjunction with the yellow used. The colors available for this purpose are those known commercially as algol corinth, algol red, algol olive, algol brown, cibanone brown, indanthrene corinth, indanthrene brown, algol brilliant violet, and indanthrene blue.

By using combinations of these dyes, the fastest khaki shades for cotton are produced. It would be interesting to study the chemical constitution of these dyestuffs, and note the effects of constitution, first, upon the dyeing method, and, second, upon the fastness of the colors produced. This discussion involves so many factors that it is not possible at this time. The vat colors cannot be used for the dyeing of wool (at least, according to the present dyeing method) because the amount of caustic soda required to dissolve the leuco compounds is sufficient to dissolve or permanently weaken or destroy the wool fiber.

The khaki-dyed fabrics, being primarily for military purposes, should be manufactured having in view the production of a fabric of the highest quality, the production of the greatest yardage in a given time, and the manufacture of the cloth at the lowest possible cost per yard. The specifications have uniformly called for a fabric to be made from wool or cotton dyed in the stock. The production of fabrics following these specifications is thus of necessity confined to the mills having facilities for dyeing raw stock. The cost of yarns manufactured from stock-dyed cotton or wool is greater than the cost of yarns spun from white or gray cotton or wool. The quality of the fabrics made from stock-dyed yarns is no better, and frequently is inferior to the quality of piece-dyed goods. The production per unit of machinery of stock-dyed fabrics is lower than the production of gray or white goods. It is the opinion of the author that to procure the highest quality of fabrics, the greatest quantity in the shortest time, and at the same time the lowest cost, the piece-dye method should be adapted both for cotton and wool and worsted fabrics. A large percentage of the cotton fabrics now used for military purposes is manufactured by the piece-dyeing method. If these goods are satisfactory there is no argument against extending this method of manufacture to include all fabrics. Serge blues or worsted piece goods, as they are termed, are recognized as standard for quality. There is no valid argument against making khaki-colored serges, dyed in the piece, standard also.

When we consider the work done, and the progress made in the dyeing of khaki in the United States, we need not feel ashamed. Our manufacturers have produced fabrics equal to the best foreign goods. Our dyers have developed methods not used abroad, and have accommodated dyeing methods to manufacturing procedure, so that the foreign manufacturer has been compelled to imitate some of the methods developed in this country.

We are dyeing cotton piece goods by the iron-chrome chemical or oxidation method, equal in quality to the foreign goods. Our dyers have developed machinery for this process, so that the process may be said to be truly American, as it is practiced in this country to-day.

It is true, we have not developed the diamine oxidation process for cotton; but, should economic conditions recommend or warrant the development of this process, it can be safely predicted that the method will soon be developed into a practical dyeing process for khaki-colored piece goods.

We have developed both the iron-chrome and the diamine oxidation methods for wool. These methods have been used very successfully, and have demonstrated that the colors obtained are the fastest for the depth of shades produced. It does not appear that either of these methods has been used abroad.

The after-treating or chrome-in-the-bath methods are practiced by our dyers, producing goods by the raw stock, yarn and piece-dyeing methods equal to the best foreign fabrics.

Large quantities of sulfur dyestuffs are used for dyeing raw cotton for khaki-colored goods, and for dyeing piece-goods producing both the true khaki shades and the olive-drab colored cloth. The dyeing methods generally used are the same as those used abroad, and the quality of the color produced is equal in every respect to the color on the foreign fabrics. We have an American method, however, for dyeing piece goods with the sulfur colors, which permits the dyer to produce a full shade of either khaki or olive-drab by making one passage through the dyeing apparatus. The color produced by the use of this method is equal to the best produced by other methods. This continuous method of dyeing piece goods is not generally in use here, however, and had apparently not been used abroad.

We have produced from raw stock and yarn dyed with the vat colors the fastest known shades for cotton fabrics used for military purposes. The fabrics have been manufactured in large quantities, and have proved the value of both the dyeing and manufacturing method used. The continuous process for dyeing piece goods for sulfur colors may be, with slight modification, used for the dyeing of piece goods with the vat dyestuffs. By this special method cotton fabrics dyed with the vat colors may be manufactured at the lowest cost, and in the greatest volume.

When we cast up the account as rendered by the American dyer, we must be convinced that he has made a particularly good showing in this particular branch of his industry. With intelligent coöperation between the Government, the dyer, and the manufacturer, we can have an army clothed with the strongest, best-wearing, and warmest uniforms in the world. May this result be attained!

NEW YORK CITY

THE STATUS OF CHEMICAL ENGINEERING IN OUR UNIVERSITIES AND COLLEGES IMMEDIATELY PRIOR TO THE DECLARATION OF WAR

By HARPER F. ZOLLER[1]

Received May 3, 1918

It was while I was engaged in gathering data on a certain problem connected with curriculum work that I forwarded the following questionnaire to the departments of chemistry in the various universities and colleges. The questionnaire was mailed on February 5, 1917, and by March 21, 1917, all replies that were forthcoming had been received. In respect to the nature of the questionnaire and the replies, several have suggested to me that they should be tabulated and published, since they reflect the probable status of the chemical engineering courses in our schools at the time the United States declared war. The replies have, therefore, been arranged in a table as far as their nature would permit. I take this opportunity to express my appreciation of the readiness on the part of those in charge of the departments of chemistry to coöperate by answering the questionnaire. Of the total number sent out, only one failed to answer and I attribute that instance to the inexactness of the third question. A few colleges have been included in the table to which the questionnaire were not sent. These are indicated. The data concerning these was secured from Volume II of the Report of the Commissioner of Education. A bulletin or catalogue of the courses in chemistry was also requested of each of the schools and received.

QUESTIONNAIRE

1 Do you offer a course in chemical engineering?

2 In what year was the course first offered?

3 Do you lay special emphasis on the course?

[1] Formerly of the department of chemistry of the Kansas State Agricultural College, Manhattan, Kansas.

Name of Institution	Course in Chemical Engineering	Year Course Was First Offered	Does the Course Receive Special Emphasis?	Remarks
Alabama, University of[1]	Yes	..		
Amherst College	No	..		
Arizona, University of[1]	Yes	..		
Arkansas, University of	Yes	..		
Armour Inst. of Tech	Yes	..		
Brown University	No	..		
Bucknell University[1]	Yes	..		
California, University of	Yes	..		
Carnegie Inst. of Tech	Yes	..		
Chicago University	No	..		
Cincinnati, University of	Yes	..	"Same as other courses in engineering."	Coöperative course in chemical engineering.
Clark University	No	..	"Hope to institute course soon."	Course in chemistry.
Clemson Agr. College	No	..	"Four years' work in chemistry."	
Colgate University	No	..		
Colorado, University of	Yes	1903	"Same as other engineering courses."	
Colorado School of Mines[1]	Yes	..		
Columbia University	Yes	..		
Connecticut Agr. College	No	..		
Cornell University	Yes	1910	"Designed to train young men in the profession of chemistry."	
Dartmouth College	No	..		
Drake University[1]	No	..		
Florida, University of	No	..		
Georgia Inst. of Tech	Yes	1901	"Advise students in chemistry to take engineering course."	
George Washington Univ.[1]	No	..		
Harvard University	No	..		
Idaho, University of	Yes	1910	"In training future chemists, yes."	
Illinois, University of	Yes	1894	"Yes."	
Indiana, University of	Yes	..		
Iowa, University of	Yes	1904		Receiving special impetus through the introduction of five-year courses.
Iowa State Agr. College	Yes	1908	"Special emphasis since 1914."	
James Milliken University[1]	No	..		
Johns Hopkins University	No	..		
J. B. Stetson University[1]	Yes	..		
Kansas, University of	Yes	1900		
Kansas State Agr. College	No	..		
Kentucky, University of	No	..		
Lehigh University	Yes	1902	"Yes."	
Leland Stanford Jr. Univ	Yes	1892	"Yes."	Four-year A.B. degree. Five-year engineering degree.
Louisiana, University of	Yes	..		
Maine, University of	Yes	..		
Maryland Agr. College	No	..		
Massachusetts Inst. of Tech	Yes	1900	"Assuming an important place at present."	Five-year courses offered.
Massachusetts Agr. College	No	..		
Michigan, University of	Yes	1898		Receiving special announcement through department bulletins.
Michigan Agr. College	Yes	1916	"Receives same emphasis as other engineering courses."	
Minnesota, University of	Yes	..		
Mississippi, University of[1]	No	..		
Missouri, University of	Yes	..	"Coördinated with school of engineering."	Five-year course anticipated.
Montana, University of	No	..		
Nevada, University of	No	..		
Nebraska, University of	No	..		
New Hampshire Agr. College[1]	Yes	..		
New York University	Yes	1898	"Equal prominence with civil and mechanical engineering."	
New York, Coll. of the City of	No	..		
New Mexico, University of[1]	Yes	..		
North Carolina, University of	Yes	..		
North Carolina Agr. College[1]	No	..		
North Dakota Agr. College	Yes	1911		
North Dakota, University of	No	..		
Northwestern University	Yes	..		
Notre Dame, University of	Yes	1908	"Yes."	
Ohio State University	Yes	1906	"Yes."	
Oklahoma, University of	Yes	..		
Oklahoma Agr. College	No	..		
Oregon, University of	Yes	..		
Oregon Agr. College	No	..		
Pennsylvania, University of	Yes	1893	"Yes."	
Pennsylvania State College	Yes	1902	"Yes."	Called industrial chemistry.
Pittsburgh, University of	Yes	1913	"No."	Mellon Institute stimulates.
Polytechnic. Inst. of Brooklyn[1]	Yes	..		
Princeton University	No	..		
Purdue University	Yes	1907	"Yes."	
Rensselaer Polytechnic. Inst	No	..		
Rochester, University of	No	..		
Rose Polytechnic. Inst	Yes	1909	"Receiving emphasis along with other courses."	
Southern California, Univ. of	Yes	..		
South Carolina, University of[1]	No	..		
South Dakota, University of	No	..		"Course in chemistry" (1908); elect from engineering courses.
South Dakota Agr. College	No	..		
Swarthmore College	Yes	1904		
Syracuse University	Yes	..		
Tennessee, University of	Yes	1912		
Texas, University of	No	..		
Texas Agr. College	Yes	1908	"Pushing as rapidly as possible."	
Throop Polytechnic. Inst	Yes	1916		
Tufts College	Yes	..		
Tulane University	Yes	1913	"Receiving special stress."	
Utah, University of	Yes	1905	"No, because of lack of proper equipment."	
Vermont, University of	No	..		
Virginia, University of	Yes	1909	"Very great emphasis."	
Virginia Polytechnic Inst	Yes	1913	"Same as other courses."	Four-year course A.B. Five-year course in chemical engineering.
Washington, University of	Yes	1904		Coördinately with college of engineering.
Washington State College	Yes	1915	"Yes."	
West Virginia, Univ. of[1]	No	..		
Wisconsin, University of	Yes	1904	"No more than other engineering courses."	Advanced work offered in chemical engineering.
Wyoming, University of	No	..		
Yale University	No	..		

[1] Questionnaire not sent.

DISCUSSION

One might engage in endless differentiations of the courses as offered in the above schools, but this would be neither apropos nor beneficial. My purpose is merely to call attention to some erroneous impressions which might be received on a too hasty glance at the foregoing tabulations.

In glancing through the bulletins one finds that several of the so-called courses in chemical engineering are nothing other than courses in industrial chemistry and often weak ones at that, and would not fit a young man for plant control; that is, he would not be an engineer in the true sense of the term. Other schools give an abridged engineering course; abridged in the sense that the course is given through the department of engineering and not through the department of chemistry. This would tend towards the production of chemical engineers deficient in chemistry, whereas the former would produce chemists without the fundamental knowledge of engineering. It is to be hoped that the present situation into which this country has been plunged as regards hasty, efficient, and voluminous production, will influence educational institutions to recognize the danger in these two extremes, and will lead them to correct it. Those universities which instituted chemical engineering in the early 90's have emerged with a well-rounded engineering course for the chemist. They have also found that the engineer can not acquire very special knowledge along chemical lines within the 4-year limit, and have therefore offered 5 and 6 year courses in chemical engineering with appropriate degrees.

One or two universities, notably the University of Iowa, have instituted courses in business training along with the engineering work. Whether or not this will be a success remains to be seen, though one must admit that the plan is a good one. The time element has been considered by making the combined course require 5 years for completion.

The University of Michigan and the University of Washington, following the early example of the University of Kansas as planned by the late Professor Duncan and the later example of the Mellon Institute, are offering industrial fellowships to chemists of ability. Michigan, I believe, has been doing this for several years. While this is not strictly a chemical engineer's problem, it serves to stimulate interest among the student engineers and furnishes to them an opportunity to witness some of the manipulations and also to consider some of the problems which they may be called upon to solve.

One will judge from the table that the Middle West and West were foremost in developing courses in chemical engineering, the pioneers being Leland Stanford Jr. University, University of Pennsylvania, University of Illinois mentioned in the order of priority. However, these early courses were much like the courses in industrial chemistry as now offered and contained few engineering subjects. It would be entirely wrong to allow the impression to remain concerning the similarity of courses among those institutions which have signified that a course in chemical engineering is offered. Some of the institutions offering it are not in proximity to manufacturing industries of any size, neither do they plan inspection trips for their engineering students. The courses are, therefore, at their best, only weak courses in industrial chemistry as before intimated.

I might be criticized for not including the number of graduate students in chemical engineering for the various schools in the above table, but I purposely refrained from so doing. The figures would have been entirely misleading, since I found that in some institutions where the courses were well ordered only a small number of graduates appeared, whereas the converse was also pronounced.

In closing it should be mentioned that the AMERICAN CHEMICAL SOCIETY as a unit has done very little towards the influencing of young men to take up chemical engineering as a life work. Neither has it offered to act in an advisory capacity for the young men by suggesting to them the type of training that they should seek, or for that matter what should be embodied in a chemical engineering course. Very often the administrative officers of the institutions interested would welcome destructive and constructive criticism while they were shaping their chemical engineering curricula. It has frequently entered my mind that THIS JOURNAL could well afford to give over one page to university and school activities in the field of chemistry. While the Personal page now run deals primarily with the personnel of various enterprises, the one I have in mind should treat exclusively of chemical department curricula, improvements and changes in school laboratories, school problems, open criticism on the nature of various chemical courses now given with unification and improvement as an objective. THIS JOURNAL, since it is to be found on the periodical shelves of nearly every city library in the country, would then become an object of value to the high-school student, as well as to the young man who has become infected with the chemical engineering bacillus.

A young man should, when planning to enter a university or college to study chemical engineering, carefully consider the following questions, and not immediately pick up his grip and hie himself to a college of his father's or teacher's connection or for some other similar unsound reason: (1) Has the school a well-balanced department of chemistry with an efficient corps of teachers? (2) Is the engineering department among the best in the country? (3) Is the equipment of laboratories sufficiently modern to train the chemist in the modern methods and processes? (4) Is the course in chemical engineering of standard type, or is it of hyphenated nature, or possibly camouflaged? (5) Is the school contiguous to large manufacturing enterprises involving chemical control and chemical processes, or does it offer opportunity to its students in chemical engineering to visit such plants at a distance?

It would be well if the bacillus mentioned above would produce a wholesale epidemic during the coming decade, or better still if THIS JOURNAL could sow the seed of infection broadcast. However we should control the nutritive character of its medium by the employment of standardized constituents.

WASHINGTON, D. C.

COLLEGE COURSES FOR INDUSTRIAL CHEMISTS

By CHARLES W. HILL

Received December 4, 1917

In secondary education, we have recognized the fact that a large proportion of students are compelled by force of circumstances to become self-supporting at the end of their high school course. We have successfully supplemented the old college preparatory course by business and trade courses, and have established technical high schools, with the object of giving these students the best preparation possible for their entrance into the commercial or industrial world. Similarly in university education, we have supplemented the classical course by courses in engineering, agriculture, forestry, etc., and have established technical institutions for the benefit of students who are limited to four years of college training.

Among our students in chemistry we have those who are limited to four years of college and those who may pursue special or graduate work. For the first class, we have courses in chemical engineering and the B.S. course in chemistry. The latter course usually serves as the undergraduate work for those who will continue above the four years.

Judging by the volume of published discussion on the subject, there is a serious question whether we are giving our four-year students in chemistry the best preparation possible for their future work in the chemical industries. It is the writer's opinion, after some years of contact with a large number of graduates from various colleges, that our chemical engineers are quite

likely to be hyphenates with the accent on the last word of their title. They seem to be engineers primarily and secondarily, and chemists—at best—only thirdly. They are well grounded in engineering but not in chemistry, either pure or applied. They are frequently weak in the application of their engineering knowledge to industrial chemical processes or machines.

The B.S. course in chemistry seems to leave the graduate decidedly "up in the air" as far as the industrial applications of his training are concerned. If he is trained for anything, it may be for the duties of an analytical chemist. However, I have been told by some who are experienced in this line, that he is not well trained for this work. Be that as it may, it does not seem to the writer that this is a field for which we should train more than a small proportion of our students. It is his experience that the position of analytical chemist in the industries is one in which "the maximum of labor means the minimum of pay" to paraphrase a recent war poem. The opportunities for increasing compensation usually depend upon the transfer of the chemist into the factory. Possibly if we could keep more of our graduates from becoming analytical chemists, the diminished supply would result in higher pay for the analytical chemist who usually deserves much more than he is receiving.

The sins of our teaching are those of commission and omission. It strikes the writer that our greatest sin of commission is the time and energy required by courses in analytical chemistry, which could be used on other matters of more importance and usefulness. We have qualitative analysis, general quantitative analysis, and a host of small courses such as gas and fuel, water, mineral, food, electro, etc. The laboratory work of nearly all these courses consumes a large portion of the student's time. Like the classics, many teachers cherish these courses for their "disciplinary" value. We administer them to all comers. Engineers and others who will never be called upon to make an analysis (and could not make it were they called upon) are sent through the routine. An engineer or an industrial chemist should of course appreciate the general methods and operations of analytical chemistry. He should appreciate the accuracy or lack of it in an analysis. How many colleges teach the theory of errors in connection with analytical chemistry? He should know when to call upon an analyst for his services and he should be able to interpret the analysis. Do the tedious hours spent in following a laboratory outline for the analysis of a limestone or a clay teach him this? It is very doubtful if the usual experiments in analysis give the student a broad view of the accuracy or the application of the subject.

It has often occurred to the writer that a course might well be arranged of the nature of the following outline, which could be given in a shorter time than the present courses to engineers and industrial chemists. The engineers could then be given the elementary principles of physical chemistry, while the industrial chemists would have more time for the same subject and a course in advanced inorganic chemistry and increased work in industrial chemistry along the lines outlined in the latter part of this article.

- Sampling (Fineness and Size of Sample)
  - Influence on value of analysis
- Preparation of Sample
- Weighing
  - Error
  - Weight of sample for analysis
- Solution
- Precipitation
  - Effect of
    - Concentration
    - Acidity
    - Temperature
    - Time
  - Precipitate
    - Occlusion
    - Washing
    - Drying
    - Igniting
    - Weighing
- Titration
  - Indicators and test plates
- Oxidation and Reduction
- Absorption Methods
  - Gas analysis
- Combustion Methods (Including Calorimetric Determinations)
- Electrochemical Methods
- Interpretation of Analysis
- Short Tests
  - Specific gravity
  - Ash, etc.
- Study of errors and variables in all operations and determination of accuracy in each step

The cardinal sin of omission in our instruction of industrial chemists is that we give them little training in industrial chemistry that is of real benefit. The usual course in industrial chemistry, so-called, consists in a brief study of the chemical reactions involved in a wide variety of chemical industries. The information given regarding any one industry is naturally general and limited in amount. Doubtless the student can learn more regarding any one industry during a week or two in a factory than he can get in college from the best of texts or teachers. The chances of his ever becoming directly interested in any one of the industries usually described are not great, and if he does, he can soon learn the business first-hand. The remainder of the time spent on other subjects is largely wasted except as a matter of general information. This information he can get after graduation by reading a standard text on the subject.

However, there are matters which apply to almost any industry and which might well be substituted for the usual course in industrial chemistry, using some of the time gained by shortening the work in analytical chemistry. The writer had the opportunity of giving a course along the lines indicated by the following outline to a class of senior chemists and chemical engineers. Since these students have gone out into industrial work, unsolicited letters have been received from several of them to the effect that this course was the most beneficial of all their college work. Admittedly this is an exaggeration, since the course depended for its success on the training which the student had received in previous courses; but it is a good check on the application of the material to several industries. Naturally, the writer in presenting the course was limited by his experience to those phases of the subject in which he had had industrial experience. Since this is not full, as shown by the outline, it would be interesting to publish the outline in order that others may suggest additions which will then present to our educators a rather complete outline of subjects which those in industrial work regard as important and which it would be desirable to have covered in the college training of our young industrial chemists. There is pressing need for a good book on this line, which could be used not only in college but in actual practice. Special chapters should be written by those in authority on the various lines and the book should be edited by one of broad industrial experience.

The criticism has been made of the course that it is really chemical engineering and not industrial chemistry. The name is not important. While some of the subjects are touched upon in the course in chemical engineering, the topics are usually developed from the purely engineering standpoint. It is not necessary for one to be able to design an electric motor to be able to use it properly, and no great amount of electrical training is needed to enable the student to recognize the various types of motors, their characteristics and their applications.

In presenting the following course, the students were required to work up a bibliography from the scientific and patent literature, and to prepare a paper on one of the general subjects, using indexes, abstracts and catalogs with which so many of our graduates are unfamiliar. They were asked to order books for a library and to make a list of manufacturers of certain important raw materials, equipment, and apparatus.

OUTLINE OF COURSE

LITERATURE
- Indexes and Abstract Journals
- Scientific and Trade Journals
- Books
- Patent Records
- Private Files of Data and Reference

POWER
- Production
  - Steam
    - Boilers—Boiler Water
    - Combustion—Flue Gases
    - Stokers—Draft
    - Producer Plants
  - Gas Engine
  - Electric
- Distribution
  - Shafts—Belting—Gears
  - Electrical
    - A. C. and D. C. Systems
    - Transformers—Resistances
    - Circuit Breakers—Switches
    - Motors
- Fuel
  - Liquid
  - Coal—Kinds and Properties
    - Powdered
  - Gas—Kinds—Production

MEASUREMENTS
- Weight
  - Scales
  - Automatic Weighers and Proportioning Apparatus
- Meters
  - Uses—Accuracy—Calibration
  - Electric
    - Types and Application
    - Wiring
  - Pressure
    - Volume—Gas and Liquid
  - Recording
- Heat
  - Thermometers
  - Cones
  - Thermocouples
  - Optical Pyrometers
- Time
- Speed

POINTS COVERED IN STUDY OF EACH MACHINE OR PROCESS
- Machines
  - Manufacturer
  - Principle
  - Design
  - Capacity
  - Power
    - Starting—Operating
    - Running Idle

Machines (*Continued*)
- Cost
  - Purchase
  - Operating
    - Power
    - Supervision and Attendance
    - Repair
    - Depreciation and Interest
  - Cost of Product
- Variables
  - Controlled
  - Uncontrolled
  - Effect of Variables on Product
- Sources of Trouble

Processes
- Principle
- Variables
  - Controlled and Uncontrolled
  - Effect on Product
- Efficiency
- Costs

PROCESSES AND MACHINES
- Handling—Conveying—Storing
  - Solids
    - Conveyers
    - Bins
  - Liquids
    - Pumps—Lifts—Valves—Sprays
    - Flow of Liquids
    - Tanks
  - Gases
    - Pumps and Blowers
    - Tanks
    - Purifying and Absorption Apparatus
- Sampling and Testing
- Crushing and Grinding
- Classifying
  - Screens—Filters Centrifuges
- Mixing
- Solution and Absorption
  - Gas in Liquids
  - Solids in Liquids
  - Washing and Purification
  - Air Conditioning
- Autoclaves
- Evaporation—Distillation—Drying
- Crystallization
- Heating or Baking
  - Furnaces
    - Gas
      - Melting Types
      - Baking and Heat Treatment
      - Continuous

Furnaces (*Continued*)
- Electric
  - Resistance—Inductance
  - Vacuum
  - Arc
  - Shaft Type
- Destructive Distillation
  - Retorts
- Refractories
  - Properties
  - Tests
  - Heat Flow—Radiation
  - Bonds
- Finishing
- Fumes
  - Mechanical Retention
  - Electrical Precipitation

INDUSTRIAL APPLICATIONS OF PHYSICAL CHEMISTRY
- Change of State—Vapor Pressure
- Law of Mass Action
- Phase Rule
- Catalysis
- Adsorption—Surface Action
- Colloids
- Electrochemistry

INDUSTRIAL MATERIALS
- Construction
  - Building and Apparatus
- Cements

THEORY OF ERRORS
- Industrial Applications

INDUSTRIAL ORGANIZATION

SCIENTIFIC MANAGEMENT
- Motion Study—Bonus Systems, etc.

LIGHTING AND VENTILATION

SPECIFICATIONS AND PURCHASES

COST ACCOUNTING
- Materials—Processes—Labor
- Overhead—Depreciation

PATENTS

GRAPHIC REPRESENTATIONS
- Scientific Data—Production—Follow-up Systems
- Process Records

INDUSTRIAL RESEARCH
- Factory Control
- Processes
- Machines
- Outline and Attack
  - Establishment of Variables
- Reduction to Factory Practice

Laboratory work may be made extremely interesting and instructive. Frequently local manufacturing plants have machines or processes which the student may study directly as a laboratory exercise, while the manager is often interested in securing the power or production data which result from the tests.

EAST PITTSBURGH, PA.

CURRENT INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

OIL OF CLOVES

According to the *Times*, London, there is a considerable probability that distilleries of a fairly large scale will be set up in Natal for the purpose of treating the cloves brought in from Zanzibar and other East African producing centers. The enormous demand for clove oil for a particular war purpose has caused the supply available for vanillin manufacture to run very short, and British distillers have all they can do to fill their orders. Vanillin has, in the meantime, risen to very nearly $14 per lb.

SHELLAC SUBSTITUTE

Naphthol pitch, according to a recent German patent, can be converted into a shellac by the following treatment: Two parts of β-naphthol are dissolved in 16 parts alcohol and the filtered extract evaporated to drive off the solvent. The residual resin is dissolved in 24 parts of benzol, toluol, xylol, or solvent naphtha and mixed with 4.8 parts of ligroin. This precipitates the mahogany-colored resin and leaves in solution a colorless resin which is recovered by evaporating the solvent. Both resins act as substitutes for shellac.

SOUTH AFRICAN REQUIREMENTS

One of the most urgent problems, says the *Mining World*, 94 (1918), 325, which have arisen in South Africa since the outbreak of war has been the discovery of a suitable disinfecting and oxidizing agent to take the place of permanganate of potash which, owing to the cutting off of supplies of potash from Germany, is now only obtainable in very small quantities at prohibitive prices. It is noted with satisfaction that a South African firm of chemical manufacturers recently erected a plant for the production of chloride of lime, the demand for which is proving so insistent that the firm in question in order to meet the situation has taken steps temporarily to utilize their gold chlorination plant for the purpose. By this means the company has succeeded in supplying the most pressing needs of clients pending the erection of the special plant necessary for the production of the article on a larger scale. The new plant has been designed to supply the whole of the estimated requirements of South Africa, and the successful production of this important commodity, from materials wholly within the Union, marks a further step in the industrial development of the country.

ACID-PROOF ALLOYS

Some experiments by Dr. R. Irmann described in *Metall und Erz*, have an interesting bearing on acid-proof alloys. It has been assumed that electrolytic corrosion tests of voltaic couples of two metals afford an indication as to the corrosion of the alloys of these metals. The investigation by Dr. Irmann of alloys of copper and nickel to which tungsten and iron were further added apparently disproves this assumption. Much depends upon the proportion and the formation of compounds. Irmann was in search of an alloy not to be attacked by hot concentrated sulfuric acid. An alloy of nickel with 20 per cent tungsten was more resistant in this respect than nickel alone, but was difficult to machine, and expensive. To introduce tungsten into the nickel, he started from copper-nickel. A voltaic couple of nickel and copper gave an e. m. f. of 0.55 volt which soon went down to 0.25 volt. Nickel was dissolved, the copper becoming polarized with hydrogen. He then introduced other elements, especially tungsten, into the nickel-copper alloys, studying also the alloys of copper and tungsten. An alloy of 47 per cent copper and 4.98 per cent tungsten proved highly resistant and mechanically strong. The electric resistance was greater than that of constantan. Very good results were also obtained with ternary nickel-tungsten-copper alloys, but quaternary alloys containing also iron proved far superior to the ternary alloys.

FACTORY LIGHTING

A list sent by the British Thomson-Houston Company, Upper Thames St., London, gives details of the Mazdalux metal reflectors for use in connection with the lighting of factories, workshops, and other industrial buildings. About a dozen different types, suitable for lamps of both the half-watt and the vacuum types, are described, including dispersive, extensive, focusing, concentrating, intensive, and the various angle types of distribution. The focusing-concentrating type for half-watt lamps is a new design which is characterized as being most generally suitable for average industrial lighting conditions; it is supplied for all sizes of half-watt lamps, including the largest, of 1,500 watts and 3,000 c. p. All the reflectors are made of sheet steel with a reflecting surface of vitreous enamel, though for vacuum lamps there are alternate designs in steel with aluminum matte reflecting surfaces. The list also describes weatherproof and other housings with adequate ventilation for half-watt lamps and contains four pages of tables, illumination charts and instructions to facilitate the calculation of illumination and the preparation of plans for direct lighting equipment.

CHEMICAL INDUSTRY IN CHINA

Japanese activity in establishing works in Kwantung has prompted the suggestion that great possibilities exist for the establishment of similar enterprises in other parts of China. The factories already set up cover the manufacture of sulfuric acid, compounds of barium, caustic soda, creosote, bean oil for soap, manufacture of stearin and glycerin. There is little doubt that these products emanate from materials available in Manchuria itself and that a further investigation of China's natural products would result in the discovery of numerous further sources of supply which could be advantageously exploited. Oil suitable for making ointments and medicated soaps, etc., should be readily obtainable from China. Wool is available for the preparation of lanolin, kelp for the manufacture of iodine, and Shantung cotton for the manufacture of sterilized and medicated cotton. Raw material is within reach for the production of calomel, and caffeine could be produced from the tea sweepings in Hankow, while a wide range of valuable products could be extracted from coal deposits and coal oil. A writer in the *Far Eastern Review* asserts that alcohol and ammonia could be made in any quantity; the most important acids could be cheaply made together with such products as nitrate of silver. It is suggested that a conference of Chinese and foreign physicians, chemists, and pharmacists should take up the question of interesting capitalists in the matter and should place themselves at their disposal with a view to supervising manufacture.

COPPER AND ALUMINUM IN GERMANY

Discussing the statements recently made by the chairman of the British Aluminum Company, a leading German newspaper observes that it is no secret that Germany has embarked upon the production of aluminum on a large scale during the war, although opinions differ as to whether Germany, in this matter, will be able to meet international competition after the war. It is considered to be certain that the reported increase in British production of aluminum proceeding simultaneously with a very large augmentation in the output of copper in the period succeeding the war will render not improbable some over-production of the latter metal. If the copper needs of Britain and her allies are estimated at 50,000 tons per month for war purposes, the requirements will be considerably reduced the moment peace is declared. This circumstance is regarded as of importance to Germany as the same newspaper states that it awakens the hope that the present exceptionally high prices for copper will fall through this disproportion between supply and demand, and especially that there will be no question that it will be rendered possible for Germany to obtain supplies of the indispensable copper despite the competition of aluminum and other metals.

COLOR PHOTOGRAPHY SCREENS

A new process for making screens for color photography was recently described in *La Nature*. It is the versicolor process of Dufay. A thin sheet of celluloid is passed between two cylindrical rolls; the lower roll is plane, the upper is provided with very fine parallel ring grooves, flat on top; fine hollows are thus rolled into the upper surface of the celluloid. This surface is inked with a red transparent matter and the ink wiped off again so that the hollows are left red. The ridges are then inked with blue and in this way a two-color screen is obtained. The process may be repeated with the lower surface of the celluloid or the two systems of rulings may simultaneously be produced. The first two colors, for example, may be yellow and blue, and the third and fourth, red and green; or the four colors may be yellow, red, blue and orange. In these cases, the third color is the one missing in the first pair and the fourth color is complementary to the latter.

THE ALCOHOLS AND BASES IN VACUUM TAR

Messrs. Ame Pictet, O. Kaiser, and A. Labouchère have sent a note to the French Academy of Science on the alcohols and bases found in vacuum tar. The alcohols amount to about 2 per cent and the bases to about 0.2 per cent of the whole. The bases may be extracted from the oils by hydrochloric acid and the remainder treated with sodium when hydrogen is given off and the alcoholates are deposited in solid form. The simplest of the alcohols is *p*-methylcyclohexanol, the others are more complicated and readily oxidizable to phenols, but each of them forms several distinct phenolic products. The simplest of the bases belong to the toluidine group, the others are secondary and unsaturated. The authors believe the alcohols to exist in the coal, the bases they consider to be products of decomposition, in spite of the low pressures under which the vacuum tar was found. The bases that can be extracted from coal are not the same as those found in tar.

GREASE RECOVERY

The recovery of grease from waste materials by the solvent extraction process was explained by Mr. J. H. Garner at a recent meeting of the Society of Dyers and Colorists held at Bradford, England. There is no doubt, he said, that a very large proportion of the oils and fats used in the form of soap and wasted as suds ought to be recovered, not only from mills engaged in the woolen industry, but from the sewage of those towns in which the industry is established and where considerable volumes of trade waste are discharged into the sewers. The main consideration, he observed, is to make the process of extraction an economical one.

MODERN EXPLOSIVES

Thermite, according to a paper by Mr J. Young, of Woolwich Military Academy, is the explosive used by Zeppelins in their attacks on England and may be taken as the modern substitute for the ancient burning oil. It causes molten blazing iron to fall through the air at a temperature of 5000° C. The famous fiery furnace, according to him, was a cooling place compared with it. It is used in incendiary bombs and shrapnel, and it sets even wet grass on fire. Mr. Young expresses surprise that some chemists should imagine that if we kept cotton from Germany it would stop the war. He did not believe this to be true as Germany was doubtless getting what it required from wood.

PRIMUS STOVES

The Primus stove is ordinarily started by a flame of methylated spirit which heats the burner until it gasifies the paraffin forced into it by the air pressure in the container. Methylated spirit is practically unobtainable now and many of these stoves have consequently gone out of use. To enable them to be again employed Messrs. Condrup, 78 Fore St., London, have brought out a paraffin starter to replace the spirit starter. This comprises an annular dish which replaces the former spirit dish below the burner and contains an asbestos wick. A small quantity of paraffin is placed in the dish and burns from the wick heating the main burner to the required temperature.

NEW ALUMINUM ALLOY

According to the Queensland *Mining Journal*, aluminum alloyed with 10 per cent of calcium makes a metal of superior qualities, lighter than aluminum. These castings machine well, are free from brittleness, and take the minutest impressions of the mould. Alloys of copper, tin, or zinc with aluminum are less resistant to corrosion. The calcium also neutralizes the tendency of the aluminum to oxidize. It does not decompose in water and can be remelted as readily as pure aluminum.

DEMANDS FOR GLASS

In nearly all the South American capitals, says the *Times Trade Supplement*, there is a great shortage of plain plate glass. The largest quantities of this ordinarily came from Great Britain, but French manufacturers are reported to be making a strong bid for the Latin-American market and they are impressing upon the Argentine importers among others that delivery is assured. There is also a demand for wire mesh glass which, to be saleable, should be 6 mm. to 7 mm. (0.236 in. to 0.275 in.) thick. Since Austria-Hungary ceased to supply the market with opaque and fancy glass, there are opportunities here for manufacturers of these goods.

ALCOHOL PRODUCTION IN GERMANY

To crown the restrictions placed upon the technical production of alcohol in Germany, says the *Chemical Trade Journal*, 62 (1918), 415, all such production from cellulose and calcium carbide is now, under the Imperial Monopoly Bill to be laid before the Reichstag, to be reserved for the Empire. Another clause of the Bill embodies an even severer attack upon the chemical industry subjecting acetic acid produced chemically by the calcium carbide factories, the aldehyde vinegar industry, and the wood vinegar industry to a special tax of $40 per cwt. in comparison with the acetic acid produced by fermentation from potato alcohol. The quantity of acetic acid produced in the 680 vinegar factories amounted in 1913 to about 12,000 tons, while the quantity produced from calcium acetate and wood vinegar amounted to 23,000 tons of anhydrous acid. During the war, several large factories for the production of acetic acid from carbide have been completed, while others are in course of construction with a view to the manufacture of artificial rubber. The factories, if fully utilized, are capable of producing 25,000 tons of acetic acid annually. Before the war, 3,400,000 cwt. of potatoes were worked up annually for fermentation vinegar; this quantity could be saved for human food without difficulty if the chemical synthetic process for spirit production were employed and not stifled by an immense burden of taxation. Apart from all such considerations, an important step in chemical progress, *viz.*, the production of acetic acid from purely inorganic substances, is being obstructed in its incalculable further developments for the sake of protecting agrarian interests.

URUGUAYAN MARKETS

The Republic of Uruguay has had, says the *Times Trade Supplement*, a very good market for the best quality of textile goods. There are a few small factories in existence but the people are refined enough and wealthy enough to demand the best that can be produced in the way of cotton fabrics, dress materials, laces, ribbons, gloves, and all feminine requirements. The large and handsome emporiums in Montevideo vie with some of the leading Paris and London houses in the diversity and attractiveness of their drapery displays. The value of the textile market in Uruguay largely exceeds $6,000,000, including cotton, silk, and woolen goods.

BRITISH BOARD OF TRADE

During the month of May, the British Board of Trade received inquiries from firms at home and abroad regarding sources of supply for the following articles. Firms which may be able to supply information regarding these things are requested to communicate with the Director of Commercial Intelligence Branch, Board of Trade, 73 Basinghall St., London, E. C.

Blue mottled soap, 2000 cases
Flints for tinder lighters
Luminous calcium sulfide

MACHINERY AND PLANT FOR
Making cardboard food holders
Wax coating cardboard
Moulding paper pulp
Making papier mache
Making small glass beads perforated for threading
Shcing cabbages

SCIENTIFIC SOCIETIES

FOURTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

The Fourth National Exposition of Chemical Industries will be held in the Grand Central Palace, New York City, during the week of September 23 this year. The managers are Charles F. Roth and F. W. Payne. The advisory committee consists of Charles H. Herty, *Chairman*, Raymond F. Bacon, L. H. Baekeland, Henry B. Faber, Ellwood Hendrick, Bernhard C. Hesse, A. D. Little, Wm. H. Nichols, H. C. Parmelee, R. P. Perry, G. W. Thompson, F. J. Tone, T. B. Wagner, and M. C. Whitaker.

The Exposition is a war-time necessity and, regarding it as such, each exhibitor is planning his exhibit to be of the greatest benefit to the country through the men who visit it, all of whom are bent upon a serious purpose—that of producing war materials in large quantities and constantly increasing this production until the war has been won by the United States and its Allies.

The managers report that the amount of floor space already engaged is greater than last year, that the exhibits will be much more attractive, and that a movement is under way to show all exhibits of machinery in operation under actual working conditions as they would be found in the plants.

Some sections of the South are again sending exhibits, and Canada is taking the opportunity of presenting the materials it has available for development by the chemist and financier. A section for the Glass and Ceramic Industry has been added with which the American Ceramic Society is coöperating.

The program for the Exposition is in active preparation. Opening addresses will be made by Dr. Charles H. Herty, chairman of the Advisory Committee, and Dr. G. W. Thompson, president of the American Institute of Chemical Engineers. There will be a series of symposiums on "The Development of Chemical Industries in the United States, Notably since July 1914." This will embrace the period since the beginning of the European War, which, by removing the source of supply for our domestic industries, inspired the development of our own chemical industries which, now that we ourselves have entered the war, are proving so effective. The subjects to be discussed are Potash Development, Chemical Engineering, Acids, Industrial Organic Chemistry, the Ceramic Industries, and the Metal Industries. Among the speakers will be:

C. A. Higgins. Recovery of Potash from Kelp.
Linn Bradley. Recovery of Potash from Cement Dust and Other Sources by Electrical Precipitation.
A. Hough. Chemical Engineering in Explosives; T. N. T., T. N. A., Picric Acid, and Nitrobenzol.
E. J. Pranke. Development of Nitric Acid Manufacture.
S. P. Sadtler. Development of Industrial Organic Chemistry.
George H. Tomlinson. Wood as a Source of Ethyl Alcohol.
C. A. Higgins. Kelp as a Source of Organic Solvents.
Alcan Hirsch. Pyrophoric Alloys.
Joseph W Richards. The Ferro-Alloys of Silicon, Tungsten, Uranium, Vanadium, Molybdenum, Titanium.
Theodore Swann. Ferromanganese.
Leonard Waldo. The Development of the Magnesium Industry.

The American Ceramic Society, which will hold its meeting at the Exposition on Thursday afternoon, September 26, has already upon its program:

A. V. Bleininger. Recent Developments in the Ceramic Industries.
L. E. Barringer. Manufacture of Electrical Porcelain (illustrated).
H. Ries. American Clays.
F. A. Whitaker. Manufacture of Stoneware (illustrated).

Following this meeting a series of motion pictures of the ceramic industries will be shown.

The motion picture program, in the arrangement of which the Bureau of Commercial Economics is again coöperating, carries forward the idea of the symposiums, the pictures appropriate to a subject being shown on the same day as the symposium on that subject is held.

In addition there will be shown a series of motion pictures depicting studies of lakes, waterfalls, and hydroelectric power possibilities. The development of some of these sources of power will be shown through the several stages of construction, generation, and transmission of the power and its use in industrial operations. Films of several electrochemical operations will be shown, together with pictures of many chemical, mining, and related industries, and the application of electricity and electrical equipment to industrial work. Pictures of the oil industries, petroleum, asphalt, fatty oils, soaps, paints, linoleum, and oil cloth will be shown. In fact, every field of chemical endeavor will be represented. There will be a series of films depicting the results of carelessness in the destruction of life, wealth, and resources, and showing hazards and risks in industrial plants and how they may be overcome. The dangers of fire and explosives will be demonstrated, and the prevention of disease by vaccines.

The list of exhibitors is a very complete one of the best firms among or supplying the chemical industries, men who have faith in the future of America and are building to successfully conclude this war and to meet world trade competition after its close.

More complete details of the program, motion pictures, and exhibits will be given in our next issue.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The 10th Semi-Annual Meeting of the American Institute of Chemical Engineers was held at Gorham and Berlin, New Hampshire, June 19 to 22, 1918. The meeting was a pronounced success from the opening to the closing session. The meeting was called to order in the Berlin City Hall by Secretary J. C. Olsen in the absence of the President, G. W. Thompson, on urgent business. Mr. Hugh K. Moore introduced Hon. George F. Rich, Mayor of Berlin, who welcomed the Institute to Berlin, emphasizing not only the interesting technical developments of the region but also the great natural beauty of the locality. The Institute was also welcomed by Mr. John Hulan, representing the Chamber of Commerce of Berlin.

Vice President Henry Howard then took the chair. At the business session which followed, reports from the various officers were presented. The Secretary reported a membership of nearly 300, showing a substantial increase since the last meeting. The Treasurer, Dr. F. W. Frerichs, reported a balance on hand of $4,148, in addition to Liberty Bonds amounting to $1250. The Membership Committee reported that no applicants for membership were recommended for election who were not known to be loyal to the U. S. Government or its Allies in the present war.

Mr. Hugh K. Moore then read a paper on "The Human Element in the Mill" which led to a very interesting discussion on mill management, those who took part in the discussion being Dr. T. B. Wagner, Dr. A. C. Langmuir, Mr. Henry Howard, Mr. Colby Dill, and Mr. L. D. Vorce.

Mr. Walter H. Taft read a paper on "Maintenance, Construction, and Organization of a Sulfite Mill." In this paper Mr. Taft presented the technical methods employed in the operation of the mill, supplementing Mr. Moore's paper on the management of the personnel of the organization.

The meeting adjourned to The Grotto where luncheon was served, after which Vice President Howard introduced Mr. O. B. Brown, of the Brown Company, who gave a brief but very interesting account of how the business of the Company had grown from that of an old-time sawmill in the heart of the

White Mountains in 1850–54 to an aggregation of chemical plants including two pulp and paper mills, an electrolytic caustic and chlorine plant, a hydrogenated oil plant, carbon tetrachloride, chloroform, sulfur chloride, and carbon disulfide plants. All of these processes had been developed for the purpose of utilizing some by-product which was going to waste. Mr. Brown on behalf of the Company invited the members of the Institute to visit the various plants of the Company during the succeeding days of the convention.

The first plant visited was the Brown Company Sulfite Mill which is the largest sulfite mill in the world. The supply of raw material consisted of a small mountain consisting of 100,000 cords of wood. The daily wood supply if piled up 4 feet wide and 4 feet high would extend over 2 miles in length. Members were very much interested in the enormous wood-debarking drums in which the bark is mechanically removed from the logs.

On Wednesday evening the Institute met in joint session with the local section of the AMERICAN CHEMICAL SOCIETY at the Mt. Madison House, Vice President Howard presiding. Prof. Ralph H. McKee read a paper on "The Manufacture of Alcohol from Sulfite Waste Liquor." Prof. McKee showed that if air is blown through the liquor the sugars can readily be fermented with ordinary brewer's yeast. The paper was discussed by Messrs. H. O. Chute, Hugh K. Moore, Wm. Garrigue, and T. B. Wagner.

The Secretary then read a paper by Wm. M. Booth on "The Manufacturer and the Fuel Situation." An interesting discussion followed on fuel production and fuel economy participated in by Mr. Hugh K. Moore, Dr. Chas. Hollander, Dr. A. C. Langmuir, Mr. Henry Howard, Dr. J. C. Olsen, Prof. Wm. P. Mason, Dr. J. Bebie, and Mr. John Weiss.

Mr. Graham read a paper by H. E. Zitkowski on "The Seeding Method of Graining Sugar." Other methods of inducing crystallization were given by Dr. A. C. Langmuir and Dr. T. B. Wagner.

Mr. G. A. Richter read a paper on "War Pyrotechnics," giving various methods by which light and cloud effects were being produced in the present war. The Secretary read the paper by Dr. Alcan Hirsch on "Some Phases of Chemical Manufacture in Japan." Dr. Hirsch gave an interesting account of the recent chemical developments in Japan which though of great variety are not of great capacity.

Thursday morning the Brown Company saw mill was visited where lumber is being produced from the larger logs while the waste and smaller logs are sent to the pulp mill. At the photographic department members were shown by Mr. John H. Graff how color photography had been developed for the analysis of pulp and fiber.

Luncheon was again served at The Grotto, after which the Y. M. C. A. building was visited, and a paper by Dr. Edward Gudeman on "Food Conservation" was read and discussed.

During the afternoon the Cascade Paper Mill was visited. This mill produces 200 tons of news print paper daily. The four immense paper machines producing 48 tons of paper daily were examined with interest. The paper passes through the machine at the rate of 600 ft. per minute.

On Thursday evening the Institute was delightfully entertained by the Burgess Minstrel Show of the Brown Company. "A Joyous Jumble of Junk" was presented in three acts entitled "Somewhere in America." Mr. Herbert Spear, the chemist of the Burgess Mill, lead the company of ninety which presented a series of very clever and excellently acted numbers The endmen had a variety of excellent jokes, some of which were clever take-offs on members of the Institute.

On Friday morning the Institute met at the Mt. Madison House for a short business session and the reading of a number of papers. Dr. A. C. Langmuir presided. A report by Dr. Chas. F. McKenna as chairman of the Committee on Chemical Catalogue was read showing the success attained by the committee in charge of this important publication.

The paper on "Chemical Stoneware and Its Properties" by A. Malinovsky was read by Mr. P. C. Kingsbury. Mr. Whitaker in discussing the paper showed that resistance to the action of acid was not so important in chemical stoneware as ability to stand temperature changes. The paper was also discussed by Dr. Zimmerli, Mr. Kingsbury, Mr. H. O. Chute, and Dr. J. Bebie.

The Symposium on the Coal-Tar Industry was opened by a paper by Mr. F. E. Dodge on "Expansion of the Coal-Tar Chemical Industry." The paper by Mr. W. M. Russell on "The Expansion of the By-Product Industry of Coal and Water-Gas Plants in the United States" was read by the Secretary. The paper by Mr. A. G. Peterkin on "The Manufacture of Phenol" was read by Mr. John Weiss.

These papers were discussed by Mr. H. O. Chute, Dr. A. C. Langmuir, Dr. J. Bebie, and Mr. L. H. Grove.

A paper by Mr. L. A. Thiele on "The Multiple Tangent System for the Manufacture of Sulfuric Acid" was read by the Secretary.

On Friday the members of the Institute visited the chemical plants of the Brown Company. They were first shown the electrolytic cells of a design by Moore and Allen, only one of the electrodes (the anode) being immersed in the brine, the cathode being in a hydrogen chamber. A small brick furnace with a condenser consisting of a silica tube was shown and the members were surprised when told that this was a hydrochloric acid plant in which the acid was produced by burning hydrogen in chlorine gas. The caustic soda plant was also shown in which 40 tons of very pure caustic soda are produced daily, the multiple effect evaporators having been designed by Mr. Moore.

The sulfur chloride, carbon disulfide and chloroform plants were also shown. Medicinal chloroform is produced in carload lots. The carbon tetrachloride plant was not in operation. The hydrogenated oil plant in which "Kream Krisp" is produced from peanut oil was greatly admired, as well as the fiber tube mill.

The banquet of the meeting was held at the Mt. Madison House on Friday evening. One hundred and four covers were laid at the tables. This marked a record in the history of the Institute as being the largest attendance at any meeting. Dr. Wm. P. Mason acted as toastmaster and kept the company in the best of humor with his seemingly inexhaustible fund of stories and jokes. Mr. W. R. Brown spoke for the Brown Company, expressing their pleasure at having the Institute meet in Berlin and Gorham. Ex-Mayor Daily of Berlin spoke for the municipality. After a selection by the Glee Club of the Burgess Mill, Vice President Langmuir was called upon and spoke of the pleasure and profit which members of the Institute had derived from their visit to Berlin and its various industries. Mr. Hugh K. Moore was called upon and related how some of the ladies had asked as to what part of the log gave out the "Kream Krisp." Mr. David Wesson showed one of the ladies a knot in one of the logs and explained that "Kream Krisp" is knot-lard. The ladies were toasted by the Secretary. Mr. Herbert Spear spoke for the local chemists. Mrs. A. C. Langmuir responded for the ladies.

During the entire three days the ladies were entertained by a ladies' committee headed by Mrs. O. B. Brown and Mrs. Hugh K. Moore. The magnificent scenery of the White Mountains was shown to the visiting ladies on several automobile rides. In spite of rain on Saturday a party of 28 started by automobile for a 33-mile drive through Thirteen-Mile Wood to Erol Dam where the party was taken by motor boat up the Androscoggin river and across Umbagog Lake to Sunday Cove. Here automobiles had been provided by the Brown Company for the 5-mile carry to Middle Dam. This trip proved very delightful in spite of the weather and the party arrived at Middle Dam ready

for the camp dinner and the cosy fireplaces in the cottages. Seven of the party started fishing immediately. Mr. Colby Dill proved the champion fisherman and landed seven fine trout. After supper Mr. Stephen F. Tyler read his paper on "Fused Silica: Its Properties and Uses," which was discussed by the members sitting around the huge office fireplace.

Sunday was spent in walks through the Maine Woods or story-telling around the firesides. Mr. Hugh K. Moore was voted the champion story-teller. Some of the party returned to New York while the remainder took the trip by motor boat to Upper Dam, spending the night there and returning to New York Monday morning by motor boat to Bemis and then by the Rumford Falls Railroad to Boston.

The meeting had proved to be the best attended in the ten years' history of the Institute; also the most profitable from a technical standpoint and the most delightful on account of the beautiful mountain and lake scenery afforded by this popular vacation region.

CLEVELAND MEETING, AMERICAN CHEMICAL SOCIETY

The 56th General Meeting of the AMERICAN CHEMICAL SOCIETY will be held at Cleveland, Ohio, September 10 to 13, 1918. A Council meeting will be held on the afternoon of September 9, and the Council will be entertained at dinner at the University Club by the Cleveland Section. On Tuesday there will be a general meeting at the Hotel Statler, which is to be headquarters. A dinner will be given in the evening at the Statler Hotel, followed, after a convenient interval, by a smoker at the same place. Divisional meetings will be held on Wednesday morning and all day Thursday. On Wednesday afternoon trips will be taken, probably as follows:

A—Sanitary trip. Sewage disposal experiments. Water filtration. Garbage disposal.

B—Steel industries. Blast furnaces, by-product coke, steel, Bessemer, and open hearth.

C—Industrial tour of Cleveland, including all the manufacturing centers, but only a few stops.

D—Trip by special cars to Oberlin.

In the evening the President's address will be given and this will be followed by a reception at the Hotel Statler.

After the divisional meetings on Thursday, automobile trips will be taken to one of the country clubs for dinner and to the Cleveland Museum of Arts. On Friday a special excursion is planned for Akron, Ohio, where there are interesting rubber, pottery, soda, match, and other factories. Luncheon will be served in Akron and the party can leave for home from that city.

The Cleveland chemists are arranging special entertainment, not only for the men but for the ladies who may be present, and every effort is being put forth to make the meeting a success.

Special symposiums are being arranged by the chairman and secretaries of Divisions and it is believed that an unusual opportunity will be given in these active chemical times for chemists to get together and exchange views and ideas, many of which cannot at present be published.

A preliminary notice of the meeting, containing some additional data, will reach the members about the time that this issue of THIS JOURNAL goes to press. A final program will be sent shortly before the meeting to those who request it.

CHAS. L. PARSONS, *Secretary*

NORTHERN OHIO SECTION, AMERICAN CERAMIC SOCIETY

The Northern Ohio Section of the American Ceramic Society met in Cleveland on Monday, June 10, 1918.

An inspection trip occupied the greater part of the afternoon. The first plant visited was that of the Cleveland Metal Products Company, manufacturers of enameled oil stove parts, light reflectors, cooking ware, etc. From here the members went to the Euclid Glass Division of the National Lamp Works where they saw the making of all the glass parts for electric light bulbs. They next visited Nela Park, the laboratories of the General Electric Company. In the auditorium of the Engineering Building they were entertained with motion pictures of the obtaining of the raw materials and subsequent treatment of the same in the process of manufacture of Mazda lights. A short business meeting completed the afternoon session.

After dinner together, the members met with the Cleveland Section of the AMERICAN CHEMICAL SOCIETY in the Assembly Room of the Olmstead Hotel. Here Mr. A. A. Klein, of the Norton Company, Worcester, Mass., gave a highly interesting and instructive talk on "Petrographic Studies in Ceramics." This dealt with the practical application of petrography to the manufacture of cement, porcelain, brick, abrasives, and other ceramic products.

CALENDAR OF MEETINGS

American Pharmaceutical Association—Annual Convention, Chicago, Ill., August 12 to 17, 1918.

American Chemical Society—Fifty-sixth (Annual) Meeting, Cleveland, Ohio, September 10 to 13, 1918.

National Exposition of Chemical Industries (Fourth)—Grand Central Palace, New York City, September 23 to 28, 1918.

NOTES AND CORRESPONDENCE

AN AMERICAN EMBLEM FOR AMERICAN CHEMISTS

Editor of the Journal of Industrial and Engineering Chemistry:

In yesterday's parade a feature was a float demonstrating the use of the oxy-hydrogen torch. Not long ago a movie in color showed the use of this same torch in the Navy Department cutting ingots and cleaning castings. It is of invaluable use today in very many of the manufactures through which we intend to win the war.

Revisions are the order of the day. Paris honors President Wilson in naming an avenue for him. Other recognitions of American achievement are being made.

The official insignia of the AMERICAN CHEMICAL SOCIETY and of the Chemical Service Section of the United States Army are perpetuating German devices. That of the Society has a Liebig bulb, that of the Army a "benzol ring." Now, Robert Hare announced to the world the source of the greatest convenient artificial heat and light in 1801 (two years before Liebig was born), founded the platinum industry in this country, and made possible the untold advances of recent years in metallurgy, including the building of our fleet of naval and merchant vessels. He also produced calcium carbide in an electric furnace about 1840, long before the hexagon was thought of. Besides, in 1831 he devised the present method of exploding charges at a distance, plunge battery, and incandescent wire. Then, too, he was a member of the first Chemical Society in the world, the Chemical Society of Philadelphia.

We have just commemorated the lighting of the Torch of Liberty at Philadelphia; why not also perpetuate this Scientific Torch, with its glow! Let *it* be the emblem for American chemists whether in military or civil life.

Yours for patriotism,

CHARLES A. DOREMUS

229 EAST 68TH ST., NEW YORK CITY
July 5, 1918

TRANSFER OF THE EXPERIMENT STATION AT AMERICAN UNIVERSITY TO THE WAR DEPARTMENT

The White House
Washington, June 26, 1918

DR. VAN. H. MANNING,
Chief, Bureau of Mines,
Department of the Interior

MY DEAR DR. MANNING:

I have had before me for some days the question presented by the Secretary of War involving the transfer of the chemical section established by you at the American University from the Bureau of Mines to the newly organized Division of Gas Warfare in which the War Department is now concentrating all the various facilities for offensive and defensive gas operations. I am satisfied that a more efficient organization can be effected by having these various activities under one direction and control and my hesitation about acting in the matter has grown only out of a reluctance to take away from the Bureau of Mines a piece of work which thus far it has so effectively performed. The Secretary of War has assured me of his own recognition of the splendid work you have been able to do and I am taking the liberty of enclosing a letter which I have received from him in order that you may see how fully the War Department recognizes the value of the services.

I am to-day signing the order directing the transfer. I want, however, to express to you my own appreciation of the fine and helpful piece of work which you have done and to say that this sort of team work by the bureaus outside of the direct war-making agency is one of the cheering and gratifying evidences of the way our official forces are inspired by the presence of a great national task.

Cordially yours,
(Signed) WOODROW WILSON

War Department
Washington, June 25, 1918

MY DEAR MR. PRESIDENT:

In connection with the proposed transfer of the chemical section at American University from the Bureau of Mines to the newly constituted and consolidated Gas Service of the War Department, which you are considering, I am specially concerned to have you know how much the War Department appreciates the splendid services which have been rendered to the country and to the Army by the Department of the Interior and especially by the Bureau of Mines under the direction of Dr. Manning. In the early days of preparation and organization Dr. Manning's contact with scientific men throughout the country was indispensably valuable. He was able to summon from the universities and the technical laboratories of the country, men of the highest quality and to inspire them with enthusiastic zeal in attacking new and difficult problems which had to be solved with the utmost speed. I do not see how the work could have been better done than he did it and the present suggestion that the section now pass under the direction and control of the War Department grows out of the fact that the whole subject of gas warfare has assumed a fresh pressure and intensity and the director of it must have the widest control so as to be able to use the resources at his command in the most effective way possible. The proposal does not involve the disruption of the fine group of scientific men Dr. Manning has brought together, but merely their transfer to General Sibert's direction.

Respectfully yours,
(Signed) NEWTON D. BAKER

EXECUTIVE ORDER

It is hereby ordered that the Experiment Station at American University, Washington, D. C., which station has been established under the supervision of the Bureau of Mines, Interior Department, for the purpose of making gas investigations for the Army, under authority of appropriations made for the Ordnance and Medical Departments of the Army, together with the personnel thereof, be, and the same is hereby, placed under the control of the War Department for operation under the Director of Gas Service of the Army.

(Signed) WOODROW WILSON

THE WHITE HOUSE
June 25, 1918

CHEMICALS AND EXPLOSIVES DIVISIONS WAR INDUSTRIES BOARD

The War Industries Board has created two new divisions to be known as the Chemicals Division and the Explosives Division. Charles H. MacDowell, formerly chief of the Chemicals Section, has been made Director of the Chemicals Division, and M. F. Chase, Director of the Explosives Division.

The Chemicals Division will be sub-divided into sections to handle the various commodities with which it is concerned, the chiefs of which will be as follows:

Acids and Heavy Chemicals—Albert R. Brunker, Russell S. Hubbard, and A. E. Wells.
Artificial and Vegetable Dye—J. F. Schoellkopf, Jr.
Alkali and Chlorine—H. G. Carrell.
Asbestos, Chemical Glass and Stoneware—Robert M. Torrence.
Coal Gas Products (benzol, toluol, etc., including commandeering and allocation of toluol)—J. M. Morehead, Ira C. Darling, associate.
Rare Gases, Nitrogen and Oxygen—Chief not named.
Creosote—Ira C. Darling.
Electrodes and Abrasives—Henry C. DuBois.
Ethyl Alcohol (molasses and grain)—William G. Woolfolk.
Ferro-alloys (chrome, manganese, and tungsten ores)—Hugh W. Sanford, C. D. Tripp, J. H. McKenzie.
Fine Chemicals—A. G. Rosengarten.
Nitrates—Charles H. MacDowell, J. A. Bocker.
Paint and Pigment—Russell S. Hubbard.
Platinum—C. H. Conner, R. H. Carleton, G. I. DeNike.
Refractories—Charles Catlett.
Sulfur and Pyrites—William G. Woolfolk, A. E. Wells.
Tanning Materials including inedible oils, fats, and waxes—E. J. Haley, E. A. Prosser, Frank Whitney, Harold G. Wood.
Technical and Consulting—E. R. Weidlein, Herbert E. Moody, Thomas P. McCutcheon.
Wood Chemicals—C. H. Conner, A. H. Smith, R. D. Walker, Frank Whitney.
Statistics, Chemical (joint office)—Captain Willis B. Rice, Army; Lieutenant M. R. Gordon, Army; Assistant Paymaster Raymond P. Dunning, Navy; Arthur Munnick, Chemicals Division.

A representative of the Army, the Navy, the Marine Corps, and other departments have been assigned to each section, and with the Commodity Chief constitute the sections' membership.

In the Explosives Division, Mr. Chase coördinates with representatives of the Army, the Navy, and other departments concerned, and consults with the various section chiefs of the Chemicals Division.

THE OFFICIAL U. S. BULLETIN

Owing to the enormous increase of Government war work, the governmental departments at Washington are being flooded with letters of inquiry on every conceivable subject concerning the war, and it has been found a physical impossibility for the clerks, though they number an army in themselves now, to give many of these letters proper attention and reply. There is published daily at Washington, under authority of and by direction of the President, a Government newspaper, *The Official U. S. Bulletin*. This newspaper prints every day all the more important rulings.

decisions, regulations, proclamations, orders, etc., etc., as they are promulgated by the several departments and the many special committees and agencies now in operation at the National Capital. This official journal is posted daily in every postoffice in the United States, more than 56,000 in number, and may also be found on file at all libraries, boards of trade and chambers of commerce, the offices of mayors, governors, and other federal officials. By consulting these files most questions will be found readily answered; there will be little necessity for letter writing; the unnecessary congestion of the mails will be appreciably relieved; the railroads will be called upon to move fewer correspondence sacks; and the mass of business that is piling up in the Government departments will be eased considerably. Hundreds of clerks, now answering correspondence, will be enabled to give their time to essentially important work, and a fundamentally patriotic service will have been performed by the public.

COLLAR INSIGNIA FOR CHEMICAL WARFARE SERVICE

Editor of the Journal of Industrial and Engineering Chemistry:

The present collar insignia of the Chemical Service Section of the National Army is shown in the accompanying figure. For the newly organized Chemical Warfare Service, with which the Chemical Service Section has been merged, it has been proposed to adopt the insignia of the latter. The only criticism which has been raised is that this emblem is not sufficiently warlike in appearance and suggests too much the peace and seclusion of the laboratory. Our artistic fellow-chemists are requested, therefore, to sharpen their pencils and send us designs which they regard as preferable. The device must be, of course, compact and simple, and not likely to be confused with the insignia of any other branch of the service.



The sketches can be sent to the undersigned and, in the event of one being adopted in place of the present insignia, the fact will be published in THIS JOURNAL together with a copy of the design and the name of the chemist. The designer will have the satisfaction of knowing that his emblem will be brought forcibly to the attention of the Hun by the boys "over there."

MARSTON T. BOGERT
Col., Chem. Warfare Service, N. A.

UNIT F, CORRIDOR 3, FLOOR 3,
7TH AND B STREETS, N. W.
WASHINGTON, D. C.
July 12, 1918

GERMAN POTASH AND THE WAR[1]

Germany has a world monopoly on potash. Even before the war foreign countries were making efforts to find potash outside of Germany, and rumors have often been afloat as to potash finds in France, Spain, Russia, Austria, and California; but nowhere has potash been found to any extent which in any way could compare with the German supply. During the war the enemies have suffered greatly from lack of potash. Grain and cotton harvests in the countries where these are the most important crops show the results of potash shortage. More energetic efforts than ever are now being made to find potash. After the war the enemies, now intent on an economic war, will again have to ask for German potash. Only the dreamers are still hoping that it will be possible to force the turning over of the Alsatian potash mines to France. In reality, not only France, but the whole Entente will be dependent upon Germany for potash. Before the war the Alsatian works delivered about one-tenth of the whole German potash output. It has, however, been possible to increase their yield considerably, so that it is a fact that many countries could be supplied with potash from Alsace alone. As it is out of the question that Alsace will be separated from Germany, all dreams of breaking the German potash monopoly are vain.

It is extraordinary that while the Entente countries are dreaming of supplying themselves from Alsatian potash works, they are at the same time trying to discredit the German potash industry at large. This has even gone so far that the Reuter Bureau one day brought the information that the German potash fields were exhausted, and that when peace came, Germany would not again be able to export potash. Before the war the complaint was constantly made that Germany had too much potash and too many potash works. The German potash industry did not suffer from exhaustion, but rather from overproduction. Although the whole world was being exclusively supplied from Germany, the demand did not keep up with the increasing capacity of the potash works. The potash mines had to reduce their output from year to year. The combination of German Potash Works (Kali Syndicate) finally had to close some of the new mines until the potash already on hand could be disposed of; it had to develop a great propaganda at home and abroad for potash fertilizer.

To what great extent the war has changed these conditions! The enrolling of laborers in the Army hit the potash industry as well as others. When the export was stopped, the decrease in demands for potash was only natural. Soon, however, a greater demand for potash developed among German agriculturists, so that the potash works again had to put out all energy to satisfy the demands. Partly in consequence of the lack of other fertilizer, the German agricultural demands for potash are, after three years of war, as great as that of the whole world before the war. And if the deliveries are not still larger, it is due to various causes which have prevented the mining of the potash, mainly the lack of skilled laborers (in the potash works it is hardly possible to use unskilled workmen or war invalids), and the transportation difficulties. The demands upon the German potash works are now, after three years of war, only a little less than the highest yields ever reached, in 1913. When peace comes, the difficulties which are now preventing the full utilization of the works will disappear. The demands for potash will be much greater than before the war. German agriculture uses much more than before, and according to their own reports the agriculture of the United States and other countries is simply starving for potash.

Will the German potash works be able to satisfy these greater demands? The reply to this in competent circles is that only a lack of sufficient labor, transportation, and coal can prevent the German potash works from doubling their present production; that is to say, they will be able to yield a value of 500 million marks, or twice the production of former peace times. After a few years the yield might reach 1000 million marks. It is not possible to think of exhausting all the potash fields which actually are found all over Germany. It is hardly exaggerating to say that the potash mines of Germany will be able to supply the whole world for 500 years and more. The potash fields are practically inexhaustible. There are now in Germany 209 potash works with a complete outfit, and their mines will last for several hundred years. The value of these mine products show the great importance which potash will have in bringing German currency again to a normal footing.

The potash monopoly is an important weapon in the economic war which the Entente intends to carry on with Germany. Even during the war, potash has been an important article in the exchange trade between Germany and its neutral neighbors, whose agriculture has derived great benefit from this important fertilizing element.

[1] Translated from *Deutsche Wirtschafts-Zeitung of* Jan. 15, 1918.

CHECK MEAL CONTEST

The Society of Cotton Products Analysts announces the conditions of their check meal work for the coming season.

There are to be forty weekly samples of carefully prepared cottonseed, or other feed meal, sent to, not only any of its members, but also to any other chemist in the country who so desires. These samples are to be analyzed for moisture, oil, and ammonia content and prizes of silver cups given to those who turn in the most accurate results for oil and ammonia.

The conditions of the contest are stated in the July number of *The Cotton Oil Press* and any chemist interested should obtain a copy of this or apply to F. N. Smalley, *Chairman*, Southern Cotton Oil Co., Savannah, Ga., for details.

This work, now in its third year, has done a great deal of good as a means of bringing closer agreement between all chemists engaged in cottonseed work, and the committee in charge of the contest believe that chemists engaged in other lines of food work where similar analyses are made would gain much by entering the contest.

PLATINUM RESOLUTION BY THE STATE COUNCIL OF DEFENSE FOR CALIFORNIA

838 Phelan Building
San Francisco, California
June 6, 1918

Mrs. Ellwood B. Spear
27 Walker Street
Cambridge, Mass.

My Dear Mrs. Spear:

At a recent meeting of the Executive Committee of the California Women's Committee of Councils of National and State Defense, the following resolution was adopted:

"That, in view of the shortage of platinum, due to the fact that 95 per cent of the world's supply comes from Russia, and the need for platinum to make the assets which are necessary for explosives and the making of guns, and in the laboratories which are at the service of the Government; and because one-third of the whole world's entire supply of platinum has been put into the production of jewelry, the California Women's Committee of the Councils of National and State Defense resolves to discourage the use of platinum for jewelry, or other articles not necessary for the winning of the war."

I have sent the leaflets throughout the State and will be glad to distribute anything further.

With cordial regards, I am
Yours sincerely,
(Signed) Julia George

ORGANIC REAGENTS FOR RESEARCH AND INDUSTRY

Editor of the Journal of Industrial and Engineering Chemistry:

In order to provide for the supply of organic reagents for research and industrial purposes the Eastman Kodak Company has determined to commence their preparation in its Research Laboratory.

This decision was arrived at as a result of the articles published by Dr. Roger Adams and of a recent letter by Professor Gortner in *Science* (June 14, 1918, p. 590), which drew our attention to the need for an adequate supply of these materials produced by a firm of standing.

In order to carry on the work a separate section of the Laboratory has been established under the title of the "Department of Synthetic Chemistry" which will be under the immediate direction of Dr. H. T. Clarke, well known for his publications on organic chemistry.

In order to make available to research laboratories in this country the organic chemicals which they require, it is proposed that chemicals for research work shall be supplied at the lowest possible price. At first, no doubt, this price will necessarily be higher than that charged by the German firms before the war, but it is hoped that eventually the profit made on chemicals supplied for commercial purposes may enable the rarer materials made in small quantities for research work to be sold at a price which will be within the reach of all who require them.

At first, of course, the Laboratory will be able to supply only a limited number of substances, and these in small amounts, but the department will be expanded to meet the demand, and with the assistance of other laboratories interested in organic chemistry, and of the firms who are producing dyes and intermediates, it is hoped that after a time an adequate supply of synthetic organic reagents can be made available.

It is possible that laboratories may have in stock unusual reagents which they are unlikely to require. If any laboratories possessing such reagents will write to us, we shall be glad to make an offer for the materials, thus making them available on the market.

Our thanks are due to many of the chief chemists of the country who have encouraged us to commence this work and especially to Dr. Roger Adams for the way in which he has received our proposals and has assisted us by placing at our disposal the information as to this work which he has accumulated.

Communications regarding reagents should be addressed to the Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

C. E. K. Mees

Eastman Kodak Company
Rochester, N. Y.
July 12, 1918

WASHINGTON LETTER

By Paul Wooton, Union Trust Building, Washington, D. C.

Since plenty of advance notice had been given, no flurry followed the announcement by the War Industries Board that it would take full control of all sulfur materials. William G. Woolfolk, who is to represent the War Industries Board in controlling the production and distribution of sulfur materials, already is known to the trade interested in those commodities as the chief of the Board's sulfur-pyrites-alcohol section.

It is known that the War Industries Board has entire confidence in the Chemical Alliance and there is every reason to believe that this body will be given practically a free hand in carrying out a program looking to equitable distribution of brimstone, pyrites, and coal brasses. It also is known that the War Industries Board has been unusually impressed with the ability of A. D. Ledoux, who is the chairman of the Production-Distribution-Control Committee of the Chemical Alliance. With everything favoring harmonious cooperation between the War Industries Board and the Chemical Alliance, it is believed that the intricate problems involved can be solved without serious disturbance of the industries concerned. With Mr. Ledoux on the committee are W. D. Huntington and C. G. Wilson. At this writing, the committee has not gone deep enough into its plans to make any announcement. A questionnaire, which is to go to all users of sulfur materials, is now in progress of compilation. The office of the committee will be in Room 135 of the Interior Building. The offices of the Chemical Alliance will continue to be maintained in the Woodward Bldg.

The full text of the announcement of the War Industries Board in taking over the control of chlorine is as follows:

Owing to the shortage of chlorine in the United States, the War Industries Board, with the approval of the President, has passed a resolution taking over control of its production and distribution. For the present, however, the Board is doing no more than allocate the product, and this is being done under the direction of H. G. Carrell, Chief of the Alkali and Chlorine Section of the War Industries Board.

Chlorine has a wide range of uses, the most important from the present Government point of view being in the manufacture of gas shells and in carbon tetrachloride, which is the basis of one of the most effective smoke screens and also of the best fire extinguishers.

One of the most important commercial uses of chlorine is in the bleaching of paper and various cloth fabrics.

Judging from the communications being received by members of Congress, much interest was aroused by the appearance before the Ways and Means Committee of representatives of the chemical industry and of the jewelry trade. Meyer D. Rothschild, of New York, represented, as he said, every jewelry organization with the exception of the National Jewelers' Association. Robert B. Steele also contributed voluminously to the record. Dr. Charles H. Herty, of New York, presented to the committee the view of the platinum situation as taken by chemists.

While an effort was made to discredit the entire proceedings by alleging that the committee was taking up two days of its time to enable the chemists and the jewelers to stage a row, this version of the matter was not accepted. Representative Longworth, of Ohio, one of the members of the committee, expressed the opinion that the threshing out of the platinum situation in such a thorough manner was one of the most important things that the committee had done.

The jewelers took particular exception to the fact that the Bureau of Mines is coöperating with the AMERICAN CHEMICAL SOCIETY in a campaign to discourage the use of platinum in jewelry. There was extended discussion of the various proprieties involved which finally led Mr. Longworth to ask, "Which is more essential now to this country in the prosecution of the war, jewelry or chemistry? If there is one thing more useless in time of war than is jewelry, I do not know what it is, unless it be artificial flowers. The jewelers made the same fight against the abolition of aigrettes that they are making now against the sale of platinum. Congress took the 'bull by the horns' and provided that they should not sell aigrettes, although they said that they would be ruined."

The high point of Dr. Herty's testimony was that there should be no platinum available for taxation. He recommended that all the platinum in the hands of jewelers be taken over by the Government, after equitable compensation had been allowed and placed in the vaults of the subtreasuries, where it would be accessible when the need comes. He suggested that it would not be necessary to call for the platinum in the hands of private individuals, as he believes they will hold on to the platinum until it is needed, thus relieving the Government of the expense of carrying it.

After asking special permission to insert it in the record, Dr. Herty made this significant addition to his testimony: "My conviction in this matter is that any chemist who sells his platinum to any one other than the Government would be just as unpatriotic as would be any jeweler."

After a hearing on the national trade mark bill before the Senate Committee on Commerce, it was agreed that the measure should be made more concise but should retain the salient features of the measure which was recommended by department officials. It contains the essential features of the International Convention of August 20. In the opinion of J. T. Newton, the commissioner of patents, of Dr. L. S. Rowe, assistant secretary of the treasury, and of C. P. Carter, of the Bureau of Foreign and Domestic Commerce, the measure "if enacted into law will be of great advantage to American trade mark owners who are doing business in the Central and South American republics."

The principal objection to the bill which was before the Senate was to the first section of that bill. Concerning this section, Mr. Newton said, "My idea about this bill is that there is no use in passing any bill at all, if we cannot benefit our own people. The first section provides for an examination of something that the Patent Office already has granted as a trade mark; because probably four-fifths of these registrations will go from this country, and I think it is the sense of the convention that nothing will be done in Havana until the mark has been registered in the country of origin." The bill which will be substituted, however, will take care of that point.

In their zeal to keep from the Germans such few facts concerning American-made war gases as would have been valuable to them, those charged with such work seem to have been most successful in keeping from the chemical industries, and the public in general, the information to which many believe they are entitled. The principal criticism heard in this connection is that the chemists of the country are not being allowed to concentrate such time as they have available on gas problems. As it is, so little is known of the situation that a great force of brain power, which might be directed against these problems, is not being utilized. Even in the War Department itself there were examples of appalling misinformation regarding the gas situation. One high official of that department made the statement that no gas mask developed by the Allies was able to withstand effectively the gas used in the March drive. To counteract very general misinformation in this regard, the Chemical Warfare Section on July 12 issued the following statement:

Protection against any of the gases now in use by the Germans is given to American soldiers by the masks now being worn. Statements that American masks do not protect soldiers from the effects of mustard gas are not warranted.

The masks now worn will protect soldiers as long as they are required to remain in areas drenched by gas. The clothing worn by the soldiers will resist the effects of the gas for a normal period. As an added precaution, the soldiers are now provided with a neutralizing ointment to be rubbed on those parts of the body where mustard gas is likely to penetrate through the clothes.

This ointment is being prepared in quantities greater than the demand for it. The first month's shipment consisted of 800,000 tubes. It is a new preparation made after a formula prepared by chemists connected with the Chemical Warfare Section. Rubbed on the body before a gas attack, it has the power to neutralize the poisonous effects of mustard gas.

For the protection of the special men whose duty it is to clear trenches of all traces of the gases, special underwear is now being provided. These suits are chemically treated and neutralize poisonous gases.

Men are being thoroughly trained in gas defense so that every soldier who enters the zone of fire thoroughly understands the measures of gas defense. Every man is drilled in the adjustment of his gas mask before he is subjected to a gas test, either here or overseas.

An announcement by the Secretary of War issued July 2 with regard to the Chemical Warfare Service reads as follows:

The organization of the Chemical Warfare Service has been completed. Henceforth all phases of gas warfare will be under the control of the Chemical Warfare Service commanded by Major General William L. Sibert.

Heretofore, chemical warfare has been carried on by divisions in the Medical Department, the Ordnance Department, and the Bureau of Mines. All officers and men who have been connected with offensive or defensive gas warfare here will be responsible to the Chemical Warfare Service. The field training section at present is under the Corps of Engineers.

Defensive warfare has been under the control of the Medical Department. This work has consisted of the designing and manufacture of masks both for men and animals and the procurement of appliances for clearing trenches and dugouts of gas.

Offensive gas warfare consists principally of manufacturing gases and filling gas shells. The work has been under the direction of the Ordnance Department.

The new department will take over the work of chemical research for new gases and protection against known gases, which work has been carried on by the Bureau of Mines. All testing and experiment stations will be under the direction of the Chemical Warfare Service.

The responsibility of providing chemists for all branches of the Government and assisting in the procurement of chemists for industries essential to the success of the war and Government has been entrusted to the Chemical Warfare Service.

All chemists now in the army will be removed from their units and placed under the authority of the Chemical Warfare Service. Newly drafted chemists will be assigned to the Chemical Warfare Service.

Authority to assign enlisted or commissioned chemists to establishments manufacturing for the Government has been granted to the new section.

A number of amendments to the Trading with the Enemy Act have been drafted. One of these amendments will enable the Alien Property Custodian to grant licenses for the full term of life of a foreign patent. The amendments have been submitted to the Committee on Commerce of the Senate, but as yet have not come up for consideration.

As a means of coöperating in the efforts being made by the Government to stimulate production of the war minerals, Fuller Calloway, who has been referred to as "one of the most progressive thinkers among business men in the South," has perfected an organization among southern producers of pyrites. An effort is being made, without actually pooling all the product, for the pyrite miners to secure the benefits of the pooling method in so far as there is need.

PERSONAL NOTES

Mr. R. Norris Shreve has been made assistant general manager of the six organic plants of the Marden, Orth and Hastings Corporation, control of which has been centered at the plant of the Calco Chemical Co., Bound Brook, N. J., recently acquired by the Corporation.

Mr. R. H. McKee who has been associate in chemical engineering at Columbia University has been made professor of chemical engineering. Professor McKee is also a director of the Tennessee Copper Company and consulting chemical engineer for the U. S. Industrial Alcohol Company.

Associate Professor D. D. Jackson, Columbia University, has been made professor of chemical engineering.

Mr. Ellwood Hendrick, President of the Chemists' Club, recently addressed the New Jersey Science Teachers' Association, the president of which writes, "It was the consensus of opinion that his talk was not only delightful but masterful."

Dr. James F. Norris, who has been with the Bureau of Mines Experiment Station, has been commissioned a Lieutenant Colonel in the Chemical Service Section of the National Army and is to be stationed in London as the representative of the Army, in chemical warfare, in England. The following men, all in the Chemical Service Section, are to be with him to help in the work: Capt. A. B. Ray, Capt. G. M. Rollason, Lieut. H. A. F. Eaton, and First Sergeants E. O. Hobbs, L. C. Benedict, C. E. Wood, and J. A. Bowers.

Mr. R. E. Parks, assistant general manager of the Aluminum Company of America, Maryville, Tenn., has been promoted to the position of general manager of the company's plant at Badin, N. C.

Colonel John Joseph Carty, Signal Corps, U. S. Army, was the recipient of the Edison medal awarded by the American Institute of Electrical Engineers on May 17, 1918.

Mr. George B. Hogaboon has been granted a leave of absence by the Scovill Manufacturing Company in order to accept the appointment as electroplating advisor for the Bureau of Standards.

Mr. John A. Traylor has resigned from the position of Western Manager of the Traylor Engineering and Manufacturing Company, and will devote his time to his mining interests, with headquarters in Salt Lake City.

Mr. Joseph V. Meigs, formerly research chemist for the Barber Asphalt Company, is now serving in the Ordnance Department of the National Army. He is detailed for chemical duty at South Charleston, Charleston, W. Va.

Mr. Harold E. Woodward, for six years connected with the Food Research Laboratory of the Bureau of Chemistry in Philadelphia, is now doing research work in the Jackson Laboratory of E. I. du Pont de Nemours and Company at Deepwater, N. J.

Mr. H. B. C. Allison, Schenectady, N. Y., died on May 7, 1918. Mr. Allison graduated from the Massachusetts Institute of Technology in 1911. In the fall of that year he became associated with the research laboratory of the General Electric Company, Schenectady, N. Y., where his capabilities and diligent work rapidly advanced him to a position of importance and responsibility.

Mr. Irving S. Ellison, who has been studying at the University of Michigan, has been called to serve with the Medical Supply Depot at Camp Wheeler, Macon, Ga.

Mr. W. W. Battle, city chemist of Dallas, Tex., has been elected secretary-treasurer of the Central Texas Section of the American Chemical Society.

Dr. F. E. Carruth, who was formerly with the chemical division of the North Carolina Experiment Station, has become associated with the Schaefer Alkaloid Works, Maywood, N. J.

Dr. H. L. Abramson, for the past five years assistant health officer in New York, has been appointed chief of the public health laboratories for New Brunswick, Canada, with headquarters at St. John.

Dr. R. F. Ruttan, director of the department of chemistry of McGill University, and chairman of the chemical committee of the Honorary Advisory Council for Scientific and Industrial Research, was recently elected vice president of the Royal Society of Canada. Dr. Ruttan is also vice president this year of the Society of Chemical Industry of Great Britain.

Provost Edgar F. Smith received the honorary degree of Doctor of Letters from Swarthmore College at its commencement on May 20.

Dr. Eugene R. Kelley, formerly commissioner of health at Worcester, and director for the past three years of the department of communicable diseases in the Massachusetts organization, has filled the vacancy in the health commissionership of Massachusetts left vacant by the recalling of Dr. Allan J. McLaughlin to the United States Public Health Service to become assistant surgeon-general in charge of the Division of Interstate Quarantine.

Dr. S. K. Lee, formerly professor of chemistry at the University of Wyoming, has resigned his position to become chief chemist for the Midwest Refining Company. His office will be located at Casper, Wyoming.

Mr. W. J. McGee, formerly of the Bureau of Chemistry, U. S. Department of Agriculture, stationed at Savannah, Ga., has been transferred to San Juan, Porto Rico, where he is engaged in the inspection of food and drugs.

Dr. Lauder W. Jones, head of the department of chemistry in the University of Cincinnati, has resigned to become head of the department of chemistry in the University of Minnesota. He has been granted a leave of absence for a year in order to take charge of the Research Division of the Gas Offensive at the American University in Washington.

Dr. Harry S. Fry, associate professor of chemistry at the University of Cincinnati, has been appointed acting head of the department of chemistry in the University of Cincinnati.

Mr. Walter M. Russell, who for several months has been chemical engineer for the Providence Gas Company, is now superintendent of manufacturing.

Mr. James H. Readio, Jr., who recently came from the Pawtucket Gas Company to the Providence Gas Company, R. I., as assistant chemical engineer, will take over most of the work of the chemical department, also assisting in plant operation.

Mr. M. L. Hartmann, formerly professor of chemistry at the South Dakota State School of Mines, has resigned his position to accept a position as research chemist-in-charge for the Carborundum Company, at Niagara Falls.

Mr. Walter M. Scott, formerly in charge of the department of chemistry at the Osceola Township High School, Dollar Bay, Michigan, is now connected with the Aluminum Company of America, at Massena, N. Y.

Mr. John Putnam Marble has resigned his position as assistant in chemistry at Williams College and is now awaiting his call to the Chemical Service Section of the National Army.

Mr. H. C. Holden has resigned his position as research chemist with the Washburn Crosby Co., of Minneapolis, and has accepted the position of research chemist for the N. K. Fairbank Co., Chicago, Ill.

Prof. T. Brailsford Robertson, formerly professor of biochemistry and pharmacology at the University of California, has been appointed professor of biochemistry at the University of Toronto.

Dr. E. B. Forbes has been commissioned a Major in the Food Division, Sanitary Corps. Dr. Forbes was head of the department of nutrition of the Ohio Experiment Station.

Dr. Abraham Henwood, of the Philadelphia Section of the A. C. S., has relinquished his connection with the faculty of Drexel Institute and entered the service of the Hercules Powder Company in special research work.

Prof. Charles H. LaWall, of the Philadelphia Section of the A. C. S., has been elected chairman of the U. S. Pharmacopoeia Revision Committee.

Dr. D. L. Randall has resigned his position with Baker University, Baldwin City, Kansas, to accept an associate professorship at Wesleyan University, Middletown, Conn. During the summer months he is working in the research laboratory of the Merrimac Chemical Company at North Woburn, Mass.

Dr. Henry Drysdale Dakin received the degree of doctor of science at the commencement exercises of Yale University.

The following named officers of the Food Division, Surgeon-General's Office, are on duty in France: Majors Philip A. Shaffer and A. J. Carlson, Captains Walter H. Eddy, Arthur W. Thomas, F. B. Kingsbury, and M. C. Mastin, all S. C., N. A.

Dr. Raymond Foss Bacon, director of Mellon Institute, University of Pittsburgh, and Lieutenant Colonel in charge of the chemical work of the American forces in France, has received from the University of Pittsburgh the degree of Doctor of Science.

Dr. N. Edward Loomis, for the past four years in charge of physical chemistry at Purdue University, has resigned to become chief chemist of the Wood River, Ill., plant of the Standard Oil Company.

Mr. A. Strickler, assistant professor of chemistry at the Michigan State Normal College, Ypsilanti, is on leave of absence for the summer. In the Fall he will resign his position to take up his new work as research chemist for the National Biscuit Company in their new laboratories, 14th Street, New York City.

Mr. R. B. Stringfield, formerly chemical engineer with the Western Precipitation Company, has accepted the position of chief chemist with Poindexter and Company, Manufacturing Chemists, of Los Angeles and Vernon, Cal.

Dr. William Battle Phillips, formerly of Chapel Hill, N. C., died recently at Houston, Texas. At the time of his death Dr. Phillips was a private geologist at Houston. Dr. Phillips had a varied career. He had been president of the Colorado School of Mines, chemist at the North Carolina Experiment Station, professor of agricultural chemistry and mineralogy at the University of North Carolina, professor of chemistry and metallurgy at the University of Alabama, chemist for the Tennessee Coal, Iron and Railway Company, and director of the Texas Mining Survey.

Mr. Ralph T. Govilivin, formerly employed at the Hercules Powder Company, San Diego, California, has accepted the appointment as organic chemist with the Bureau of Aircraft Production, Pittsburgh, Pa.

It was inadvertently stated in the July issue of THIS JOURNAL that Prof. Herman I. Schlesinger had been promoted to an assistant professorship at the University of Chicago. This should have read "an associate professorship."

Dr. Chas. W. Burrows, associate physicist and chief of the Magnetic Section of the Bureau of Standards, Washington, D. C., has resigned to take up the work of commercial research and consultation, with laboratories equipped for research on problems involving magnetic materials and apparatus and located at Grasmere, Borough of Richmond, New York City. He opened his laboratory July 15, 1918.

Mr. Walter T. Schrenk has joined the Chemical Service Section and is stationed temporarily at the Edgewood Arsenal, Edgewood, Md., until assigned to active duty.

Mr. William T. Pearce, formerly associate professor of general chemistry at the North Dakota Agricultural College, has been promoted to a full professorship.

Mr. Julius Alsberg has recently opened metallurgical and chemical engineering consulting offices in the Tribune Building, Chicago.

Mr. P. B. Chillas, Jr., formerly in the research laboratory of the National Carbon Company, Inc., is now at the Frankford plant of the Barrett Co., Philadelphia, Pa.

Mr. A. Lincoln Konwiser, formerly superintendent of the Hygiene Chemical Co., Elizabethport, N. J., and until recently connected with the chrome plant of the Metals and Thermit Corporation, has been appointed factory superintendent and chemical engineer for J. S. & W. R. Eakins, Inc., Brooklyn, N. Y.

Mr. Frank Marvin, formerly chief chemist of the Howard Smokeless Powder Company plant and Aetna Research Laboratory at Emporium, Pa., has been appointed explosives chemist in the Bureau of Mines, and is stationed at Pittsburgh, Pa.

Mr. E. P. Mathewson, who has been with the Anaconda Copper Company, then with the British-American Nickel Corporation, recently returned to the American Smelting & Refining Company as consulting metallurgist. He will be stationed in the New York office.

Mr. Roger Taylor, formerly with the engineering firm of Frederick deP. Hone & Co., New York, has been assigned to the Ordnance Reserve Corps.

Mr. W. F. Geddes, of the Ontario Agricultural College, Guelph, Ont., has accepted a position with the British Chemical Company, Ltd., of Trenton, Ont.

Dr. Ernest Anderson is now professor of agricultural chemistry at Transvaal University College, Pretoria, Transvaal.

Dr. H. H. Helmick has entered the Sanitary Corps and is now attending the training school at the Rockefeller Institute.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1912	1,014,824	Gottlob Honold, Stuttgart, Germany, Max Rall, Paris, France, Paul Mumprecht, Brussels, Belgium	Robert Bosch, Stuttgart, Germany	Electric ignition system for internal-combustion engines	Splitdorf Electrical Company, 98 Warren St., Newark, N. J.
1912	1,030,817	Gottlob Honold, Stuttgart, Germany	Robert Bosch, Stuttgart, Germany	Binding-post for connecting electric cables	Splitdorf Electrical Company, 98 Warren St., Newark, N. J.
1908	982,897	Karl Schirmacher and Hermann Landers, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red vat dye	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1908	906,367	Oscar Bally, Mannheim, and and Hugo Wolff, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1909	916,029	Albrecht Schmidt and Ernst Bryk, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Red-violet dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1909	925,917	Filip Kacer, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compound of the anthracene series and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1909	929,442	Max Henry Isler, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1909	931,598	Louis Haas, Heidelberg, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Sulfur dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1906	818,336	Oscar Bally, Mannheim, and Hugo Wolff, Lugwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Blue dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1906	809,892	Oscar Bally and Max Henry Isler, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Violet dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1905	807,422	Karl Elbel, Biebrich, Germany	Kalle and Company, Aktiengesellschaft, Biebrich, Germany	Zinc azonaphthol dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1905	787,859	Roland Heinrich Scholl, Karlsruhe, and Oscar Bally, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compound and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1905	796,393	Oscar Bally, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene coloring matter and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1904	770,177	Paul Julius, Hans Reindel, and Fritz Carl Gunther, Ludwigshafen - on - the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Bavaria, Germany	Azo dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City

List of Applications for Patents

Year	Pat. No.	Patentee	Assignee	Patent	Applicant
1903	741,029	Richard Glov and Otto Gebert, Berlin, Germany	Actien-Gesellschaft fur Anilin Fabrikation, Berlin, Germany	Red azo lake	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1911	784,768	Edward Hepp, Frankfort on the-Main, and Ernst Wolpert, Hochst on the Main Germany	Farbwerke vorm. Meister Lucius & Brüning, Hochst-on-the-Main, Germany	Process for making anthraquinone dyes	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1903	734,866	Edward Hepp, Frankfort on the Main, and Christoph Hartmann Hochst on the-Main, Germany	Farbwerke vorm Meister Lucius & Bruning, Höchst-on-the-Main, Germany	Blue anthraquinone dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1903	734,325	Otto Hess, Hochst on the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Hochst on the-Main Germany	Green anthraquinone dye and process of making same	National Aniline & Chemical Company, Inc. 21 Burling Slip, New York City
1902	715,662	Max H. Isler, Mannheim Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1902	714,882	Otto Ernst, Hochst on the-Main, Germany	Farbwerke vorm. Meister Lucius & Bruning, Hochst-on-the-Main, Germany	Monoazo dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1907	863,397	Max Isler and Filip Kacer, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthraquinone compound and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	948,204	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Indanthrene monosulfonic acid and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	955,105	Roland Scholl, Gratz, Austria-Hungary, and Max Henry Isler, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1909	938,566	Paul Fischer, Elberfeld, Germany	Farbenfabriken vorm. Friedr. Bayer & Co., Elberfeld, Germany	Yellow dye	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1908	876,810	Max Albert Kunz, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1907	875,390	Paul Thomaschewski, Elberfeld, Germany	Farbenfabriken vorm. Friedr. Bayer & Co., Elberfeld, Germany	Anthraquinone derivative	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1907	858,065	Otto Ernst and Gillis Gullbransson, Höchst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Brüning, Höchst-on-the-Main, Germany	Monoazo dye for lakes and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1907	856,811	Roland Heinrich Scholl, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Dye of the anthraquinone series and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1907	853,041	Paul Thomaschewski, Elberfeld, Germany	Farbenfabriken vorm. Friedr Bayer & Co., Elberfeld, Germany	Anthraquinone derivative	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1906	828,778	Roland Heinrich Scholl, Karlsruhe, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Compound of the anthraquinone series and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1906	818,992	Oscar Bally and Max Henry Isler, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1913	1,063,173	Christian Rampini, deceased, by William E. Warland, administrator, Brooklyn, N. Y.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing aminoanthraquinones and derivatives thereof	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1913	1,063,172	Christian Rampini, deceased, by William E. Warland, administrator, Brooklyn, N. Y.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Producing aminoanthraquinones and derivatives thereof	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1911	1,003,268	Richard Just and Hugo Wolff, Ludwigshafen - on - the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1911	999,439	Karl Elbel and Edward Wray, Biebrich, Germany	Kalle & Company, Aktiengesellschaft, Biebrich, Germany	Vat-dyeing coloring-matter	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1911	999,062	Fritz Singer, Offenbach-on-the-Main, Germany	Chemische Fabrik Griesheim Elektron, Frankfort-on-the-Main, Germany	Manufacture of anthranol	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1911	998,596	Wilhelm Bauer, Vohwinkel, and Alfred Herre and Rudolph Mayer, Elberfeld, Germany	Farbenfabriken vorm. Friedr. Bayer & Co., Elberfeld, Germany	Vat dye	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	970,878	René Bohn, Mannheim, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Vat dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	968,697	Albrecht Schmidt, Ernst Bryk, and Robert Voss, Hochst-on-the Main, Germany	Farbwerke vorm. Meister Lucius & Bruning, Hochst-on-the-Main, Germany	Vat dye and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	965,170	Karl Elbel, Biebrich, Germany	Kalle & Company Aktiengesellschaft, Biebrich, Germany	Process of condensing reduction products of acenaphthenequinone, etc.	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	961,612	Max Henry Isler, Mannheim, and Hugo Wolff, Ludwigshafen - on - the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Anthracene compound and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	961,048	Fritz Ullmann, Berlin, Germany	Actien Gesellschaft für Anilin Fabrikation, Berlin, Germany	Anthraquinone-diacridones	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	958,325	Albrecht Schmidt and Georg Kranzlein, Hochst-on-the-Main, Germany	Farbwerke vorm. Meister Lucius & Bruning, Hochst-on-the-Main, Germany	Urea of the anthraquinone series and process of making same	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	957,042	Joseph Demet, Elberfeld, Germany	Farbenfabriken vorm. Friedr. Bayer & Co., Elberfeld, Germany	Vat dye	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City
1910	957,040	Joseph Demet Elberfeld, Germany	Farbenfabriken vorm. Friedr. Bayer & Co., Elberfeld, Germany	Orange vat dye	National Aniline & Chemical Company, Inc., 21 Burling Slip, New York City

An item in the May issue of THIS JOURNAL, taken from *Drug & Chemical Markets*, April 3, 1918, announcing the establishment of a school for poison-gas workers at the Case School of Applied Science, Cleveland, Ohio, was incorrect. We have received a note from Prof. W. R. Veasey stating that no such school has been contemplated.

On the afternoon of June 18, 1918, the National Aniline and Chemical Company held open house in their recently equipped Main Office Building, 21 Burling Slip, New York City, the whole building being open for the inspection of the visitors.

The third trial of the suit of the Baugh Chemical Company against the Davison Chemical Company for $500,000 damages, breach of contract by failure to deliver the quantity of sulfuric acid stipulated in a contract entered into between the two corporations being alleged, ended in the Supreme Court, June 2, when the jury returned a verdict for $139,433.65. The award was not only for damages held to have been sustained by the Baugh Company, but also for interest added from the date of the breaking of the contract.

Under the direction of Dr. E. R. Pickrell, chief chemist of the United States Appraiser's Laboratory in New York City, the census of chemical imports being taken for the Government is progressing rapidly, and definite ideas of value, which the completed work will have, are now apparent. Data concerning the tonnage brought into the country, valuation concerning some 2,500 chemical descriptions, and allied products not heretofore available anywhere, have been unearthed, so to speak, and are now in process of tabulation by Dr. Pickrell and his small staff of assistants. While a great amount of work has been accomplished in the two months that have elapsed since the work was started, there still remains a vast amount of detail to be completed, and it will be probably a number of months more before the results can be published. This work was undertaken primarily to show those engaged in the chemical and allied industries in the United States just what foreign competition they will encounter after the war.

The Bragdon, Lord and Nagle Company, *Textile World Journal*, has issued a directory of textile brands and trade marks which is a most valuable reference book, and is the first of its kind issued in this country. A list of over 13,000 trade marks and brands is in the first issue, and a brief description is given to identify the product.

The War Trade Board has adopted the following additional rule and regulation with respect to the issuance of licenses to export any commodity to the United Kingdom, France, Italy, and Belgium (excluding their respective colonies, possessions, and protectorates): Written approval of the mission in the United States of the country to which the exportation is to be made must be obtained in order to file applications for licenses to export any commodity to the Allied Nations.

Due to the increasing need of petroleum oil which is steadily outdistancing the visible supply, oil shales are already being considered not only to make up a developing shortage, but as the future oil reserve.

Several western coast concerns are now engaged in the manufacture of potash from kelp. The Bureau of Soils of the United States Department of Agriculture began the construction of an experimental plant for the extraction of potash from kelp last April at Summerland, California. The purpose of this plant is to determine the cost of producing potash from kelp, and also to determine what by-products can be produced commercially. The kelp char, containing about 30 per cent K_2O, has been the most important product up to date.

Due to the excessive prices charged in some instances for toluol when sold under release for other than military purposes, the War Industries Board has extended the Government price to cover all toluol sold.

The Kaiser has approved the foundation of a Trust to be known as the *Kaiser Wilhelm Trust for Promotion of the Science of War*. The aim of the Trust is to further the development of scientific and technical aids to warfare, by uniting the scientific and the military forces of the country for work together. The scientific work is to be carried on by the following technical committees:

1—Committee for the chemical raw materials for the production of munitions-manufacturing materials.

2—Committee for chemical war materials (powder, explosives, gas, and the like).

3—Committee for physics, including ballistics, telephony, telegraphy, determination of targets and distances, measurements, and the like.

4—Committee for engineering and communication.

5—Committee for aeronautics.

6—Committee for obtaining and preparation of metals.

The Cleveland Salt Company has bought land near Lorain, Ohio, for a plant which will produce salt and by-products used in the manufacture of pharmaceutical chemicals. The investment will be close to $6,000,000.

The Grand Jury of Richmond County, S. I., handed up a statement to Supreme Court Justice Kelby on June 21 condemning the Staten Island garbage plant as a nuisance. At the same time the Grand Jury agreed to give the Metropolitan By-Products Company, the operators of the plant, an extension of sixty days in order that they might install machinery to abate the nuisance complained of.

44,347,780 barrels of petroleum taken from the oil fields east of the Mississippi River were marketed in 1917, compared with 44,628,693 barrels in 1916 and 51,083,331 barrels in 1914. The value of the oil at the wells in 1917 was $15,887,864, which was 26 per cent more than the value of the output from these fields in 1916, though the 1917 production was a fraction smaller than the output of 1916.

The Gulf Sulfur Company, Big Hill, Texas, is developing a sulfur mine at Big Hill, Texas. The company has already bored several wells and has penetrated a large deposit of sulfur of great thickness.

The Applied Chemical Corporation, Manhattan, N. Y., manufacturing chemicals, has been incorporated with a capital of $100,000. The incorporators are J. S. Robinson and others.

The Palatine Aniline and Chemical Corporation, Poughkeepsie, N. Y., has been incorporated with a capital of $150,000. The incorporators are A. R. Mullaly, C. O. Terwilliger, and D. DeForest.

Spalding, Inc., of Manhattan, N. Y., manufacturing drugs, chemicals, etc., has been incorporated with a capital of $100,000, by D. H. Dutton, L. Lens, G. C. Spalding.

The United States Chemical Laboratory in Madison, Wisconsin, reports that turpentine may be produced from resin and pitch of the larch trees of the Montana forests, especially in District No. 1.

The output of all potash materials produced and marketed in the United States in 1917, as reported by the manufacturers to the United States Geological Survey, Department of the Interior, was 126,577 short tons, which contained 33,366 short tons, or an average of 26.4 per cent of pure potash. This is more than three times the quantity produced in 1916 and corresponds very closely with the output predicted for 1917 by H. S. Gale, of the Survey, from a review of the mid-year statistics. The total value of the potash produced in the United States in 1917 was $13,791,922.

The Commercial Cylinder Co., Hackensack, N. J., has been incorporated with a capital of $800,000. The incorporators are A. R. Oakley, Pearl River, N. Y., and Paul E. Britsch, Brooklyn, N. Y.

With a capital of $150,000 the Croton Color and Chemical Company has been incorporated at Croton, Westchester County, N. Y., to manufacture aniline dyes. The incorporators are Paul P. Ihrig, Edward R. Vollmer, and Frank C. Schmitz.

The United States Government has bought five acres of land east of the Niagara Smelting Company's plant as a site for the new million-dollar electrolytic alkali plant. The contract for the erection of the plant has been given to J. G. White Engineering Co., New York City.

The Hercules Oil Company, Delaware, has been incorporated with a capital of $2,000,000. The incorporators are W. F. O'Keefe, G. G. Steigler, and J. H. Dowdell of Wilmington.

The War Industries Board announced on June 27 that, as a result of a meeting of the manufacturers of sulfuric and nitric acid with the Price-fixing Committee of the War Industries Board, maximum prices have been agreed upon and approved by the President, taking effect immediately, and expiring September 30, 1918. The prices agreed upon are as follows:

Sulfuric acid, 60° Bé., $18 per ton of 2,000 lbs.

Sulfuric acid, 66° Bé., $28 per ton of 2,000 lbs.

Sulfuric acid, 20 per cent oleum, $32 per ton of 2,000 lbs.; f. o. b. at manufacturers' works in sellers' tank cars.

In carboys in carload lots, 1/2 cent per lb. extra. In carboys in less than carloads, 3/4 cent per lb. extra. In drums, any quantity, 1/4 cent per lb. extra.

Nitric acid, 42° Bé., 8 1/2 cents per lb., f. o. b., manufacturers' works in carboys.

A schedule of maximum prices on mixed acids is being prepared, and will be announced later. It is understood and agreed that any deliveries made after Sept. 30 will be subject to any revision in price which the Government may make.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

GEOLOGICAL SURVEY

Lime in 1916. G. F. Loughlin. From Mineral Resources of the United States, 1916, Part II. 30 pp. Published March 11. The total quantity of lime sold in 1916 was 4,073,433 short tons, valued at $18,509,305, an increase over the revised figures for 1915 of 450,623 tons, or more than 12 per cent. in quantity, and of $4,088,269, or 28 per cent. in value. This was the first year in which the lime marketed in the United States equaled or exceeded 4,000,000 tons.

The increase in output was accompanied by the greatest increase in average price per ton ever recorded by the United States Geological Survey, an increase due both to greater demand and to greater cost of fuel and labor. These same causes account largely for the decrease of 128 in the number of active plants, which in 1916 was 778, the lowest ever recorded by the Survey. The decrease was principally among the small producers in Pennsylvania, where there were 116 fewer operators active in 1916 than in 1915. The number of kilns in operation increased from 2,340 in 1915 to 2,341 in 1916.

A quantity of marl burned or dried for agricultural use, some of which has been formerly included in the lime figures for Arkansas, California, New York, Pennsylvania, South Carolina, and Virginia, is here stated separately for the first time. The total quantity of marl sold for this use in 1916 was 35,588 short tons, valued at $107,768, or $3.03 a ton. Individual reports gave prices ranging from $1 to $3 a ton in the Southern States and from $4 to $6 a ton in the Northern States and California.

Lime Sold in the United States in 1916 by Uses

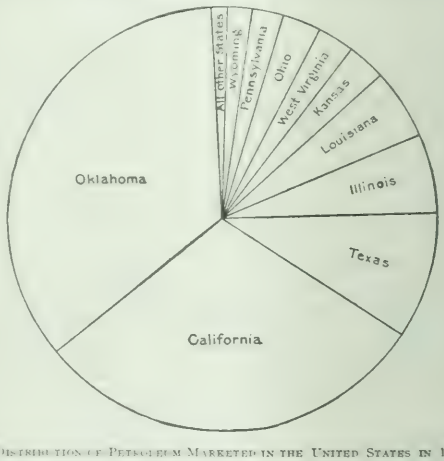
	Quantity, Short Tons	Value	Average Price Per Ton
Building lime	1,509,908	7,859,614	5.21
Chemical works	621,120	2,298,246	3.70
Paper mills	353,182	1,461,412	4.14
Sugar factories	51,923	281,832	5.41
Laundries	59,919	278,003	4.64
Agriculture	613,855	2,224,491	3.63
Plaster	150,035	593,786	3.96
Dealers, use not specified	374,011	1,846,780	4.98
Other uses	340,760	1,710,226	5.02
	4,073,433	18,509,305	4.54
Percentage of increase in 1916	12.4	28.3	
Hydrated lime included in total	12,382	3,626,998	5.06
Percentage of increase in hydrated lime in 1916	23.4	47.6	

Fuel Briquetting in 1917. C. E. Lesher. From Mineral Resources of the United States, 1917, Part II. 3 pp. Published May 6. The production of fuel briquets in 1917 was 496,886 net tons, valued at $2,533,885, an increase compared with 1916 of 111,501 tons, or 28 per cent. in quantity, and $785,226, or 45 per cent. in value. The production in 1917 was the greatest recorded. The progress of the industry for the 11 years from 1907 to 1917, inclusive, is shown graphically in a diagram accompanying the article.

Of the 13 plants in operation in 1917, 4 used anthracite as a raw material, 1, Arkansas semi-anthracite, 2, a mixture of anthracite and bituminous slack, 2, bituminous slack and subbituminous coal, 1, semi-bituminous coal, 1, brown lignite; and 2, oil as fuel. At 1 plant coal-tar pitch was used as a binder; at 1, mixed coal-tar pitch and asphaltic pitch; at 5, asphaltic pitch; at 1, a patent binder; and at 4, no binder whatever.

Petroleum in 1916. J. D. Northrop. Separate from Mineral Resources of the United States, 1916, Part II. 207 pp. Issued April 26. The quantity of petroleum marketed from the oil fields of the United States in 1916, which amounted to 300,767,158 barrels of 42 gallons each, establishes a new record of petroleum output in this country that is nearly 7 per cent greater than the former maximum yield of 281,104,104 barrels, established in 1915.

The average price received at the wells for this oil was $1.10 per bbl., and the total market value of the output was $330,899,868, a gain of 36 cents in average unit price, and of $151,436,978, or 84 per cent, in gross market value, compared with 1915.



Distribution of Petroleum Marketed in the United States in 1916

The accompanying figure shows graphically the relative importance of the several States as contributors to the marketed production of petroleum in the United States in 1916.

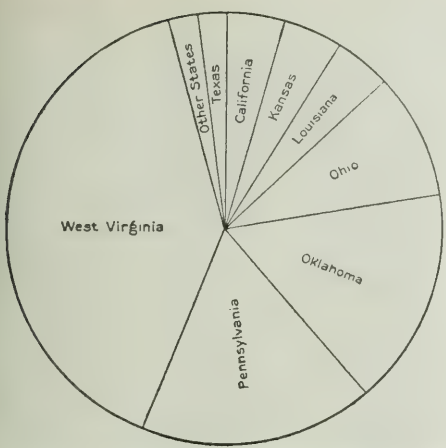
Natural Gas in 1916. J. D. Northrop. Separate from Mineral Resources of the United States, 1916, Part II. 93 pp. Issued May 4, 1918.

The volume of natural gas commercially utilized in the United States in 1916 was greater than that so utilized in any other year in the history of the natural-gas industry. The volume used, which amounted to 753,170,253,000 cu. ft., constituted a new record of production, exceeding by nearly 125,000,000,000 cu. ft., or 20 per cent, the former record, established in 1915.

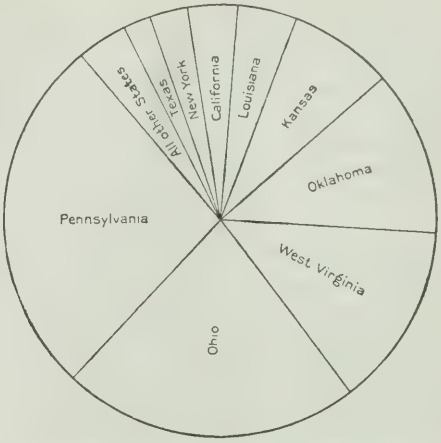
The market value of this gas likewise attained record proportions. It amounted to $120,227,468, a gain of $18,915,087, or 18.6 per cent, over the market value of the output in 1915. The average price per 1000 cu. ft. was 15.96 cents, a loss of 0.16 cent compared with 1915.

Credit for the increased production in 1916 belongs, in the order given, to West Virginia, Oklahoma, Pennsylvania, California, Louisiana, Kansas, Texas, and Arkansas, which together produced 132,000,000,000 cu. ft. more gas in 1916 than in 1915.

Of the total volume of natural gas produced and consumed in 1916, it is estimated that 235,380,764,000 cu. ft., or 31 per cent were distributed to 2,202,194 domestic consumers at an



DISTRIBUTION BY STATES OF PRODUCTION OF NATURAL GAS IN THE UNITED STATES IN 1916



DISTRIBUTION BY STATES OF CONSUMPTION OF NATURAL GAS IN THE UNITED STATES IN 1916

average price of 28.63 cents per 1000 cu. ft., and that the remaining 69 per cent, or 517,789,489,000 cu. ft., was distributed to 18,278 industrial consumers at an average price of 10.21 cents per 1000. Compared with 1915, these data show gain of 8 per cent in volume, of 8 per cent in number of consumers, and of 1 per cent in average unit price of gas supplied for domestic use, and a gain of 26 per cent in volume and of 5.5 per cent in average unit price, but a decrease of 0.4 per cent in the number of consumers of gas supplied for industrial use.

The proportion of natural gas supplied to industrial consumers in 1916 was 4 per cent larger than in 1915.

The history of the natural-gas gasoline industry in the United States is the history of one of the most effective movements in the direction of true conservation of natural gas that has ever been undertaken in this country. Although the foundations of this industry were laid in 1903 and 1904, the period of its greatest expansion is included in the seven years since 1909. In 1911, the first year for which statistics on the subject are available, 176 plants in 9 states produced 7,425,839 gal. of raw gasoline from natural gas. In 1916, only 5 years later, 596 plants in 12 states produced 103,492,689 gal., a gain in this remarkably brief period of nearly 239 per cent in the number of plants and of nearly 1,294 per cent in the annual output of raw gasoline. The volume of natural gas treated in the production of the output of gasoline in 1911 was only 0.5 per cent of the volume of gas produced and utilized in the entire country in that year. The volume treated in 1916 represents 27.7 per cent of the volume produced and utilized in that year and is greater by 8,330 per cent than the volume treated in 1911. The fact that the output of gasoline from natural gas has increased in the last 5 yrs. more rapidly than the number of plants is evidence that the trend of the industry has been toward the erection of plants of larger individual capacity than were at first considered feasible. The fact that the volume of gas treated annually has increased in the same period at a rate far greater than that of the raw gasoline produced, emphasizes the trend of the industry toward the successful utilization of gas leaner in its content of gasoline vapors than was believed possible in the early days of the industry. The trend in the latter direction has been most pronounced in the last 2 yrs., as a consequence of the development of the absorption process, which renders feasible the treatment of gas containing as low as 1 pint of gasoline to 1,000 cu. ft.

Prior to 1916 the greater proportion of the gasoline produced from natural gas was obtained from casing-head gas, oil-well gas, or "wet" natural gas by the compression and condensation method which, however, is restricted in its profitable application to gas that contains not less than 1 gal. of gasoline to 1,000 cu. ft. The development of the absorption process has extended the field of the natural-gas gasoline industry to include practically all the natural gas produced in the United States, for there is but little gas produced in this country that does not contain appreciable percentages of pentane and hexane, the hydrocarbons of the paraffin series that are the principal constituents of gasoline. Much of the so-called "dry" gas obtained from oil wells when they are first opened and from gas wells that produce no petroleum has been found sufficiently rich in gasoline vapors to warrant treatment by the absorption process, though excluded from successful treatment by compression and condensation.

Mineral Waters in 1916. A. J. ELLIS. With a Comparison of American and European Mineral Waters by A. A. CHAMBERS. Separate from Mineral Resources of the United States, 1916, Part II. 47 pp. Issued March 13.

The number of active mineral springs was slightly smaller, but the production and value were greater in 1916 than in 1915. The increase in production was 3,814,958 gal., or 7 per cent. The increase in value of medicinal waters was $61,522 and in value of table waters was $534,719; thus the total increase in value of sales was $596,241, or 12 per cent.

Practically four-fifths of the mineral waters was sold at prices ranging from one-half cent to 10 cents per gal. during 1913, 1914, 1915 and 1916. The percentage sold for more than 30 cents per gal. was nearly double what it was in 1915 and constituted a little more than 8 per cent of the quantity sold in 1916. The water from 487 springs was sold for 10 cents or less per gal. and the water from 9 springs was sold for more than $1 per gal. The average price per gallon in 1916 was 10 cents.

The total imports of mineral waters have decreased more than 50 per cent in four years, from 3,562,863 gal. in 1913 to 1,723,440 gal. in 1916. It is worthy of note that, large as these figures for imports are, they represent only a relatively small percentage of the total consumption of mineral waters in the United States. Rarely do they amount to more than 6 per cent of the total consumption, and for the years 1913 to 1916, inclusive, they are somewhat less than 4.5 per cent.

Those who have found it difficult or impossible to obtain waters that were previously imported will doubtless be interested in the possibility of substituting domestic waters for certain famous mineral waters of Europe as indicated by the following comparisons of analyses of mineral waters from this country and from abroad. In the analyses only the more common constituents are given, and for the convenience of those desiring more detailed information regarding these and other analyses a bibliography has been appended. To discover two or more natural waters, each of whose dozen or more constituents is exactly the same in kind and concentration, would be difficult if not impossible, but an attempt is made here to show that the waters compared are similar in chemical character, degree of mineralization, and relative proportion of various constituents. As medical practice varies sometimes as much as 100 per cent in the dosage of many of the inorganic substances present in natural solutions, it seems reasonable to assume that waters differing not too widely in composition might be used for the same purpose with similar if not identical physiologic effects.

Five common types of mineral waters are discussed here—chalybeate (or iron), carbonate, sulfide or "sulfur," chloride, and sulfate waters.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Railway Materials, Equipment, and Supplies in Australia and New Zealand. F. RHEA. Special Agents Series No. 156. 164 pp. Paper, 25 cents

Textile Markets of Bolivia, Ecuador, and Peru. W. A. TUCKER. Special Agents Series No. 158. 106 pp. Paper, 15 cents.

Construction Materials and Machinery in Colombia. W. W. EWING. Special Agents Series No. 160. 75 pp. Paper, 15 cents.

COMMERCE REPORTS APRIL 1918

By the terms of the "Nonferrous Metal Industry Act," recently passed by Great Britain, no persons or firms having any enemy connections are permitted for a period of 5 yrs. after the end of the war to engage in extracting, smelting, refining, or dealing in nonferrous metals or ores, including **zinc**, copper, tin, lead, nickel, and aluminum. (P. 4)

A new Danish by-product of **fish offal**, known as "cornimite," is proposed for **electrical insulators** and as a substitute for "galalith," the plastic made from **casein**. Other products of the herring industry are fish oil, "fibrin," fish bones, and guano. (P. 20)

In a report of a special British committee appointed to consider the status of the **sulfuric acid** and **fertilizer** industries after the war, it is suggested that extended measures be taken to increase the use of fertilizers, by education, coöperation, and improved transportation of sulfuric acid and fertilizers. In order to avoid a future surplus of sulfuric acid from the present munitions plants, provision is suggested for (*a*) an increased rate of depreciation on acid plants in figuring taxes, (*b*) scrapping of plants not required, or (*c*) temporary shut downs, with interest paid by the government. Of special interest to chemists is the following recommendation: "In view of the importance of scientific control of chemical operation, we desire to draw attention to the need for improving the status of the technical chemist. We consider that it is essential to the success of the chemical industries of the country that the value of men of liberal education who have specialized in chemistry and its cognate sciences and have experience of manufacturing operations should be more adequately recognized." (P. 29)

The cultivation and preparation of "alfa grass" or **"esparto"** in Tunisia, Africa, is described in detail. (Pp. 40–44)

Among new sources of **alcohol** suggested in Australia, is the nut of the zamia palm, or fern-tree palm. The nuts contain 28 per cent of starch, which can be malted, fermented, and distilled, yielding 45 gal. of alcohol per ton, at a very low cost. (P. 45)

In a report on the **dyestuff** industry in Great Britain, evidence of satisfactory progress is shown in the list of important dyes being made by several companies. (P. 52)

In a British conference on careers for **girls** with secondary education, emphasis was laid upon the need and opportunity for **women chemists** in the chemical industries. (P. 60)

Increased production of **pig iron** and **steel** in Canada is due chiefly to the increased output of electric furnaces. (P. 70)

The use of the **metric system** has been made obligatory in Uruguay. (P. 107)

The use of seaweed, previously freed from saline material, as **fodder** for horses, is receiving serious consideration in France. (P. 108)

Production and shipments of **nitrate** from Chile has increased, and is now considerably above that of 1914, when it commenced to decline. (P. 132)

Experiments are in progress in Norway to operate **automobiles** with **acetylene**, which can be readily produced from the calcium carbide now made by water power. (P. 144)

Production of **mica** in Brazil has greatly increased on account of greater demands for mica for electrical insulation, and as an absorbent of nitroglycerine in dynamite. (P. 148)

Detailed consideration of the **natural indigo** industry of India shows that its future prospects depend upon the possibility of controlling the Eastern (Chinese and Japanese) markets. (P. 168)

It is estimated that the Tofo **iron ore** mines in Chile (controlled by the Bethlehem Steel Company) contain 100,000,000 tons of ore with 68 per cent iron. A large loading basin and breakwater, and large bins, etc., have been constructed at Cruz Grande, a port 14 miles from the mines. Electric locomotives will be used, with regenerative braking system on the loaded, downward-bound trains. (Pp. 170–3)

Bolivian **tin** ores are now being smelted in Chile, using California petroleum residuum as fuel. (P. 187)

Wood alcohol, obtained from sulfite pulp mills, is being used as a substitute for gasoline for motor fuel in Sweden. (P. 218)

Extensive deposits of **molybdenum** ores have been found near Christiania, Norway. (P. 311)

A new **insulating material** known as **"molersten"** and used for covering hot air and steam pipes has been developed in Denmark. It is made by mixing loam from heath clay beds with cork dust and molding into bricks which are then burnt, producing a porous structure. (P. 312)

Cardboard containers for jams, biscuits, etc., have largely replaced tin containers in England. (P. 323)

Analyses are given of 25 varieties of **coal** mined in Japan. (P. 331)

All supplies of **fertilizers** in Sweden have been requisitioned by the government. (P. 334)

The Brazilian government has offered to finance factories for making **caustic soda**. (P. 353)

SPECIAL SUPPLEMENTS ISSUED IN APRIL

UNITED KINGDOM—19*a* and *b*	FRENCH INDO CHINA—54*a*
MEXICO—54	AUSTRALIA—60*a*
BRITISH INDIA—58	ALGERIA—63*a*

SUPPLIES OF INTEREST TO THE UNITED STATES

BARCELONA (P. 58)	CHRISTIANIA, NORWAY	DENMARK (P. 267)
Argols	(P. 280)	Chalk
Glycerin	Cane sugar	Diamonds
Licorice	Sodium nitrate	Flint pebbles
Calcium nitrate	Hides	Hides
Potassium carbonate	Matches	Ink
Cork	Paper	Paper
Olive oil	Wood pulp	Porcelain
Paper stock		Rags
		Rennet

STATISTICS OF EXPORTS TO THE U. S. (*Concluded*)

CALCUTTA (P. 126)
Drugs
Hides
Manganese ore
Mica
Shellac

LONDON—Sup. 19*a*
Bismuth
Coaltar products
Senna leaves
Gum copal
Gum lac
Gum shellac
Gum tragacanth
Rosin
Indigo
Mineral wax
Diamonds
Fertilizers
Hides
Rubber
Iridium
Leather
Coconut oil
Palm oil
Palm kernel oil
Paper
Platinum
Graphite
Tin
Chalk
Alkalies
Ergot
Buchu
Gum arabic
Opium
Celluloid
Glue
Grease
Rapeseed oil
Castor beans

MALAGA, SPAIN (P. 403)
Thymol
Olive oil
Essential oils
Iron ore
Barite
Ochre
Iron oxide pigment

ENGLAND (Misc.)—Sup. 19*b*
Aeroplane parts
Chalk
Ammonium carbonate
Ammonium chloride
Sulfur
Sodium bicarbonate
Glass
Iridium
Indian red
Varnish
Artificial silk
Fullers' earth

AUSTRALIA—Sup. 60*a*
Casein
Hides
Manganese ore
Osmiridium
Eucalyptus oil
Tin
Zinc ore

ALGIERS—Sup. 63*a*
Argols
Bones
Dyewood
Glue stock
Hides
Zinc ore
Infusorial earth

VERA CRUZ (P. 390)
Chicle
Hides
Lead
Mercury
Silver

MEXICO—Sup. 32*a*
Antimony
Guano
Beeswax
Bones
Calamine
Copper
Cottonseed oil
Cottonseed cake
Glycerin
Gold
Hides
Lead
Lead ore
Mercury
Tin
Zinc
Zinc ore

BRITISH INDIA—Sup. 50*b*
Hides
Indigo
Paraffin
Lac
Manganese ore
Mica
Myrabolans
Vegetable oils
Saltpeter
Castor seed
Linseed

COMMERCE REPORTS—MAY 1918

Production of **tin** and **tungsten** ores in the Siamese Malay States is increasing. (P. 418)

Efforts are being made to increase the production of **oil from seeds** and **nuts** in West Africa, including n'gore nuts and n'kamba nuts. (P. 420)

It is estimated that by proper methods of extraction, over 300,000 tons of **potash** could be secured annually as a by-product of the nitrate deposits of Chili. The average potash content of the crude nitrate is estimated at 1.73 per cent. (P. 437)

Exports of **logwood** and **fustic** from Jamaica to the United States show a marked increase. (P. 454)

The world's demand for **bismuth** is not great (about 600 tons annually). The present output could be greatly increased and the price reduced if there were sufficient demand. The principal sources are Bolivia and Australia. The chief use is in alloys, including those used for stereotype metal (very occasionally); for silvering mirrors; for fusible boiler plugs, automatic sprinklers, electric fuses, low melting solders, and dental alloys; and for tempering baths for steel. Salts of bismuth are used medicinally and for porcelain painting and enameling, and in staining glass. (P. 474)

Brazil is now manufacturing sufficient **calcium carbide** not only for domestic consumption, but for export. (P. 475)

Statistics of the War Industries Board show that the annual consumption of **tin** in the United States is about 76,000 tons; and imports only about 70,000 tons. Part of the deficit is made up by tin recovered by detinning, etc. (P. 506)

More than half of the **gypsum** mined in England is obtained from the Nottingham district, where it is especially white. It is used for making mineral white or terra alba, plaster of Paris and Keene's cement. (P. 521)

Owing to lack of transportation **cottonseed cake** is being used in large amounts as a fuel in Egypt. The ash is a valuable **fertilizer.** (P. 531)

The Brazilian government has offered to lend to the first three parties engaging in the manufacture of **caustic soda,** 75 per cent of the cost of the plant (but not more than $500,000). It is expected that electrolytic plants will be erected. (P. 534)

Among measures proposed in Brazil to provide supplies of fuel for **iron smelting** is that of planting eucalyptus trees to be used for making **charcoal,** and the subsidizing of coal and steel producers. (P. 568)

Exports of **manganese ore** from Brazil have increased from 122,000 tons in 1913 to 533,000 tons in 1917. (P. 637)

Efforts to develop the pressing of **linseed oil** in Argentine for export, thus conserving cargo space, have failed because of (*a*) limited capacity of existing factories, (*b*) use of pressing facilities for edible oils, (*c*) lack of machinery, (*d*) lack of local market for linseed cake, and (*e*) necessity of importing cans or drums for shipping the oil. (P. 666)

Production of **quebracho extract** in Argentine could be greatly increased under favorable conditions. At present a considerable amount of quebracho wood is exported to the United States, requiring increased tonnage. (P. 682)

Exports of **antimony** from China show a decrease, owing to the return to normal prices. The most successful process in use is the "oxide process" devised by a Frenchman, Herrenschmidt. In the process the low-grade ores are mixed with charcoal, and burned in a furnace, producing antimony oxide, which partly condenses and is partly recovered by washing the gases. The oxide is reduced to metal by heating with soda and charcoal. The processes are described in some detail. (Pp. 699–703)

Mineral products of Tunisia include ores of **lead, zinc, iron,** and **manganese,** and **phosphates** and **lignite.** (P. 704)

Production of **divi-divi** in the Dominican Republic is decreasing. (P. 708)

Iron ore containing 66 per cent of iron has been discovered in Queensland, Australia. (P. 777)

Other mineral products of Queensland are **tin, tungsten, copper, gold, diamonds,** and **petroleum.** (P. 778)

Imports of **chemicals** and **drugs** into Great Britain in March 1918 show an increase of 30 per cent over March 1917, while exports show a decrease of 8 per cent. (P. 783)

The use in Germany of "cellulon," a fiber produced from **wood pulp,** is increasing greatly, especially as a substitute for **jute** for army needs. The details of the manufacture are not available, but it is claimed that some cotton or wool waste is mixed with the wood pulp cellulose. (P. 788)

Large supplies of **dyewoods,** including fustic, brazilwood, and mora, are available in Mazatlan, Mexico. (P. 804)

The following **mineral products** of Canada show increased output in quantity: Cobalt, molybdenite, nickel, zinc, magnesite, natural gas, petroleum, pyrites, quartz, salt, lime, sand, and gravel. These show a decrease: Copper, gold, pig iron, lead, silver, asbestos, coal, graphite, gypsum, and cement. (Supplement 23*a*, P. 7)

SPECIAL SUPPLEMENTS ISSUED IN MAY

GREECE—7*a*
NETHERLANDS—9*a*
LEEDS—19*c*
SCOTLAND—19*d*
CANADA—23*a* and *b*
BRITISH EAST AFRICA—65*a*

STATISTICS OF EXPORTS TO THE UNITED STATES

HULL, ENGLAND (P. 483)
Gum copal
Cresol
Rubber
Castor seeds

NETHERLANDS—Sup. 9*a*
Beeswax
Chemicals
Drugs
Dyes
Diamonds
Earthenware
Fertilizers
Glassware
Glue
Hides
Ink
Matches
Paper stock
Paraffin
Rubber
Stearin, pitch

SCOTLAND—Sup. 19*d*
Linoleum
Paper
Acids
Ammonium sulfate
Bone charcoal
Brass wire cloth
Corundum
Creosote oil
Sodium cyanide
Fertilizers
Grease
Hides
Leather
Magnesite
Manganese ore
Paper stock
Sumac extract

VANCOUVER—Sup. 23*b*
Coal
Copra
Fertilizer
Gold
Magnesite
Rubber

GLASGOW (P. 469)
Acids
Ammonium sulfate
Corundum
Creosote
Sodium cyanide
Fertilizers
Hides
Magnesite
Manganese ore
Sumac extract

LEEDS, ENGLAND—Sup. 19*c*
Brass
Naphthol
Phenol
Cresol
Orchid liquor
Wool grease
Leather

BOOK REVIEWS

Methods for the Commercial Sampling and Analysis of Coal, Coke, and By-Products. Compiled by the Chemical Sub-Committee of the United States Steel Corporation under the direction of J. M. CAMP, Carnegie Building, Pittsburgh, Pa., 1917. 91 pp., 7 figs., 1 plate. Price, $1.50

The main purpose of the work has been to standardize the chemical methods used in the various plants of the United States Steel Corporation, having special reference to methods for the sampling and analysis of coal, coke, and by-products, with the addition of a special feature in the form of well-illustrated directions for determining the yield of by-products for the evaluation of coal preliminary to its use in actual coking processes. This work is of special interest at the present time for the reason that the methods cover material which is of vital importance now, setting forth, moreover, the methods in actual use by the chemists whose daily work is largely taken up with the processes here described. While the methods for the analysis of coal and coke are easily available there is not so much literature at hand covering the determination of by-products such as the ammonia liquors and still wastes, crude tar and tar distillates, light oil and benzol products, etc.

S. W. PARR

Chemistry of Materials. By ROBERT B. LEIGHOU, Sc.B., Associate Professor of Chemistry in the Carnegie Institute of Technology. 8vo xv + 449 pp. Illustrated. McGraw-Hill Book Co., New York, 1917. Price, $3.00.

The full title of this text, "Chemistry of Materials of the Machine and Building Industries," adequately expresses the author's object "to supply information concerning the chemical properties of the materials employed in the various courses in building construction and equipment and in machinery construction and operation." To this scope the author has rather rigidly adhered and no attempt has been made to satisfy the needs of the engineer and artisan in general.

The text contains chapters on Water for Steam Generation, Fuels, Refractory Materials, Iron and Steel, Corrosion of Iron and Steel, Nonferrous Metals, Nonferrous Alloys, Foundry Sands, Building Stones, Lime and Gypsum Products, Portland Cement, Clay and Clay Products, Paints, Lubricants, Glue, Rubber, Electrical Insulating Materials, Primary Electric Cells, Secondary Cells, and Hydrometry. These topics cover a broad field in themselves and the discussions throughout are designed to satisfy the requirements of the user rather than the manufacturer. Accordingly the methods of manufacture although often discussed "have not been emphasized or presented in detail."

The text as a whole is well written and the material well arranged. Other texts and the original literature, from which the material has been drawn, are cited in footnotes and at the end of each chapter is both a book and periodical bibliography, which greatly enhance its value as a textbook for the classroom.

Like all books of this character, the author has failed to satisfy the individual requirements of each instructor in applied chemistry for technical students, inasmuch as the selection of material is so frequently a matter of judgment. No mention is made, for example, of water purification, charcoal manufacture, powdered coal firing, acetylene gas, natural and tufa cement, heat insulation, etc. The user might also infer that thermite welding is the only process in use, since no mention is made of oxyacetylene and electric welding. On the other hand, considerable space is given to the theories of iron corrosion as developed by Cushman, Friend, and others, to which the user might well be directed for a full discussion. Some eighteen pages are given over to a discussion of the metallography of iron and steel though it is doubtful if the user might not find it advantageous to consult Sauveur's larger text.

The author has succeeded in classifying the properties of the various materials in an excellent manner. Especially is this true of the paint and rubber industries, where the diversity of material is very large. The chapters on electric cells are also timely and a very desirable addition to a textbook of this kind. The text has been well edited and is a useful contribution to the subject matter of applied chemistry.

H. K. BENSON

The Examination of Milk for Public Health Purposes. By JOSEPH RACE. vi + 224 pp. John Wiley & Sons, Inc., New York. Price, $1.75.

This compact and well arranged book gives in convenient compass all the essential information for the public health official concerning the composition of milk, together with its chemical and bacteriological examination. The material is about equally divided between the chemical and biological sides, although the latter is taken up with possibly a somewhat greater wealth of detail. Especially worthy of commendation are the statements regarding the chemical composition and natural variations in normal milk, and the discussion of methods for the enumeration of total bacteria and of excremental organisms. The standard bacterial methods of the American Public Health Association are discussed in a spirit of friendly criticism.

A pleasing feature is the rather unusually full treatment given to the effect of breed and of period of lactation on the protein : fat and lactose : protein ratios. The interesting relation between the calculated protein derived from the Olsen and Van Slyke formulae as affected by the addition of water or the removal of fat is well stated, but the calculation of the proportion of added water is hardly so mathematically exact as might be inferred by the unwary reader from the statements on page 58. The relative importance of preservatives in milk and of methods for their detection is perhaps somewhat exaggerated. The only feeling that remains, however, on laying the book down, is one of pleasure at finding essential facts so clearly stated by one who knows his subject through working with it.

A. G. WOODMAN

Aids in the Commercial Analysis of Oils, Fats and Their Commercial Products. A Laboratory Handbook. By GEORGE FENWICK PICKERING, Head Chemist and Works Manager, formerly Research Assistant to the late Dr. J. Lewkowitsch. 133 pp. Charles Griffin & Company, Ltd., London, 1917. Price, $2.50.

As the title states, this is a book for the laboratory, and the book assumes that the user is an experienced analyst and accustomed to oil work. As such, it will be found very valuable on account of its brevity and of the large number of tables. It will be particularly helpful in the analysis of commercial and waste products. Being a work of this kind it is not surprising to note the absence of references to the literature and of cuts. Some points that attracted the attention of the reviewer are: the statement in the preface that "the following methods are given as works methods, and it must be clearly understood that the chemical methods used in the analysis of oils and fats cannot have no pretence to a degree of accuracy such as is usually found in metallurgical work." This being the fact, it is interesting to note that in very many analyses results are given to 0.01 per cent.

The French spelling of gramme and centimetre is used throughout the book as well as "meter" rather than "metre." The refractive indices are given at 17° C. rather than 25° C. as is usual; also

viscosities at 70° F. which has been abandoned. The table, however, gives as well 140° F., 180° F., and 212° F., and will be found very useful. It would help, however, to know exactly what oil is meant by the term "animal oil" used here, and also in other places in the book. The description of the flash point (p. 14) is crude. In the extraction of unsaponifiable matter, no caution is given regarding the "petrol" used—that it should leave no residue on evaporation at 100° C. The statement "the original method of Hubl is still the standard" is not true; it is still somewhat used, but is not *the* standard. Similarly the statement (p. 27) regarding the Maumené test, that the addition of "mineral oil is a hindrance," is not in accord with the fact. In the directions for the determination of the specific gravity of pitches (p. 107), the procedures for the light and heavy pitches have been confused.

The volume is unique, and should be in the library of every one having to do with the analysis of oils and fats.

A. H. GILL

Reagents and Reactions. By E. TOGNOLI. Translated from the Italian by C. AINSWORTH MITCHELL. P. Blakiston's Son & Co., Philadelphia, 1918. Price, $2.00.

The tests for purity of chemical reagents are useful but being limited to more important reagents only it is not as useful a book as many others which are in use. Listing the reactions under the name of the chemist is unusual and impracticable unless one is already familiar with the work of the analysts whose names are given in alphabetical order instead of the names of the reagents.

J. T. BAKER

Coal Gas Residuals. By FREDERICK H. WAGNER, M.E. 2nd Ed. xii + 244 pp., with diagrams. McGraw-Hill Book Co., New York, 1918. Price, $2.50.

The first edition was reviewed in THIS JOURNAL, 7 (1915), 362. The war has greatly increased interest in coal by-products which are used in making explosives, dyestuffs, fertilizers, etc., and hence this new edition. The layout of the book is the same as in the first edition, with very few changes, but with the addition of some 65 pages.

It is to be regretted that this book, like many other "scientific" books, is so uneven in value. The author as a gas engineer may give an interesting discussion with dependable conclusions in some lines, but the ambitious demands of the book lead him into coal tar and chemical lines with which he cannot be so familiar and this results in his apparently accepting and setting forth data without discrimination and containing many misleading statements. The reviewer appreciates it is easier to sit on the side lines and criticize than to take the active part, but it does seem that continued publication of books, which purport to be equally authoritative in all directions and are misleading in some parts, will bring so-called "scientific" books into ever-increasing disrepute. The burden seems to be fairly on those who wish to be authors to know fully about their subject or else to differentiate clearly in their books between what they can personally vouch for and what is condensed or compiled from other sources, and to give their authorities so that the reader may have some check on the statements made. It would also be a most important improvement if scientific authors giving description of various processes would indicate, when possible, those which represent good current practice as distinguished from those which are mere theories or patents.

Speaking more specifically, the main additions in the present edition are pages 35 to 51, entirely new matter on tar products; 69 to 73 and 85 to 88, some additions on cyanogen; 154 to 163, additions on ammonia; 185 to 190, additions on benzol; 191 to 199, a new chapter on sulfuric acid; and 214 to 222, new matter on determination of benzene, toluene, etc., in light oils.

There is a certain glamor at present surrounding tar and tar products, and other publications besides this, including some from Washington, have given a misleading idea as to the scource of most of the so-called coal-tar products used in explosives and dyestuffs. Two of the materials most prominent are toluene, as the source of T. N. T., and benzene, as the source of various products, particularly synthetic phenol. It is proper to point out that, strictly speaking, only negligible amounts of these are derived from coal tar and that the large source is from the so-called light oil which is separately washed from the gas and is not condensed with the tar. Some phenol is obtained from oils distilled from tar as well as considerable naphthalene, some cresylic and some anthracene, but in practice the portion of coal tar entering into the coal-tar chemical products prominent to-day is less than 10 per cent of the total tar and some 90 per cent remains to be disposed of in less poetic lines. Some little emphasis is laid on this because the present book, like others, does not give a fair perspective of this portion of the subject and touches lightly, and often incorrectly, some of the high spots.

Without commenting in much detail, it may be pointed out that some of the errors in the first edition continue. For example, on page 5, alizarin obtained from anthracene is still mentioned as the base of indigo. On page 30, Table VI, the temperature of saturation of Oil I presumably should read 89° to 76.8°, instead of 98° to 76.8° C.; and that of Oil III should probably read 35° to 20°, instead of 78° to 20°. On page 31 the same doubtful figures are still quoted as to the results obtained with the Feld process of fractional distillation (should be condensation) of tar products. Table VIII, page 32, still incorrectly gives "anyline" instead of aniline. There are many inaccuracies of statement in the pages on tar products. In several cases crude products are given as finished products and vice versa. In others several crudes are mentioned one after another and they are said to yield several finished products, but no clear idea is given as to which crude yields a given finished product. The figures of yield often are far from United States practice.

In the chapter on benzol, the well-known Koppers system is given first place, as it deserves, in view of its wide use in the United States, but it is followed by a discussion of the Feld system in such way that the reader might also think it was a prominent system here, whereas it is not. The author also refers to the fact that if the benzol were extracted from the gas from the coke ovens existing at the time the statement was made by Puening, certain amounts of benzol would be recovered, and appears to overlook stating the important fact that all of these installations have since been made and that more than the amount of benzol mentioned is being recovered. In general, the author uses Fahrenheit scale, which is not in conformity with the practice of this country in such installations.

The chapter on cyanogen contains considerable additions, comprising the discussion of the processes followed by the British Cyanide Company and the Commercial Gas Company of London, pp. 69–93, also the treatment of spent oxides, pp. 84–88. A few additions have also been made to the detailed description of the Feld and Bueb processes.

The chapter on ammonia covers a number of recovery systems in considerable detail. It is not always clear to the reader whether the description is that of an operating plant or whether it is based on patent specifications, a distinction frequently based on important differences. There is an interesting table from an enemy source on the influence of foreign matter on the color of sulfate of ammonia. The Feld process both by itself and in combination with the Bueb cyanogen plant is covered very thoroughly, leading to somewhat extensive and argumentative "conclusions" to the effect that the economy of the Feld plant is superior.

There is also brief timely discussion of the methods of converting ammonia to nitric acid and the production of nitrate

of ammonia, together with a diagram of a conversion plant, pp. 154–163. This comprises most of the text that has been added to the ammonia chapter.

It is earnestly to be hoped that when a third edition of the book is forthcoming it will be thoroughly revised. There is certainly a demand for a good up-to-date book treating with the subject in hand

R. P. PERRY

A Manual of Chemical Nomography. By HORACE G. DEMING, Associate in Chemistry, University of Illinois. 71 pp. The University Press, Champaign, Ill., 1918. Price, $1.25.

The subject of nomography or calculation by graphical methods was developed a generation ago. Outside of a few elementary books and treatises for engineers, almost nothing is published on the subject in English. Dr. Deming's manual is accompanied by a book of charts, 18 in number, for the calculation of products, quotients, reciprocals, square roots, cube roots, and the like, all of which can also be found with the aid of the slide rule. The great advantage in the nomographical method is that it can be extended to the solution of algebraic equations, which are frequently encountered in chemical calculations. Thus, the calculations following the analysis of mixtures or the analysis of organic compounds are very simple. In the latter case, after the percentages of C and H are known from analysis (in a compound containing C, H and O), the formula is found by simply joining the percentages on two scales by a straight edge and reading numbers from other scales traversed by the straight edge.

The method not only gives as accurate results as an ordinary slide rule but also suggests the construction of special scales for special problems where algebraic equations must be solved. Chemists and engineers having many numerical calculations to make, owe a debt of gratitude to Dr. Deming for bringing to light another powerful method of simplifying computations.

JAMES M. BELL

Edible Fats and Oils. By C. AINSWORTH MITCHELL, B.A., F.I.C. 159 pp. Longmans, Green and Co., New York and London, 1918. Price, $2.00.

This little volume is a very valuable addition to the literature of the subject. It is remarkable how much useful material the author has condensed into a small space. The treatment of the manufacturing processes for production of various oils and fats must be considered as simply a sketch tending to give general outlines rather than specific methods. The greater part of the work consists of a description of up-to-date analytical processes and is in such form as to give anyone unfamiliar with the subject of fat analysis a very clear idea of what the various methods indicate, while at the same time it is a very useful reference book to the specialist.

The bibliography of the subject, covering 27 pages, is particularly useful.

The chapters dealing with margarine manufacture and hydrogenation, considering the very short space occupied, give very clear general ideas of these two processes.

The author in his preface states he has "endeavored to give a concise outline of the chemical composition and properties of the more important oils and fats, together with a description of the methods of extracting them from the crude materials, and of purifying and preparing them for food purposes. A chapter dealing with the physical and chemical methods of examining edible oils is also included, and tables of so-called "constants" are given with the descriptions of the individual fats, with the object of enabling anyone who has no specialized knowledge of the subject to understand the technicalities of an analysis. With this end in view, the principles rather than the working details of well known analytical methods have been described."

The book is fully up to the above description.

DAVID WESSON

Annual Report of the Chemical Laboratory of the American Medical Association. Volume 10, January–December 1917. Pamphlet, 140 pp. American Medical Association, 535 Dearborn St., Chicago.

This, the tenth volume of what is familiarly termed by its friends "The A. M. A. Lab. Reports," is as valuable to every pharmaceutical chemist as has been its predecessors. In fact, the 1917 issue is of even more value, since it includes a general index to the entire ten volumes, so that now the chemist desiring information concerning preparations examined by the A. M. A. laboratory staff need only refer to one index instead of to ten.

The purpose of the pamphlet is two-fold: (*a*) to acquaint physicians, pharmacists, and others interested in the subject, with the composition of proprietary preparations found in the American market; (*b*) to inform pharmaceutical chemists of the methods found most satisfactory in examining preparations of complex character. It is in this second function that the book is of great value to the chemist interested in the pharmaceutical side of our calling.

H. V. ARNY

The Storage of Bituminous Coal. By H. H. STOEK. 192 pp., 63 figs. Circular No. 6, Engineering Experiment Station, University of Illinois, Urbana, Illinois, March 4, 1918. Price, 40 cents.

Professor Stock has prepared a valuable and timely publication on the storage of bituminous coal, the purpose being "to present a review of modern practice governing the storage of coal and a statement of the facts which have developed in the experience of those who have successfully or otherwise undertaken to store coal. The discussion is confined largely to bituminous coal, which has given so much trouble owing to its tendency toward spontaneous combustion while stored, and to storage systems and mechanical devices."

The subject matter of the bulletin is given in the following seven chapters and three appendices:

I—Introduction.
II Reasons for Storing Coal.
III Places of Storage for Different Purposes.
IV Coal Storage Practice.
V Storage Systems
VI Effects of Storage upon the Properties of Coal.
VII Expense of Storing Coal.
Appendix I Questionnaire on Coal Storage Data.
Appendix II Summary of Conclusions and Suggestions Regarding Coal Storage.
Appendix III Experiences of Firms and Individuals Storing Coal.

The author is to be commended for not only covering the published literature on coal storage, but also in collecting much valuable information by sending out comprehensive questionnaires to coal operators, dealers, and consumers.

Spontaneous combustion and the effect of storage on coal has been treated clearly and concisely, conclusions being drawn from the excellent experimental work of the Illinois Engineering Experiment Station, U. S. Bureau of Mines, and the Canadian Department of Mines.

The chapters on coal storage practice and systems, and on the expense of storing coal include numerous descriptions with cuts and photographs of modern storage plants. Actual itemized cost data are given for many of these plants.

This information is of the utmost value to those charged with the design of storage plants and should do much to minimize losses from spontaneous combustion and undue breakage of coal.

The author is to be congratulated in preparing this publication at a time when the increase of coal storage facilities becomes necessary as a war measure. His publication should be a ready reference volume on coal storage for anyone interested in the subject.

A. C. FIELDNER

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Alkali Industry. J. R. PARTINGTON. 8vo. 320 pp. Price, 7s. 6d. Bailliere, Tindall & Cox, London.

Analysis: A Manual of Qualitative Chemical Analysis. J. R. MORTON. 8vo. Price, 6s. G. P. Putnam's Sons, London and New York.

Bacteriology: A Text Book of Bacteriology. P. H. HISS AND H. ZINSSER. 8vo. 852 pp. Price, $3.75. Daniel Appleton & Co., New York.

Cellulose. C. F. CROSS AND E. J. BEVAN. 8vo. New Impression with Supplement. Price, $4.00. Longmans, Green & Co., New York.

Chemical Pathology. H. G. WELLS. 8vo. 707 pp. Price, $4.25. W. B. Saunders Co., Philadelphia.

Chemists Pocket Manual: A Practical Handbook Containing Tables, Formulas, Etc., for Chemists. R. K. MEADE. 3rd Ed. 16mo. 530 pp. Price, $3.50. Chemical Publishing Co., Easton, Pa.

Coal Tar: The Treasures of Coal Tar. ALEX. FINDLAY. 8vo. 137 pp. Price, $2.00. D. Van Nostrand Co., New York.

Crystallography: A Manual of Geometrical Crystallography Treating Solely of Those Portions of the Subject Useful in the Identification of Minerals. G. M. BUTLER. 16mo. 155 pp. Price, $1.50. John Wiley & Sons, Inc., New York.

Cyanide Process. A. W. FAHRENWALD. 16mo. 256 pp. Price, $2.00. John Wiley & Sons, Inc., New York.

Dyeing: A Manual of Dyeing. EDMUND KNECHT AND OTHERS. 4th Ed. 2 Vol. 8vo. 914 pp. Price, 42s. Charles Griffin & Co., London.

Engineering Physics: A Textbook of Physics for the Students of Science and Engineering. J. DUNCAN AND S. G. STARLING. 5 Parts. 8vo. Price, 16s. The Macmillan Co., London and New York.

Gravity and Temperature Tables for Mineral Oils. E. N. HURLBURT. 16mo. 204 pp. Price, $1.00. Taylor Instrument Co, Rochester, N. Y.

Laboratory Glassware Economy. H. B. DUNCLIFF. 8vo. Price, 4s. The Macmillan Co., London and New York.

Mining Engineers' Pocket Book. ROBERT PEELE. 12mo. 2385 pp. Price, $5.00. John Wiley & Sons, Inc., New York.

Oils and Fats: Edible Oils and Fats. C. A. MITCHELL. 8vo. 159 pp. Price, $2.00. Longmans, Green & Co., New York.

Organic Chemistry: A Class Book of Organic Chemistry. J. B. COHEN. 12mo. 344 pp. Price, $1.40. The Macmillan Co., New York.

Organic Compounds of Arsenic and Antimony. G. T. MORGAN. 8vo. 375 pp. Price, $4.80. Longmans, Green & Co., New York.

Steam Engines: A Thorough and Practical Presentation of Modern Steam Engine Practice. L. V. LUDY. 2nd Ed. 8vo. 192 pp. Price, $1.00. American Technical Society, Chicago.

Wood: The Preservation of Wood. A. J. WALLIS-TAYLOR. 8vo. 344 pp. Price, $4.00. D. Van Nostrand Co., New York.

Wood: Seasoning of Wood. J. B. WAGNER. 8vo. Price, 15s. Crosby, Lockwood & Son, London.

RECENT JOURNAL ARTICLES

Belt Concentrators and Wet Concentration. ALEX. MCLAREN. *Engineering and Mining Journal*, Vol. 106 (1918), No. 1, pp. 11–12.

Bisulfite Liquor and Its Constituents. JAMES BEVERIDGE. *Paper*, Vol. 22 (1918), No. 16, pp. 11–14.

Blast Furnace: Principal Changes in Blast Furnace Lines. J. G. WEST, JR. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 7, pp. 289–296.

Boron: Its Effect on Crops. F. C. COOK AND J. B. WILSON. *Journal of Agricultural Research*, Vol. 13 (1918), No. 9, pp. 451–470.

By-Product Coke Oven Industry. W. H. BLAUVELT. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 6, 260–261.

Cementation in Illinois Coal Field. M. L. NEBEL. *Engineering and Mining Journal*, Vol. 105 (1918), No. 24, pp. 1080–1082.

Charcoal Precipitation of Aurocyanide. A. W. ALLEN. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 12, pp. 642–644.

Chemistry and Histology of the Glands of the Cotton Plant. E. E. STANFORD AND A. VIEHOEVER. *Journal of Agricultural Research*, Vol. 13 (1918), No. 8, pp. 419–435.

Chemistry in the Pulp and Paper Industry. J. N. STEPHENSON. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 24, p. 537.

Color Classification: A System of Color Classification. E. W. PIERCE. *Textile World Journal*, Vol. 53 (1918), No. 52, pp. 63–65.

Electrification of Textile Fibers. S. A. SHORTER. *Textile World Journal*, Vol. 53 (1918), No. 49, p. 35.

Export Situation. I. B. SCHEIBER. *Color Trade Journal*, Vol. 3 (1918), No. 1, pp. 258–259.

Fuel: Substituting Powdered Coal for Other Fuels. C. F. HERINGTON *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 7, pp. 285–288.

Glass: Some Notes on American Methods and Practice in Glass Making. H. H. PITT. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 5, pp. 19–31.

Glass Making at Bolsterstone. JOS. KENWORTHY. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 5, pp. 5–12.

Iodide Copper Method with Sodium Fluoride. A. L. REESE. *Engineering and Mining Journal*, Vol. 105 (1918), No. 26, pp. 1170–1171.

Mining Industry: The Keystone of Modern Civilization. R. H. STRETCH. *Mining and Scientific Press*, Vol. 116 (1918), No. 23, pp. 791–797.

Nitrate Recovery from Water Gas. J. STEPHENSON. *The Canadian Chemical Journal*, Vol. 2 (1918), No. 6, p. 160.

Okell's Method for Size-Fastness. S. A. OKELL. *Paper*, Vol. 22 (1918), No. 17, p. 19.

Ores: To Utilize Domestic Ores. J. B. WATERHOUSE. *The Iron Trade Review*, Vol. 62 (1918), No. 24, pp. 1493–1494.

Paper Can Manufacture. S. M. LANGSTON. *Pulp and Paper Magazine* Vol. 16 (1918), No. 26, pp. 586–588.

Peat: Inorganic Composition of a Peat and of the Plant from Which It Was Formed. C. F. MILLER. *Journal of Agricultural Research*, Vol 13 (1918), No. 12, pp. 605–609.

Phosphorus Effect in Steel. J. S. UNGER. *The Iron Trade Review*, Vol. 62 (1918), No. 24, pp. 1495–1498.

Potash-Feldspar: British Supplies of Potash-Feldspar. P. G. H. BOSWELL. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 5, pp. 35–71.

Powdered Coal: The Use of Powdered Coal. W. G. WILCOX. *Mining and Scientific Press*, Vol. 116 (1918), No. 25, pp. 849–853.

Refractory Material: Selecting Suitable Refractory Material. J. W. HAULMAN. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 6, pp. 243–244.

Research Laboratory: Problems for the Consideration of the American Research Laboratory. F. H. SMALL. *Journal of the American Leather Chemists Association*, Vol. 13 (1918), No. 6, pp. 239–248.

Rubber Embargo. A. H. KING. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 1, pp. 23–26.

Rubber Substitutes. A. H. KING. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No, 12, pp. 630–636.

Scleroscopes: The Use and Abuse of Scleroscopes. A. J. SMITH. *The American Drop Forger*, Vol. 4 (1918), No. 6, pp. 212–213.

Sulfur: The Effect of Boiling Sulfur on Copper. C. R. HAYWARD. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 12, pp. 650–651.

Sulfuric Acid: How to Conserve Sulfuric Acid and Why. H. J. BROUGHTON. *The Metal Industry*, Vol. 16 (1918), No. 6, pp. 263–264.

Surface Tension: The Influences of Surface Tension. F. C. THOMPSON. *The Iron Trade Review*, Vol. 62 (1918), No. 21, pp. 1299–1304.

Synthetic Indigo. R. W. SMITH. *Color Trade Journal*, Vol. 3 (1918), No. 1, pp. 246–251.

Technical Education: Its Importance and Defects. C. V. CORLESS. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 27, pp. 605–606.

Thermochemistry of Acid Making. C. K. TEXTOR. *Paper*, Vol. 21 (1918), No. 23, pp. 60–64.

Thermocouples: Standardization of Rare-Metal Thermocouples. P. D. FOOTE AND OTHERS. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 7, pp. 343–348.

Thermostats. W. N. RAY. *The Chemical News*, Vol. 117 (1918), No. 3047, pp. 181–184.

Tinning: Mechanical Tinning of Metals. L. J. KROM. *The Metal Industry*, Vol. 16 (1918), No. 6, pp. 261–262.

Trade Paper and Its Industry. B. S. STEPHENSON. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 6, pp. 268–270.

Triplex Electric Steel Process. T. W. ROBINSON. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 6, pp. 245–251.

Turpentine: Recovery System for Sulfite Turpentine. H. F. OBERMANNS. *Paper*, Vol. 22 (1918), No. 4, pp. 11–13.

Ultraviolet Energy and Its Use. M. LUCKIESH. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 5, pp. 232–236.

Ultraviolet Light: Its Application in Chemical Arts. C. ELLIS AND A. A. WELLS. *The Chemical Engineer*, Vol. 26 (1918), No. 5, pp. 181–188.

Valuing Oil Lands. M. L. REQUA. *Engineering and Mining Journal*, Vol. 105 (1918), No. 12, pp. 544–548.

Vanadium Ores, Occurrence and Uses. H. RIES. *Mineral Foote-Notes*, Vol. 2 (1918), No. 5, pp. 3–11.

Vulcanization of Rubber. A. H. KING. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 5, pp. 243–248.

Waste Prevention in Power Plants. V. J. AZBE. *The Iron Trade Review*, Vol. 62 (1918), No. 7, pp. 421–428

Water for Bleaching Purposes. J. M. MATTHEWS. *Color Trade Journal*, Vol. 2 (1918), No. 6, pp. 225–227.

Waterproofed Canvas Manufacture. E. P. CLARK. *Textile World Journal*, Vol. 53 (1918), No. 46, pp. 43–45.

MARKET REPORT—JULY, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON JULY 17, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal	
Alum, ammonia, lump	100 Lbs.	4¾ @	5¼
Aluminum Sulfate, (iron free)	Lb.	3½ @	4
Ammonium Carbonate, domestic	Lb.	nominal	
Ammonium Chloride, white	Lb.	20 @	22
Aqua Ammonia, 26°, drums	Lb.	nominal	
Arsenic, white	Lb.	9¼ @	17
Barium Chloride	Ton	65.00 @	70.00
Barium Nitrate	Lb.	12 @	14
Barytes, prime white, foreign	Ton	30.00 @	35.00
Bleaching Powder, 35 per cent	Lb.	2 @	3¼
Blue Vitriol	Lb.	9¼ @	9½
Borax, crystals, in bags	Lb.	7¼ @	10¼
Boric Acid, powdered crystals	Lb.	13¼ @	15
Brimstone, crude, domestic	Long Ton	nominal	
Bromine, technical, bulk	Lb.	75 @	85
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00 @	25.00
Caustic Soda, 76 per cent	100 Lbs.	4 @	
Chalk, light precipitated	Lb.	4½ @	5
China Clay, imported	Ton	20.00 @	30.00
Feldspar	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered	Ton	nominal	
Fuller's Earth, domestic	Ton	20.00 @	30.00
Glauber's Salt, in bbls	100 Lbs.	1.50 @	3.00
Green Vitriol, bulk	100 Lbs.	1.15 @	1.25
Hydrochloric Acid, commercial	Lb.	C. P. nominal	
Iodine, resublimed	Lb.	4.25 @	4.30
Lead Acetate, white crystals	Lb.	17 @	18
Lead Nitrate	Lb.	C. P. 85	
Litharge, American	Lb.	7¾ @	8
Lithium Carbonate	Lb.	1.50	
Magnesium Carbonate, U. S. P.	Lb.	20 @	21
Magnesite, "Calcined"	Ton	60.00 @	65.00
Nitric Acid, 40°	Lb.	7¾	
Nitric Acid, 42°	Lb.	8½	
Phosphoric Acid, 48/50%	Lb.	35 @	40
Phosphorus, yellow	Lb.	1.35 @	1.40
Plaster of Paris	Bbl.	2.00 @	2.50
Potassium Bichromate	Lb.	46 @	46½
Potassium Bromide, granular	Lb.	1.35 @	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	38 @	40
Potassium Chlorate, crystals, spot	Lb.	39 @	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%	Lb	78 @	80
Potassium Iodide, bulk	Lb	3.75 @	4.00
Potassium Nitrate	Lb.	27 @	30
Potassium Permanganate, bulk	Lb.	1.75 @	2.65
Quicksilver, flask	75 Lbs.	125.00 @	130.00
Red Lead, American, dry	100 Lbs.	10.79 @	12.75
Salt Cake, glass makers'	Ton	20.00 @	25.00
Silver Nitrate	Oz.	62¼ @	65
Soapstone, in bags	Ton	10.00 @	12.50
Soda Ash, 58%, in bags	100 Lbs.	2 @	2¼
Sodium Acetate	Lb.	30	
Sodium Bicarbonate, domestic	100 Lbs.	3 @	3½
Sodium Bichromate	Lb.	27½ @	29½
Sodium Chlorate	Lb.	24 @	26
Sodium Cyanide	Lb.	37 @	43
Sodium Fluoride, commercial	Lb.	17 @	18
Sodium Hyposulfite	100 Lbs.	2.60 @	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.12½ @	5.00
Sodium Silicate, liquid, 40° Bé		2¼ @	3¼
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal	
Sodium Bisulfite, powdered		6 @	7
Strontium Nitrate	Lb.	28 @	30
Sulfur, flowers, sublimed	100 Lbs.	4.05 @	4.50
Sulfur, roll	100 Lbs	3.70 @	4.10
Sulfuric Acid, chamber 66° Bé	Ton	18.00	
Sulfuric Acid, oleum (fuming)	Ton	60.00 @	65.00
Talc, American white	Ton	15.00	
Terra Alba, American, No. 1	100 Lbs.	1.17½	
Tin Bichloride, 50°	Lb.	28 @	30
Tin Oxide	Lb.	1.00 @	1.10
White Lead, American, dry	Lb.	9½ @	10½
Zinc Carbonate	Lb	18 @	22
Zinc Chloride, commercial	Lb	14 @	15½
Zinc Oxide, American process XX	Lb	12½ @	13½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	68 @	70
Acetic Acid, 56 per cent, in bbls	Lb	nominal	
Acetic Acid, glacial, 99½%, in carboys	Lb.	65 @	70
Acetone, drums	Lb	nominal	
Alcohol, denatured, 180 proof	Gal.	67 @	68
Alcohol, sugar cane, 188 proof	Gal.	4.90 @	4.95
Alcohol, wood, 95 per cent, refined	Gal.	92 @	92½
Amyl Acetate	Gal.	5.25 @	5.30
Aniline Oil, drums extra	Lb.	26 @	28
Benzoic Acid, ex-toluol	Lb.	3.00 @	3.40
Benzol, pure	Gal.	23 @	28
Camphor, refined in bulk, bbls	Lb.	1.12	
Carbolic Acid, U. S. P., crystals, drums	Lb.	44 @	47
Carbon Bisulfide	Lb.	8½ @	9
Carbon Tetrachloride, drums, 100 gals	Lb.	15½ @	16
Chloroform	Lb.	63 @	65
Citric Acid, domestic, crystals	Lb.	82 @	83
Creosote, beechwood	Lb.	2.00 @	2.10
Cresol, U. S. P.	Lb.	18 @	20
Dextrine, corn (carloads, bags)	Lb.	8 @	9
Dextrine, imported potato	Lb.	nominal	
Ether, U. S. P. 1900	Lb.	27 @	30
Formaldehyde, 40 per cent	Lb.	16½ @	18
Glycerine, dynamite, drums extra	Lb.	62 @	64
Oxalic Acid, in casks	Lb.	43 @	45
Pyrogallic Acid, resublimed, bulk	Lb.	3.25	
Salicylic Acid, U. S. P.	Lb.	90 @	1.00
Starch, cassava	Lb.	—	
Starch, corn (carloads, bags) pearl	100 Lbs.	6.50 @	7.00
Starch, potato, Japanese	Lb.	13¼ @	13½
Starch, rice	Lb.	12½ @	13
Starch, sago flour	Lb.	9½ @	10½
Starch, wheat	Lb.	nominal	
Tannic Acid, commercial	Lb.	68 @	75
Tartaric Acid, crystals	Lb.	85 @	86

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63 @	65
Black Mineral Oil, 29 gravity	Gal.	22 @	23
Castor Oil, No. 3	Lb.	33 @	34
Ceresin, yellow	Lb.	17 @	18
Corn Oil, crude	100 Lbs.	17.50 @	17.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½ @	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.50 @	21.50
Menhaden Oil, crude (southern)	Gal.	1.00 @	1.10
Neat's-foot Oil, 20°	Gal.	3.45 @	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	9¼ @	10
Paraffin Oil, high viscosity	Gal.	40 @	41
Rosin, "F" Grade, 280 lbs.	Bbl.	10.95 @	11.00
Rosin Oil, first run	Gal.	60 @	65
Shellac, T. N.	Lb.	65 @	67
Spermaceti, cake	Lb.	32 @	34
Sperm Oil, bleached winter, 38°	Gal.	2.23 @	2.25
Spindle Oil, No. 200	Gal.	38 @	40
Stearic Acid, double-pressed	Lb.	24 @	25
Tallow, acidless	Gal.	1.58 @	1.60
Tar Oil, distilled	Gal.	35 @	36
Turpentine, spirits of	Gal.	73 @	75

METALS

Aluminum, No. 1, ingots	Lb.	33 @	34
Antimony, ordinary	Lb.	13 @	13¼
Bismuth, N. Y.	Lb.	3.50 @	3.65
Copper, electrolytic	Lb.	26 @	
Copper, lake	Lb.	26 @	
Lead, N. Y.	Lb.	8.05	
Nickel, electrolytic	Lb.	55 @	56
Platinum, refined, soft	Oz.	nominal	
Silver	Oz.	95⅞	
Tin, Straits	Lb.	nominal	
Tungsten (WO_3)	Per Unit	20.00 @	24.00
Zinc N. Y.		8.70 @	8.90

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.75 @	8.00
Blood, dried, f. o. b. Chicago	Unit	6.70 @	6.75
Bone 3 and 50 ground, raw	Ton	37.00 @	40.00
Calcium Cyanamide	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian	100 Lbs.	—	
Castor Meal	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.30 and	10c
Phosphate acid, 16 per cent	Ton	16.00 @	17.00
Phosphate rock, f. o. b. mine	Ton	nominal	
Florida land pebble, 68 per cent	Ton	3.50 @	3.75
Tennessee, 78–80 per cent	Ton	5.50 @	6.00
Potassium "muriate," basis 80 per cent	Ton	nominal	
Pyrites, furnace size, imported	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	6.65 @	6.70

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | SEPTEMBER 1, 1918 | No. 9

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD H. K. BENSON F. K. CAMERON B. C. HESSE A. D. LITTLE A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized July 13, 1918.

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
- Secretary Crowell at Cleveland ... 672
- No Change in Exposition Plans ... 672
- Turn About is Fair Play ... 672
- An International Courtesy ... 673
- The Custodian in Action ... 673
- War Chemistry in the Alleviation of Suffering ... 673
- A Dyestuff Section of the American Chemical Society ... 674
- The Bull's Eye ... 674

CHEMICAL WARFARE SERVICE ... 675

AN ARMY WITHOUT RESERVES ... 685

EFFECT OF THE WAR ON AMERICAN CHEMICAL TRADE. O. P. Hopkins, Washington, D. C. ... 692

THE CHEMICAL MARKETS OF SOUTH AMERICA:
- The Chemical Markets of Argentina, Brazil and Uruguay. O. P. Hopkins, Washington, D. C. ... 701

ORIGINAL PAPERS:
- "Jelly Value" of Gelatin and Glue. A. Wayne Clark and Louis DuBois ... 707
- A New Method for the Quantitative Estimation of Vapors in Gases. Harold S. Davis and Mary Davidson Davis ... 709
- The Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases. Harold S. Davis, Mary Davidson Davis and Donald G. MacGregor ... 712
- Studies on the Absorption of Light Oils from Gases. Harold S. Davis and Mary Davidson Davis ... 718
- The Effect of Frost and Decay upon the Starch in Potatoes. H. A. Edson ... 725
- The Reticulation of Gelatine. S. E. Sheppard and F. A. Elliott ... 727

LABORATORY AND PLANT:
- Methods of Analysis Used in the Coal-Tar Industry. I—Crude Tars. J. M. Weiss ... 732
- Synthetic Phenol. Albert G. Peterkin, Jr. ... 738

CURRENT INDUSTRIAL NEWS:
- Fan Dynamometer Brake; Soap and Glycerin Manufacture in India; New Voltaic Cell; Oilseed Industry of Rhodesia; Cane By-Products in Natal; The Synthetic Market; Sulfate of Ammonia; Explosive Chemicals; Determination of Oxygen in Iron; Italian Dye and Chemical Industry; Skoda Works Peace Preparations; Machinery in South America; Cement Mortars and Magnesium Chloride; Blast Furnace Practice; Chrome Tanning; Electrical Machinery; Electrolytic Process; Recovery of Tin; Analysis of Aluminum Alloys; Catalyst from Metallic Salts; New Mining Explosive; New Sources of Oil Supply in Germany; Ultra-Filter; Lubricating Material; Indian Resin; British Board of Trade ... 744

SCIENTIFIC SOCIETIES:
- Cleveland Meeting, American Chemical Society; The Chemical Societies in New York City; Calendar of Meetings; Fourth National Exposition of Chemical Industries, Grand Central Palace, New York, Week of September 23 to 28, 1918; American Electrochemical Society Fall Meeting at Princeton; American Electrochemical Society; General Symposium on the Chemistry of Dyestuffs ... 748

NOTES AND CORRESPONDENCE:
- Association of British Chemical Manufacturers; The Sulfuric Acid Industry; Chemistry for the Public; Civil Service Rules Waived for War Gas Investigators; Research Fellowship, State College of Washington; Chemical Engineering in Our Universities ... 751

WASHINGTON LETTER ... 753

PERSONAL NOTES ... 755

INDUSTRIAL NOTES ... 757

GOVERNMENT PUBLICATIONS ... 758

NEW PUBLICATIONS ... 765

MARKET REPORT ... 766

EDITORIALS

SECRETARY CROWELL AT CLEVELAND

Assistant Secretary of War Benedict Crowell will deliver the opening address at the opening session of the Annual Meeting of the AMERICAN CHEMICAL SOCIETY at Cleveland on September 10, 1918. Secretary Crowell has been a member of the Society since 1909. It will be both a pleasure and a privilege for those attending the meeting to hear the words of one who has played so important and so intimate a part in the organization of the great military machine which is destined to deliver the deciding blow for the cause of democracy.

The titles of all the addresses at the opening session indicate clearly that the keynote of the meeting will be how American chemists can contribute further to a quick and complete military victory.

The days of defensive warfare are behind us. From now on greater and still greater must grow the powerful offensive program which will crush every obstacle of resistance. The opportunity for personal conferences at the Cleveland meeting should prove an efficient means for discussion of many important problems which must be quickly solved. This feature alone should draw together for common counsel a host of chemists.

NO CHANGE IN EXPOSITION PLANS

The Fourth National Exposition of Chemical Industries will be held at the Grand Central Palace, New York City, during the week September 23–28, 1918, as originally planned. This definite announcement has been made public by the exposition management following conferences with representatives of the War Department.

The building will be taken over by the Government on September 15, 1918, for conversion into a great base hospital. No one connected with the exposition management or with the chemical industries would be willing even to suggest that any previously made plans should interfere with the promptest possible provision of relief and comfort for our returning wounded soldiers. The size of the building, however, is so great that the work of conversion into a hospital cannot reach the three floors to be utilized for the Exposition before October 1, 1918. Government officials have therefore given full sanction to the holding of the Exposition.

TURN ABOUT IS FAIR PLAY

For the past four years American chemists, particularly those in the organic field, have been working to supply serious economic needs, notably in dyestuffs and medicinals. Worthily have they met the situation! Yet in doing this these chemists have been laboring under a serious handicap, the shortage, produced likewise by war conditions, of available sets of the greatest of all reference books in organic chemistry, Beilstein's *Handbuch der Organischen Chemie*. That want should be met, and met quickly. Turn about is fair play!

Some day when the strenuous demands for war supplies happily no longer exist, American chemists must seriously face the necessity of compiling in an authoritative manner great reference works for all fields of chemistry, books written in our own language and adapted to our own methods of work. This, however, is no time for that undertaking. Every chemist is now, or soon will be, engaged upon problems directly bearing upon war supplies.

A translation of Beilstein has been suggested, but this again calls for chemists not at present available, as the work of translation should be carried out by those to whom not only German, but also the language of chemistry, is known. Furthermore, a translation is not needed, for those who are qualified to use Beilstein are able to read German.

We would suggest and urge a reprinting of Beilstein under conditions which would make it available quickly to all organic chemists. To do this through the ordinary processes of linotyping and proof-reading would be impracticable because of the present shortage of labor and the lack of knowledge of German on the part of linotypists and proof-readers accustomed to chemical literature. Fortunately, photographic methods are available, requiring a minimum of labor and insuring speed and absolute accuracy of reproduction.

To make the proposition definite we have obtained prices for zinc etchings from one of the largest engraving houses of New York City. For the 11,126 pages of Beilstein the cost of zinc etchings at standard prices would be $30,040.20. For the paper and press work (calculating on the quality of paper and charges for press work in publishing THIS JOURNAL), $6,119.30 would be required for one thousand sets, making a total of $36,159.50. Allowing for constantly advancing prices, and for royalty charges, $40,000 should safely cover the entire costs, not including binding, of course.

The legal right could undoubtedly be obtained from the Federal Trade Commission, under the Trading with the Enemy Act, for matters of copyright are included within the Act.

Do we feel any qualms of patriotic conscience about such a reproduction? Well, we should worry! Germans are daily profiting in the conduct of the war through the utilization of American inventions, the submarine, the telegraph, the telephone, the machine gun and what not. Let some one donate $30,000 and let the sets be sold at $10 each (the ordinary cost is $100) so that every organic chemist could have one right at his hand, then—let the Germans worry.

We commend this subject to the Council of the AMERICAN CHEMICAL SOCIETY at its Cleveland meeting.

Where is the $30,000 that will promptly set the zinc to etching?

AN INTERNATIONAL COURTESY

It is a pleasure to reproduce here the invitation from the Secretary of the Chemical Society (London) to all chemists who visit England, and the reply of Secretary Parsons of the AMERICAN CHEMICAL SOCIETY.

Chemical Society
Burlington House, London, W. 1
July 25, 1918

Mr. Charles L. Parsons
Secretary, American Chemical Society

DEAR SIR:

No doubt there are many members of your Society ordinarily residing in America who are now in this country, and I am writing to ask you to be good enough to use such means as may occur to you to inform your members that they are most cordially invited by the Council of this Society to avail themselves of the use of our Library and Rooms, and to attend our meetings. Perhaps, also, you would be good enough to place on your notice board a notice to this effect so that any of your members who are about to leave your shores for this country may be informed of this.

I may say that I have been in communication with Sir Harry Britain, who has very kindly promised to place on the notice board of the American Club for Officers a notice inviting them to make what use they can of this Society.

Believe me,

Yours very truly,
(Signed) SAMUEL SMILES
Honorary Secretary

. . . . . .

Washington, D. C.
August 15, 1918

Samuel Smiles, Esq.
Honorary Secretary, Chemical Society
Burlington House, London, W. 1, England

DEAR SIR:

Your letter of July 25 is fully appreciated.

Lieutenant Colonel James F. Norris at the American Embassy is one of the members of our Council and a prominent member of the American Chemical Society. He is the scientific attaché on chemical problems to the American Embassy, and I would suggest that you write him a letter calling the same facts to his attention that you have sent me. I would communicate with him, but I think he would appreciate a letter of this kind from you direct. He will be in touch with most of the American chemists that come to England, and through him I believe more of them can be reached than through me, as I do not always know when they are ordered to your country.

I am sending your letter to the Editor of our JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY, who, I am sure, will be glad to publish your kind invitation so that it may reach all of our members who may be going abroad.

With full appreciation of the courtesy of yourself and your Society, I am

Sincerely yours,
(Signed) CHARLES L. PARSONS, *Secretary*

THE CUSTODIAN IN ACTION

The appointment of Mr. James A. Branegan, of Philadelphia, as Vice President of the Heyden Chemical Works, an enemy-owned corporation recently taken over by the Government, will prove gratifying to all chemists, not only because of the high esteem in which Mr. Branegan is held by his many personal friends, but because the appointment evidences the sound policy of the Alien Property Custodian of appointing on the directing boards of seized organizations technical experts fully qualified to assure that the purposes of the Government will be carried out.

Custodian Palmer and his corps of able associates have evidently taken no vacation this summer. The thorough anti-financial-camouflage campaign which is being quietly and patiently conducted is bearing fruit, and we have a hunch that the results disclosed so far are but the forerunner of a great mass of important contributions to truth still to be made.

The interesting researches now being conducted by Custodian Palmer should be aided by every loyal chemist in possession of facts which would contribute to proof of enemy ownership masquerading in American garments.

WAR CHEMISTRY IN THE ALLEVIATION OF SUFFERING

A few days ago we asked a well-known organic chemist, one who has been particularly successful in working out methods for the manufacture of certain much-needed coal-tar medicinals, "Suppose during your researches you made some new compound which you believed would prove more efficacious against certain diseases than any of the known compounds whose details of manufacture you have solved, where would you turn to have it tested thoroughly?" He replied, "I don't know."

We were returning from a baseball game at the Polo Grounds, had walked over to Broadway and were about to enter the subway when the conversation took place. The subject proved so mutually interesting, that, perched upon an iron railing amidst the upper Broadway crowds, we carried on the discussion for an hour. He had been engrossed in the problem of reproducing compounds already known and used for the relief of the physical sufferings of humanity; we were thinking of the still greater service American scientists should be enabled to perform.

The negative answer was not surprising, rather it was confirmatory. It is a peculiar situation that exists in this country to-day. The three great commercial applications of the so-called "coal-tar chemicals" are, first, explosives, for which means are never lacking for the thorough testing of new products; second, dyestuffs, for which fortunately the equipment for testing as to standard, fastness, durability and aesthetic suitability is simple, inexpensive and accessible to every worker; third, medicinals, and here the problems of investigation become much more complex and the responsibility even greater. Rarely does the chemist possess the technique for their testing; he must rely upon the pharmacologist and the physiologist to determine the therapeutic value of his product.

In university circles there is often lacking that spirit of coöperation between the several classes of research workers which would insure a thorough examination of these new products of the organic chemical laboratory, or, if the spirit be willing, the means for conducting the tests are too limited, especially now when university finances are so severely contracted. In a few manufacturing establishments provision is made for animal experimentation, but these facilities are entirely inadequate and not available to all organic chemists. In government laboratories some provision is made for this work, but restrictions are enforced by inadequate appropriations. And still people suffer,

though much suffering has been alleviated by discoveries made in other lands.

Fortunately, through the generous provision of wealthy individuals, certain institutions have been established and endowed where the chemist and the biologist can work in the closest coöperation. The importance of the intimate coöperation of these workers is evidenced by the work on the synthesis of a new anti-syphilitic drug which was recently accomplished in the laboratories of the Rockefeller Institute for Medical Research. This remedy is now tested from the clinical viewpoint in the hospital of the same institution. Similar institutions, however, are few in number and the capacity for work of this kind is necessarily restricted.

The laboratory technique, from the chemist's standpoint, is fortunately quite similar whether in preparing explosives, dyestuffs or medicinals, and the war period has developed many brilliant organic chemists whose talent could be applied to the relief of suffering.

How can this application be made? A suggestion has been advanced which seems to cover the situation admirably—namely, that an institution somewhat analogous to the Mellon Institute be founded, in which adequate provision for laboratory tests of all kinds would be made and to which, through the establishment of fellowships, manufacturing organizations could send well-trained young men for working out specific problems. Coöperation should be established between this institution and the organic laboratories of our universities, as well as with the hospitals of the country.

An institution of this character would prove a great stimulus to the creation of more adequate research facilities within the manufacturing establishments, for the great glory of the Mellon Institute lies, it seems to us, not so much in the actual results obtained under its roof as in the indirect creation of research departments in industries which first caught the full significance of research through the fellowships established in that institution.

Perhaps there is a better method to accomplish this object. The columns of THIS JOURNAL stand at the disposal of any who will contribute to the discussion. If the heart of any man should be moved in behalf of humanity to fill this great need from the abundance of his riches, he can count with certainty upon the counsel of the ablest scientists of this country in working out the safe policies and many details of so important an undertaking.

A DYESTUFF SECTION OF THE AMERICAN CHEMICAL SOCIETY

The American Dyestuff Manufacturers' Association and the dyestuff section of the Chemical Alliance afford ample machinery to care for questions of general policy, internal and external, affecting the newly developed industry in this country. These, however, are strictly trade organizations. Without desiring to inflict any further burden of organization upon the industry, which has its hands full in supplying pressing commercial needs, we would like to second the suggestion of Mr. R. Norris Shreve (page 750) as to the formation of a dyestuff section of the AMERICAN CHEMICAL SOCIETY.

The days of experimental and large scale production of known dyestuffs have been accomplished. To rest content with the present status of the industry would not be characteristic or worthy of this nation, which is justifiably proud of its initiative, resourcefulness, and inventive spirit. New lines must be developed and new advances made in technical methods, if we are to be more than mere copyists. No surer provision could be made for these efforts than the semi-annual gathering of the research men from the various dyestuff laboratories, in the atmosphere of a great assembly of chemists. The presentation of papers and their discussion would establish facts of value to all, broader viewpoints would be obtained and sympathetic personal relationships formed which would stand in good stead.

It is natural, perhaps, that each commercial organization should desire to retain for itself the benefits of research, yet, carried too far, it is a short-sighted policy, in view of the varied workings of different minds. Too much secrecy as to certain fancied advantages has already proved in some cases the cause of industrial "dry rot." Community of knowledge as to scientific achievement, safeguarded by critical discussion of results, will prove so valuable a means of industrial advance that it must not be neglected.

Success to those who are taking the preliminary steps for the formation of a dyestuff section of the AMERICAN CHEMICAL SOCIETY!

THE BULL'S EYE



Look out for the bull's eye on the chemical products (not machinery) to be exhibited at the Fourth National Exposition of Chemical Industries.

Since its inception this annual display of the results of chemists' activities has sought to accomplish one thing above others, namely, an exhibition of progress made in products manufactured for the first time in this country during the war period. Unfortunately in the past no distinguishing mark has been given to such products, consequently only a confused idea could be obtained by the layman, and even by many chemists, as to actual progress made. An effort will be made to correct this during the coming Exposition by placing a "bull's eye" upon all new products whose manufacture has been developed since the outbreak of the war.

This new feature will prove of interest to all, and we are equally sure that the large number of exhibits bearing no such distinguishing mark will be a revelation to the public of the manifold achievements of American chemists prior to the war.

CHEMICAL WARFARE SERVICE

The unexpected waves of chlorine gas at Ypres, with the resultant casualties, called at once for intense activities by chemists, at first of a purely defensive character. Gradually, reluctantly, and finally with characteristic aggressiveness, especially after the disasters of Cambrai and Armentieres, this defensive functioning was enlarged by offensive preparations which will give to our men every advantage of this most modern development of warfare.

Into such work more and more of our chemists have been called. Some have been sent overseas for work at the front. At home, research has been conducted on an intensive and extensive scale, material has been tested, small scale operations have been proved, and finally plants have been built for manufacturing in enormous quantities products which before the war were merely laboratory curiosities, but whose deadly mission may now, in strange antithesis, bring lasting peace to the world.

Through the gradual processes of organization there has been created within the War Department the Chemical Warfare Service. For preservation in the chemical literature of this country there is printed below a complete personnel of the commissioned officers of this service. We are indebted to Major F. E. Breithut, of the Organization Division, in charge of personnel, for this material. There is also printed, through the courtesy of the heads of the several divisions, the commissioned personnel of each division.—EDITOR.



Harris & Ewing
MAJOR GENERAL WILLIAM L. SIBERT, U. S. A.
DIRECTOR, CHEMICAL WARFARE SERVICE

. . . . .

GENERAL ORDERS, NO. 62
CREATING CHEMICAL WARFARE SERVICE

War Department
Washington, June 28, 1918

I—(1) Under authority conferred by Sections 1, 2, 8 and 9 of the Act of Congress, "Authorizing the President to increase temporarily the military establishment of the United States," approved May 18, 1917, and the Act "Authorizing the President to coördinate or consolidate executive bureaus, agencies, and offices, and for other purposes, in the interest of economy and the more efficient concentration of the Government," approved May 28, 1918, in pursuance of which Act the President has issued an Executive Order dated June 25, 1918, placing the experiment station at American University under control of the War Department, the President directs that the gas service of the Army be organized into a Chemical Warfare Service, National Army, to include:

(*a*) The Chemical Service Section, National Army.

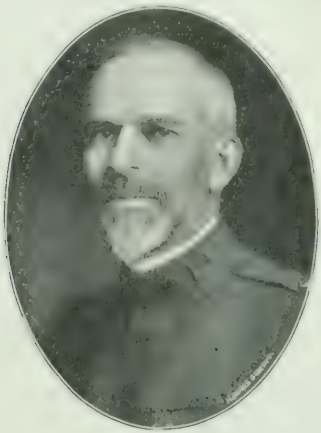
(*b*) All officers and enlisted men of the Ordnance Department and Sanitary Corps of the Medical Department as hereinafter more specifically specified (regular officers affected being detailed and not transferred).

(2) The officers for this service will be obtained as provided by the third paragraph of Section 1 and by Section 9 of the Act of May 18, 1917, the enlisted strength being raised and maintained by voluntary enlistment or draft.

(3) The rank, pay, and allowances of the enlisted men of the Chemical Warfare Service, National Army, shall be the same as now authorized for the corresponding grades in the Corps of Engineers.

(4) The head of the Chemical Warfare Service, National Army, shall be known as the Director of the Chemical Warfare Service, and, under the direction of the Secretary of War, as such, he shall be, and hereby is, charged with the duty of operating and maintaining or supervising the operation and maintenance of all plants engaged in the investigation, manufacture, or production of toxic gases, gas-defense appliances, the filling of gas shells, and proving grounds utilized in connection therewith and the necessary research connected with gas warfare, and he shall exercise, full, complete, and exclusive jurisdiction and control over the manufacture and production of toxic gases, gas-defense appliances, including gas-shell filling plants and proving grounds utilized in connection therewith, and all investigation and research work in connection with gas warfare, and to that end he shall forthwith assume control and jurisdiction over all pending Government projects having to do or con-

nected with such manufacture, production, and operation of plants and proving grounds for the Army and heretofore conducted by the Medical Department and Ordnance Department under the



Col. H. C. Newcomer, C. E.

jurisdiction of the Surgeon General and the Chief of Ordnance, respectively, and all material on hand for such investigation or research, manufacture or production, operation of plants and proving grounds and all lands, buildings, factories, warehouses, machinery, tools and appliances, and all other property, real, personal, or mixed, heretofore used in, or in connection with, the operation and maintenance of such plants and proving grounds for the purpose of investigation or research, manufacture or production, already procured and now held for such use by, or under



Col. W. J. L. Lyster, Med. Corps

the jurisdiction and control of the Medical Department of the Ordnance Department, all books, records, files, and office equipment used by the Medical Department or the Ordnance Department in connection with such investigation or research, manufacture or production, or operation of plants and proving grounds, all rights under contract made by the Medical Department or Ordnance Department in, or in connection with, the operation of such plants and institutions as specified herein, all rights under contract made by the Medical Department or Ordnance Department in, or in connection with such work, and the entire personnel (commissioned, enlisted, and civilian) of the Ordnance Department and Sanitary Corps of the Medical Department as at present assigned to or engaged upon work in, or in connection with, such investigation or research, manufacture or production, or operation of plants and proving grounds, are hereby transferred from the jurisdiction of the Ordnance Department and the Medical Department and placed under the jurisdiction of the Director of the Chemical Warfare Service, it being the intention hereof to transfer from the jurisdiction of the Medical Department and the Ordnance Department to the jurisdiction of the Director of the Chemical Warfare Service every



Major J. H. Brightman

function, power, and duty connected with the investigation, manufacture, or production of toxic gases, gas-defense appliances, including the necessary research connected with gas warfare, gas-shell filling plants, and proving grounds utilized in connection therewith, all property of every sort or nature used or procured for use in, or in connection with, said operation of such plants and proving grounds and the entire personnel of the Ordnance Department and Sanitary Corps of the Medical Department as at present assigned to, or engaged upon work in, or in connection with, the operation and maintenance of such plants engaged in the investigation, manufacture, or production of toxic gases, gas-defense appliances, including gas-filling plants and proving grounds utilized in connection therewith.

(5) All unexpended funds of appropriations heretofore made for the Medical Department or Ordnance Department and already allotted for use in connection with the operation and maintenance of plants now engaged in, or under construction for the purpose of

engaging in, the investigation, manufacture, or production of toxic gases or gas-defense appliances, including gas-shell filling plants, are hereby transferred to, and placed under the jurisdiction of, the Director of the Chemical Warfare Service for the purpose of meeting the obligations and expenditures authorized herein; and, in so far as such funds have not been already specifically allotted by the Medical Department and the Ordnance Department for the purposes specified herein, they shall now be allotted by the Secretary of War, in such proportions as shall to him seem best intended to meet the requirements of the situation and the intentions of Congress when making said appropriations, and the funds so allotted by the Secretary of War to meet the activities of the Chemical Warfare Service, as heretofore defined herein, are hereby transferred to, and placed under the jurisdiction of, the Director of the Chemical Warfare Service for the purpose of meeting the authorized obligations and expenditures of the Chemical Warfare Service.

(6) This order shall be and remain in full force and effect during the continuation of the present war and for six months after the termination thereof, by proclamation of the treaty of peace, or until theretofore amended, modified, or rescinded.

II—By direction of the President, Maj. Gen. William L. Sibert, United States Army, is relieved from duty as Director of the Gas Service, and is detailed as Director of the Chemical Warfare Service, National Army.

[322.06 A. G. O.] By Order of the Secretary of War.
PEYTON C. MARCH,
General, Chief of Staff

[Official] H. P. McCAIN,
The Adjutant General

. . . . . .

ORGANIZATION PLAN OF CHEMICAL WARFARE SERVICE

DIRECTOR
Maj. Gen. Wm. L. Sibert

STAFF
Medical Officer, Col. W. J. L. Lyster, S. C.
Assistant, Capt. H. C. Bradley
Ordnance Officer, Lt. Col. C. B. Thummel, O. D.
Assistant, Maj. C. S. Stevenson, C. W. S.
Representative of British Military Mission, Maj. J. H. Brightman.

HEADQUARTERS ORGANIZATION

ASSISTANT DIRECTOR
Col. H. C. Newcomer, C. E.
To act for the Director in his absence, in charge of all military matters and new projects. Chairman, Board of Review.

Military Assistants

Maj. J. H. Walton, C. W. S.
Capt. V. L. Bohnson, C. W. S.
Capt. S. J. Delancy, C. W. S.
Capt. J. S. Baker, C. W. S.
Capt. A. Bolenbaugh, C. W. S.
1st Lt. R. C. Henderson, C. W. S.
2nd Lt. F. C. Perkins.

Technical Assistants

Maj. S. A. Tucker, C. W. S.
Capt. G. M. S. Tait, C. W. S.
Capt. R. Franchot
1st Lt. L. Van Doren, C. W. S.

OFFICE ADMINISTRATION
Major W. W. Parker, C. W. S.
In charge of files and clerical personnel, receipt and distribution of mails, collection and transmission of papers between various sections of the office, office disbursements.

Assistants

1st Lt. F. W. Dasher, C. W. S.
2nd Lt. W. F. Kunkle, C. W. S.
2nd Lt. B. W. Tipton, C. W. S.
2nd Lt. W. D. Towler, C. W. S.

RELATIONS SECTION
Col. M. T. Bogert, C. W. S.
In charge of relations with Universities, with industries, with the office of the Director of Purchases, Storage and Traffic, and with the War Industries Board, including its committees.

Assistants

Maj. Victor Lenher, C. W. S.
Maj. W. J. Noonan, C. W. S.
Maj. Allen Rogers, C. W. S.
Maj. Samuel Avery, C. W. S.
Capt. C. V. Shechan, C. W. S.
Capt. W. H. Hickin, C. W. S.
1st Lt. H. F. Scharer, C. W. S.
Mr. Geo. S. Case, C. W. S.

PERSONNEL SECTION
Major F. E. Breithut, C. W. S.
In charge of all matters pertaining to procurement and assignments of commissioned and enlisted personnel of the Chemical Warfare Service.

Assistants

1st Lt. G. W. Phillips, C. W. S.
1st Lt. H. B. Bramlet, C. W. S.
2nd Lt. A. E. Case, C. W. S.

CONTRACTS AND PATENTS SECTION
Captain W. K. Jackson, C. W. S.
In charge of Section, Member of Board of Review

Assistant
Capt. R. B. Meckley, C. W. S.

FINANCE SECTION
Major C. C. Coombs
In charge of estimates, appropriations and allotments, of administrative audit of all disbursing accounts and of property. Member of Board of Review, C. W. S.

Assistant
Capt. Ben Jenkins, C. W. S.

REQUIREMENTS AND PROGRESS SECTION
Capt. S. M. Cadwell, C. W. S., In charge of Section.

Assistants
2nd Lt. J. A. Sohen, C. W. S.

CONFIDENTIAL INFORMATION SECTION
Major S. P. Mulliken, C. W. S., In charge of Section.

Assistant
2nd Lt. H. E. Moore, C. W. S.

TRANSPORTATION SECTION
Officer in charge not yet selected.

Assistant
Capt. H. R. Sharkey, C. W. S.

FIELD ORGANIZATION

GAS OFFENSE DIVISION
Officer in Charge, Col. W. H. Walker
The production of gas, containers and other material for use in offensive gas warfare.

GAS DEFENSE DIVISION
Officer in Charge, Col. Bradley Dewey
The production of material such as gas masks for use in the defensive.

PROVING DIVISION
Officer in Charge, Maj. W. S. Bacon
Charged with the duty of proving the efficiency of material under field condition.

DEVELOPMENT DIVISION
Chief, Col. Frank M. Dorsey
For the development of material received from the Research Division to the point where it may be turned over for proving.

RESEARCH DIVISION
Chief, Col. G. A. Burrell
Charged with research into all matters pertaining to gas warfare.

EUROPEAN DIVISION
This division includes personnel assigned to all divisions and corps and army headquarters in addition to those required for the supply of material in the field in France.

MEDICAL DIVISION
Officer in charge, Col. W. J. L. Lyster

SOME MEMBERS
OF THE
CHEMICAL WARFARE SERVICE



COLONEL MARSDEN T. PUDDET



MAJOR W. A. PARKER



MAJOR VICTOR LENHER



MAJOR SAMUEL AVERY



MAJOR S. P. MULLIKEN



MAJOR WILLIAM BOOTH

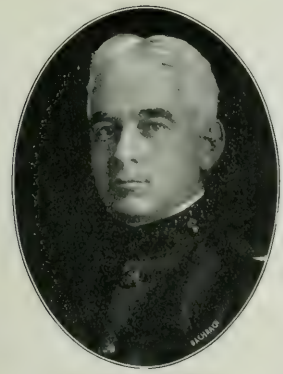


MAJOR FREDERICK J. DARROW



COL. S. M. CADWELL

SOME MEMBERS OF THE CHEMICAL WARFARE SERVICE



COLONEL WM. H. WALKER



COLONEL AMOS A. FRIES



COLONEL BRADLEY DEWEY



COLONEL R. F. BACON



COLONEL GEORGE A. BURRELL



MAJOR C. C. COOMBS



MAJOR WILLIAM S. BACON



COLONEL F. M. DORSEY

COMMISSIONED PERSONNEL, CHEMICAL WARFARE SERVICE

MAJOR GENERAL

Sibert, William L.

COLONELS

Ardery, Edward A.
Brown, Raymond F.
Bogert, Marston T.
Burrell, George A.
Dewey, Bradley
Fries, Amos A.
Johnston, Edward N.
Lanza, W. J. L.
Newcomer, H. C.
Schulz, John W. N.
Walker, Wm. H.

LIEUTENANT COLONELS

Besse, Arthur L.
Chance, Edwin M.
McPherson, Wm.
Norris, Jas. F.
Thummel, C. B.
Vaughn, Chas. F.

MAJORS

Almy, Chas., Jr.
Avery, Samuel A.
Bacon, Wm. S.
Barth, Theo. H.
Breithut, Frederick E.
Brightman, J. H.
Chance, T. Mitchell
Clark, Edward B.
Conant, J. B.
Connel, Karl
Coombs, C. C.
Demorest, Dana J.
Dewey, Frederick A.
Dunn, Edgar M.
Evans, Wm. L.
Frary, Francis E.
Free, Edw. E.
Gallowhur, Wm. G.
Hamor, Wm. R.
Hanson, Hugo H.
Haughton, Percy D.
Heritage, Arthur M.
Hildebrand, Joel H.
Johnson, Cleon R.
Jones, W. Catesby
Lenher, Victor
Lewis, Gilbert N.
Lockwood, Wm. G.
Mack, Frank W.
Morey, Stephen E.
Mulliken, Samuel P.
Nacelvoort, Adrian
Noonan, Wm. J.
Parker, Walter W.
Reed, Philip L.
Richardson, Chas. B.
Rogers, Allen
Rose, Reed P.
Schuit, Henry P.
Sibert, Wm. O.
Sill, Theo. W.
Stevens, Oscar E.
Stevenson, A. S.
Sweeney, Orland R.
Temple Sterling, M.
Tucker, Samuel A.
Van Keuren, Edgar D.
Wagner, Frank J.
Walton, J. H.
Wilson, Irving W.
Wilson, Robert E.
Woodruff, John C.
Wraith, Chas. R.
Wyckoff, Arcalons W.
Zinsser, Frederick G.

CAPTAINS

Akers, James G.
Armory, John A.
Armstrong, James
Atterbury, Kirby
Bedsdatt, J. Stanley
Barlow, R. W.
Baker, Ross A.
Balfe, T. W.
Beebe, Lawrence L.
Bever, Otto S.
Bishop, R. E.
Blake, Kenneth B.
Blanchard, Ross C.
Bliss, P. W.
Blossom, Geo. W.
Bogart, J. H.
Bohnson, V. L.
Bolenbaugh, A.
Boothman, Dale M.
Bopp, Carl G.
Bradley, H. C.
Brinton, Paul H. M.
Brodhead, Nath'l B.
Brophy, Wm. E.
Bruce, H. E.
Burns, Arthur R.
Byers, Horace G.

CAPTAINS (*Continued*)

Byrne, Samuel A.
Cadwell, Sidney M.
Campbell, H. L.
Carlisle, Paul M.
Chase, Charles H.
Chalfant, Charles C.
Chandler, Henry P.
Clucas, Richard M.
Coburn, Wm. H.
Colvin, Chas. B.
Coleman, W. H.
Corrill, Chas. H.
Corry, Edwin E.
Cover, Lester C.
Crocker, Ralph H.
Cutler, Elmer H.
Dana, Lowell E.
Dee, Thos. J.
Delancy, S. J.
Dickinson, Arnold C.
Donk, Marion G.
Douglas, Stephen A.
Duff, Levi B.
Eldredge, Orrin S.
Flood, Frank R.
Foster, Harold B.
Fulford, Lester E.
Garner, H. L.
Gartner, H. A.
Giesy, Paul M.
Gill, Benj.
Godfrey, William S.
Gordon, Robt. D.
Goss, Byron G.
Gowdy, Robt. C.
Graham, Robert McC.
Graves, Caswell
Grove, Winfield S.
Guiteras, Harold G.
Hall, Ralph R.
Hardesty, Geo. R.
Harned, H. S.
Harshberger, Clarkson E.
Hayden, Fred L.
Heath, Michael Y.
Herbert, Wilyn
Herkness, Wayne
Herman, Edw. C.
Hickin, William H.
Hoffman, Wm. E.
Hunt, Geo. A.
Jackson, W. K.
Jenkins, Ben
Joly, Chas. L.
Kay, Wm. DeY.
Kenney, A. W.
Keyes, Frederick G.
Kops, Waldemar
Kramer, Richard L.
Larson, A. F.
Latimer, Lewis L.
Lawrence, James
Lawton, Stanley H.
Levering, Arthur C.
Little, John S.
Livermore, Harris
Llewellyn, Paul R.
Lockwood, Wm. G.
Long, Chas. F.
Lovell, Frederick A.
Lyon, F. J.
McAdams, Wm. H.
McChesney, A. G.
McGovern, Thos. T.
McGrath, David J.
McKenna, Wm. J.
McKinney, Wm. S.
Mackall, John
Macomber, Leonard
Martin, Wm. C.
Meckley, Robt. B.
Melendy, R. P.
Merrill, Hamilton
Millar, Hudson C.
Millar, R. W.
Nicolet, Ben H.
Northrup, John H.
Oberfell, Geo. G.
Parks, G. A.
Parsons, L. W.
Patterson, Earl
Peabody, Stuyvesant
Pearce, Chas. H.
Perry, Gilman L.
Pope, Frederick
Pull, Raymond V.
Ray, Arthur B.
Renshaw, R. R.
Richardson, Jos. C.
Rile, Wm. M.
Roberts, O. E.
Robinson, Wm. O.
Rollason, Geoffrey M.
Rowan, Hugh W.
Rose, John D.
Rossell, Jos. B., Jr.
Ruth, E. K.
Schlesinger, Berthold E.

CAPTAINS (*Concluded*)

Schmidt, Victor B.
Scott, John A.
Shaler, H. P.
Sharpe, Harold C.
Shattuck, Edmund J.
Shaw, George Edward
Sheehan, Charles V.
Silver, Jos. E.
Smith, Earl C.
Smith, Raymond T.
Smyth, Frederick H.
Stapleton, Edward L.
St. John, Adrian
Sutherland, Leslie T.
Tait, Godfrey W. S.
Taylor, Alfred L.
Taylor, David P.
Taylor, R. E.
Teague, M. C.
Thompson, Thos. E.
Throop, Benj. H.
Torry, Harry W.
Trumbell, Harland L.
Uhlinger, Roy H.
Urbain, Leon F.
Ward, Ralph D.
Warner, Stuart D.
Wells, Harry E.
Wesson, L. G.
Wheeler, Thorne L.
Whitehouse, H. D.
Whitlock, Chas. M.
Wilkinson, J. A.
Winkelmann, Herbert
Wolf, James S.
Wood, Alfred W.
Wright, Burnett
Zanetti, J. Enrique

FIRST LIEUTENANTS

Abrahams, Clinton D.
Abrams, Allen
Adams, James F.
Alden, J. L.
Allen, Roger E.
Anderson, Harry P.
Andrus, Leonard A.
Armstrong, Charles D.
Arnold, H. C.
Ashe, Lauron H.
Ashman, L. A.
Ashman, L. H.
Ayer, Paul P.
Bach, Ronald P.
Bailey, Albert E.
Barnett, Joseph J.
Barry, John G.
Beal, William D.
Bear, H. K.
Becker, Hason K.
Bedford, Edward T.
Bell, Thomas R.
Bennett, H. S.
Best, Arthur F.
Blakney, Geo. P.
Bogue, Joseph C.
Boon, C. J.
Bowman, Reginald C.
Bramlet, Hubert B.
Bristow, James J.
Brock, Earle A.
Brodsseer, R. E.
Brown, Carl H.
Brown, Lester B.
Burt, R. A.
Cahill, Michael
Callemon, Clarence B.
Clancy, Richard W.
Clapp, Dudley
Clark, S. C.
Clarke, Theodore
Clarkson, John L.
Clifford, C. W.
Cochran, Marshall G.
Coghlan, S. R.
Cole, Howard I.
Colebrook, M. W.
Collette, W. R.
Conohay, John R.
Cool, Claude A.
Cox, Samuel F.
Cretcher, Leonard H.
Crossbaw, James L.
Crossfield, Albert S.
Cuff, James B.
Dale, Stewart T.
Darling, Harry C.
Dasher, Frances W.
Davidson, A. W.
Davidson, Joseph G.
Davis, George W.
Dunbar, Noel S.
Dwyer, C. L.
Eason, Harry Mc
Eaton, Harry A. F.
Elden, John A.
Eldridge, Arthur C.

FIRST LIEUTENANTS (*Continued*)

[illegible], Lowell A.
Elsbey, Alden G.
[illegible], Robert R.
[illegible], Frank E.
Fairbanks, Herbert S.
[illegible], Stephen
Felsing, W. A.
Fisher, Abram M.
Fitzgerald, Heber D.
Fleming, Walter F.
Francke, Hugo
Frederick, E. L.
Fuller, E. W.
Gage, Roscoe M.
Gaines, O. I.
Gauger, Alfred W.
Gibson, Richard
Goldschmidt, Samuel
Gordon, Marcus A.
Gr[illegible]n, William A.
Gurney, Harold P.
Hagerman, F. E.
Hartshorn, Fred M.
Hayden, E. M.
Henderson, L. M.
Henderson, R. C.
Heneage, Thomas H.
Hentz, William A.
Hetherington, George F.
Hillery, Harry M.
Hobson, H. T.
Hoskot, Rene
Holland, Martin A.
Holm, George E.
Holmes, Raymond M.
Hooper, Noel J.
Horton, Winthrop S.
Howe, Robert A.
Howlett, Arthur E.
Hudson, H. H.
Hudson, W. E.
Hull, Edwin J.
Hunter, Robt. C.
Iddles, Alfred
Jackson, William M.
Johnson, Robert L.
Jones, Spencer L.
Katz, Sidney H.
Keitt, Geo. W.
Keller, Alexander W.
Kelogg, Edward A.
Kempton, Robert E.
Kerns, J. T.
Kerr, George M.
Kienle, R. H.
King, Arthur C.
King, John L.
King, T. S.
Kipka, Ross E.
Kirkpatrick, Walter
Klauber, Murray
Knox, W. L.
Koldon, Dudley F.
Lamb, Lloyd B.
Lambert, Marion L. J.
Latson, Frank W.
Leavitt, George F.
Lee, Elwood B.
Lewis, Walter H.
Leyden, James, Jr.
Lloyd, Edward C.
Long, David R.
Long, Howard A.
McBride, George H.
McCoy, John G.
McCune, J. S.
McCurdy, Phillip R.
McGowan, Henry G.
McNeil, Winfield I.
McWilliams, John C.
MacNeill, N. M.
MacConnell, John G.
MacDonald, Alexander D.
Mack, Edward
Mahtman, Osburn L.
Manning, Edwin C.
Mansur, Charles I.
Marshall, William D.
Martin, H. A.
Mayer, Gustave
Mayham, Ray E.
Maynard, Leonard A.
Merrill, Leslie M.
Merryman, James R.
Meserve, Philip W.
Mitchell, John H.
Moffitt, H. R.
Morawski, Frederick
Morgan, A. M.
Morgan, John D.
Mott, John
Moulton, Paul B.
Mueller, William A.
Mulford, William J.
Murphy, Alfred L.
Murphy, Ray D.
Murtfeldt, W. Scott

COMMISSIONED PERSONNEL, CHEMICAL WARFARE SERVICE (*Concluded*)

FIRST LIEUTENANTS (*Continued*)

Nasseit, Harry B.
Noble, Edson J.
Noer, Oyvind J.
Norlin, F. C.
Northrup, William C.
Norton, A. R.
Norton, F. A.
Nowry, Irvin W.
O'Brein, Bernard
Olson, A. R.
Ott, J. E.
Parks, James G.
Parmelee, Paul R.
Patterson, G. P.
Perkins, Granville A.
Perrott, G. St. J.
Phillips, George W.
Pierce, Edward T.
Popp, Earl C.
Pratt, Francis S.
Prentice, Phillip B.
Proctor, William R.
Pyle, David H.
Racicot, P. A.
Rahn, Reinhard
Rambo, Joseph D.
Ranson, William J.
Rapee, Frank J.
Recter, Thomas N.
Regan, Edward F.
Reiling, Howard A.
Rhode, Leon M.
Riddell, John F.
Rixey, Eppa
Robinson, Chas. R.
Rogers, Rollins W.
Romilly, Edgar P.
Rowe, David H.
Royce, Harrison S.
Russell, G. P.
Rutledge, George F.
Salisbury, Donald W.
Sampson, Ernest
Sawders, J. C.
Scorp, J. W.
Scharer, H. F.
Schaufele, H. J.
Scheirz, E. R.
Schmidt, Mott B.
Schultz, Addie D.
Schwarz, M. W.
Senior, James K.
Shaw, Guthrie
Shaw, Joseph T.
Shaw, Leon E.
Sibert, Eugene
Sidelinger, Roy L.
Silsbee, James A.
Smith, Lawrence W.
Smith, Lee I.
Smith, Leslie D.
Smyth, C. P.

FIRST LIEUTENANTS (*Concluded*)

Spaulding, E. G.
Spriggs, C. I.
Staples, Scott D.
Stearns, Albert M.
Steenken, F. L.
Steinbach, E. S.
Stephens, Charles W.
Stump, Horace E.
Stupp, John C.
Suydam, John R., Jr.
Swanson, F. J.
Talbot, John C.
Talcott, Harrison W.
Thomas, Ralph M.
Thomas, Richard W.
Thompson, Louis E.
Todd, William T.
Towler, Thomas W.
Trenkman, Frederick
Truax, Harold W
Truhee, William E.
Tuttle, Neal
Urquhart, George R.
Van Doren, Lloyd
Vanvoorsees, Harold E.
Vile, Norman B.
Vincent, Max G.
Visscher, Raymond
Walker, Lester V.
Wallace, E. S.
Walsh, James F.
Wangler, Albert F.
Wardon, Edward W.
Watson, Warren M.
Weeks, Robert W.
Weinert, R. B.
Wells, Arthur G.
Welsh, Thomas W. B.
Wemple, Holland R.
Whetzel, Joshua C.
Whiton, Louis G.
Wightman, Eugene P.
Williamson, Robert B.
Willis, Oliver E.
Wilson, David W.
Wilson, John E.
Wilson, Otto
Winter, Edwin M.
Wiswall, Paul M.
Withington, Lathrop
Woodbury, Horace G.
Woodruff, William W.
Woodward, Paul G.
Wylde, Wildred A.
Yablick, Max
Yoe, John H.
Zimmerman, Joseph

SECOND LIEUTENANTS

Acker, Ernest R.
Austin, Robert W.
Bangs, B. C.

SECOND LIEUTENANTS (*Continued*)

Barren, Edmund D.
Barrho, W. H.
Battley, J. F.
Benton, Arthur F.
Biance, Fred
Birckhead, Peter H.
Blank, J. F.
Blicke, Frederick F.
Bliss, Roland R.
Bly, Robert S.
Boardman, Roland S.
Borbeck, Archibald F.
Bowers, Paul C.
Bowes, Almond N.
Bowman, Ira J.
Bowman, Lee
Brown, Raymond G.
Brumhalt, John W.
Carry, John R.
Case, Arthur E.
Chaplin, John H.
Charron, Roy C.
Clark, Ernest M.
Conrad, Frederick U.
Crowell, Geo. W.
Davidson, Benj. B.
Dennis, Richard C.
Diven, John M.
Donoho, J. B.
Duckworth, John S.
Dunn, Chas. K.
Dunn, J. S.
Eiselot, Lewis G.
Ellison, A. D.
Embree, Spencer D.
Emmons, W. H.
Fannan, H. B.
Funsten, S. R.
Giles, Jeremiah D.
Greninger, R. R.
Gross, Paul M.
Hall, Robert B.
Hammond, William A.
Harper, Walter J.
Hast, Julian A.
Heath, John R.
Heffner, Oden C.
Heidingsfeld, Ralph
Heins, Ralph W.
Higbee, Clarence W.
Holt, Herbert B.
Hood, Harrison P.
Hooker, Albert H.
Huff, W. J.
Jennings, M. E.
Kearns, J. J.
Killam, Luther L.
Kinney, Selwyne P.
Knapp, Ralph
Kunkle, Walter F.
Law, James D.
Levy, Gaston J.

SECOND LIEUTENANTS (*Concluded*)

Lindsay, Walter S.
Loeb, Edward H.
McKenzie, Clyde
McLane, Howard B.
McNaugher, Joseph W.
Miller, Russell W.
Milligan, Lowell H.
Moore, Herbert E.
Neff, Chester M.
Nichols, H. Janney, Jr.
Osmer, John W.
Overstreet, John B.
Page, C. W. C.
Pauly, Robert C.
Pease, Robert N.
Peck, Edward B.
Pelton, Harold A.
Penfield, F. Joel
Penfield, Richard
Perkins, F. C.
Pettengill, Francis W.
Probeck, E. J.
Rees, John G.
Reichert, S. Joseph
Reyerson, Lloyd H.
Ribble, Keith P.
Richardson, George C.
Riker, Carlton B.
Robinson, Otto L.
Ross, William B.
Rothchild, Henry A.
Rundlett, Arnold D.
Schoetz, Francis H.
Schweizer, James A.
Scott, Warren P.
Sebastian, Reuben L.
Serson, Fred J.
Shakman, J. G.
Shannanhouse, J. G.
Sharer, Ralph K.
Shaw, Ellis M.
Skinner, Glenn S.
Smith, Charles V.
Sohon, Julian A.
Spofford, Charles B. Jr.,
Stone, Sam P.
Stuarn, James V.
Taylor, David B.
Thayer, Bruce W.
Thompson, Frank D.
Thorp, Gerald
Tipton, Ben. W.
Towler, Eugene D.
Towler, W. D.
Vealey, W. D.
Walther, Owen N.
Wannamaker, Geo.
Weber, Harold C.
White, James M.
Woodbury, V. P.
Woods, Basil G.
Wright, Douglas B.

* * * * * * *

PERSONNEL OF DIVISIONS

EUROPEAN DIVISION

COLONELS

Ardery, Edward A.
Bacon, Raymond F.
Fries, Amos A.
Johnston, Edward N.
Schulz, John W. N.

LIEUTENANT COLONELS

Norris, James F.

MAJORS

Connel, Karl
Hamor William R.
Hildebrand, Joel H.
Lewis, Gilbert N.
Lockwood, William G.
Richardson, Charles B.
Sibert, William O.

CAPTAINS

Akers, James Greaff
Corrill, Charles H.
Corry, Edwin E
Cutler, Thomas H.
Douglas, Stephen A.
Eldredge, Orrin S.
Goss, Byron G.
Hardesty, George R.
Hunt, George A.
Joly, Charles L
Keyes, Frederick G.
Mackall, Colin
Nicolet, Ben H.
Patterson, Earl
Perry, Glenn L.
Pope, Frederick
Ray, Arthur B.

CAPTAINS (*Concluded*)

Rollason, Geoffrey M.
Rowan, Hugh W.
Smith Earl C.
St. John, Adrian
Taylor, Alfred L.
Terry, Harry W.
Urbain, Leon F.
Ward, Ralph D.
Zanetti, J. Enrique

FIRST LIEUTENANTS

Alden, J. L.
Allen, Roger E.
Anderson, Harry P.
Ashe, Lauren H.
Bach, Ronald P.
Barnett, Joseph J.
Barry, John G.
Blakney, George P.
Bowman, Reginald C.
Clancy, Richard W.
Clapp, Dudley
Clarkson, John L.
Cole, Howard I.
Cool, Claude A.
Cronshaw, James L.
Cretcher, Leonard H.
Dale, Stewart F.
Darling, Harry C.
Eaton, Harry A. F.
Fisher, Abram M.
Francke, Hugo
Gauger, Alfred W.
Goldschmidt, Samuel
Gordon, Marcus A.
Hartshorn, Fred N.
Hunter, Robert C.
Keitt, George W

FIRST LIEUTENANTS (*Concluded*)

Knox, W. L.
McGowan, Henry G.
Mack, Edward
Maynard, Leonard A.
Meserve, Philip W.
Morgan, John D.
Murphy, Ray V.
Noer, Oyving J.
Norton, Ario R.
Nowry, Irvin W.
O'Brein, Bernard
Olson, A. R.
Parks, James G.
Parmelee, Paul R.
Popp, Earl C.
Rambo, Joseph D.
Rhode, Leon M.
Robinson, Charles R.
Rowe, David H.
Salisbury, Donald W.
Senior, James K.
Shaw, Leon E.
Sidelinger, Roy L.
Stearns, Albert M.
Stump, Horace E.
Thomas, Ralph M.
Thompson, Louis E.
Vanvoorsees, Harold E.
Walker, Lester V.
Whiton, Louis G.
Wightman, Eugene P.
Williamson, Robert B.
Wilson, David W.
Wylde, Wildred A.

SECOND LIEUTENANTS

Acker, Ernest R.
Austin, Robert W.

SECOND LIEUTENANTS (*Concluded*)

Birckhead, Peter H.
Bowers, Paul C.
Bowman, Ira J.
Brumhalt, John W.
Conrad, Frederick U.
Crowell, George W.
Davidson, Benjamin B.
Dennis, Richard C.
Dunn, Charles K.
Eiselot, Lewis G.
Hall, Robert E.
Hast, Julian A.
Higbee, Clarence W.
Holt, Herbert B.
Hooker, Albert H.
Knapp, Ralph
Law, James D.
McNaugher, Joseph W.
Miller, Russell W.
Neff, Chester M.
Nichols, H. Janney, Jr.
Pauly, Robert C.
Peck, Edward B.
Ribble, Keith P.
Riker, Carlton B.
Robinson, Otto L.
Schoetz, Francis H.
Scott, Warren P.
Sebastian, Reuben L.
Shaw, Ellis M
Skinner, Glenn S.
Stuarn, James V.
Taylor, David B.
Thayer, Bruce W.
Thompson, Frank D.
Wannamaker, George
White, James M.
Wright, Douglas B.

GAS OFFENSE DIVISION

COLONEL

Walker, Wm H

LIEUTENANT COLONELS

Chance, Edwin M
McPherson, William
Vaughn, Charles F

MAJORS

Chance, T Mitchell
Demorest, Dana J
Evans, William L
Frary, Francis C
Free, Edward E
Gallowhur, Wm G
Hanson, Hugo H
Heritage, Arthur M.
Mack, Frank W.
Nagelvoort, Adrian
Partridge, Clarence E
Sweeny, Orland R
Temple, Sterling N.
Van Keuren, Edgar B
Warner, Frank J
Wraith, Charles R
Zinsser, F. G.

CAPTAINS

Beebe, Lawrence L.
Bishop, Richard E.
Blanchard, Ross C
Boothman, Dale M
Brouwer, Harold S
Burns, Arthur R.
Bever, Otto S
Campau, M W
Chandler, Henry P
Clucas, Richard M.
Donk, Marion G
Frankforter, Clarence J.
Gartner, Henry O.
Gill, Benjamin B

CAPTAINS (*Concluded*)

Gordon, Robert D
Hall, Ralph E.
Heath, Michael V.
Hoffman, William E
Hope, Robert D.
Kinghorn, Chester
Labing, Louis S
Lawton, Stanley H
Leverne, Walter H
Long, Charles F.
Lovell, Fred A.
McGovern, Thomas F.
McKenna, Wm J
Martin, Wm. C.
Olin, Hubert L.
Pearce, Charles H
Richardson, Jos. G.
Robinson, Wm O
Ross, Wm H.
Roe, John D
Schmidt, Victor R
Schlridge, John S
Seabold, Eugene
Sharkey, Howard R
Sharpe, Harold C
Taylor, David P
Thompson, Thomas P
Trumbull, Harlan L.
Wesson, Lawrence G
Whitlock, Charles M.
Wilkinson, John A.

FIRST LIEUTENANTS

Armstrong, Charles D.
Ashmun, Lewis H
Booker, Haden K
Brock, Earle A
Brown, Lester B.
Carley, Joseph T.
Carter, Donald P.
Conoley, John R.
Cuff, James E

FIRST LIEUTENANTS (*Continued*)

Cummiskey, James E.
Davidson, Albert W
Davi, George W
Durant, Thomas G
Dwyer, Charles E
Eldridge, Arthur C.
Ijams, Miles G
Fairbank, Herbert S
Felsing, Wm A
Hand, Theodore E
Hayden, E M.
Iddles, Alfred
Johnson, Robert L.
Jones, Thomas W.
Kerr, George M.
Killam, Luther M.
Kipke, Ross E
Kearney, David R.
Lamb, Lloyd
Leach, Wm B
Loving, Henry W
McBride, George H.
McCoy, John G
McGhee, Burt G.
McWilliams, John O.
Mamma, Edgar C
Marshall, William D.
Martin, Harry A.
Mueller, William E.
Nasson, Harry B
Pierce, David H.
Rahn, Reinhardt
Royce, Harrison S
Rutledge, George F.
Sawtere, C C
Schermerhorn, George D.
Schmidt, Mott B.
Schultz, Addie D
Silsbee, James A
Sprague, Charles
Stephens, Charles W.
Stupp, John G.

FIRST LIEUTENANTS (*Concluded*)

Suydam, J. R., Jr.
Thomas, Richard
Truax, Harold W.
Trubee, William E.
Wadsworth, Chas
Wallace, Edwin S.
Weeks, Robert W.
Welch, Thomas B.
Wells, Arthur C.
Wells, Burling D.
Wells, Oliver E.
Wilson, John E.
Woodward, Paul G.

SECOND LIEUTENANTS

Bakken, Herman E.
Bliss, Roland R.
Bowes, Almon N
Brown, Raymond G.
Chaplin, John H.
Dixon, John M
Fannon, Harry E.
Ford, Arthur O.
Frederick, John H.
Heidingsfeld, Ralph W.
Heins, Ralph W.
Joyce, Floyd E.
Linkins, W S
Loeb, Edward H.
McLane, Howard B.
Milligan, Lowell H.
Osmer, John W.
Penfield, Richard
Prubeck, Edwin
Reese, John G.
Sersen, Fred J
Sharer, Ralph W.
Thornburg, George W
Tolmach, Louis
Wadd, James
Watts, Anderson H.
Woods, Basil G.

GAS DEFENSE DIVISION

COLONEL

Dewey, Bradley

LIEUTENANT COLONEL

Besse, Arthur L.

MAJORS

Alms, Charles
Bacon, William S.
Barth, Theodore H
Dewey, Frederick A
Johnson, Cleon R
Noonan, William J.
Reed, Philip L
Rose, Lester L.
Schutt, Henry P
Sill, Theodore W
Stevens, Oscar E.
Whiting, Jasper
Wilson, Irvin W
Woodruff, John C

CAPTAINS

Atterbury, Kirby
Babbitt, J Stanley
Blake, Kenneth B
Bopp, Carl G
Bradley, Harold C S C
Brodhead, Nathaniel B
Brophy, Wm E
Byrne, Samuel A
Coburn, Wm H
Colby, Chas B
Cover, Lester E
Dana, Lowell B.
Dee, Thomas
Dickinson, Arnold C.
Duff, Levi R
Foster, Harold B
Fulford, Lester E.
Gilbert, Rollin P S C
Graham, Robert McC
Green, Raymond W
Grose, Winfield S
Harshberger, Clarkson E.
Herbert, Wilwyn
Herman, Erle C.

CAPTAINS (*Concluded*)

Kay, Wm. D.
Kops, Waldemar
Little, John S.
Llewellyn, Paul R.
Macomber, Leonard
McGrath, David J.
McKinney, William S.
Merrill, Hamilton
Puff, Raymond V.
Rile, Wm. M
Russell, Jos. B.
Schlesinger, Barthold E.
Shattuck, Edmund J.
Sheehan, Charles V
Silver, Joseph R.
Smith, Raymond T.
Stapleton, Edward L.
Taylor, R L
Throop, Benjamin A.
Warner, Stuart D.
West, Clarence J.
Wheeler, Thorne L
White, Clarence W
Winklemann, Herbert A.
Wolf, Jas S.
Wood, Alfred W.

FIRST LIEUTENANTS

Andrus, Leonard A.
Avery, Paul P
Bailey, Albert E.
Beal, Wm. D
Bedford, Edward T.
Bell, Thomas R.
Best, Arthur F
Bogue, Joseph C.
Boyd, Jas. S.
Bristow, James J.
Cahill, Michael
Calloman, Clarence B.
Cochran, Marshall G.
Colebrook, M. W
Crossfield, Albert S.
Dunbar, Noel S
Eason, Harry Mc
Eysten, Lester H.
Eaton, Robt K

FIRST LIEUTENANTS (*Continued*)

Elden, John A.
Elliott, Lowell A.
Esser, Alvah E.
Fairchild, Tappen
Fitzgerald, Heber D.
Fleming, Walter F
Gace, Roscoe M
Gibson, Richard
Gurney, Harold P.
Haggard, Howard W. (S. C.)
Heneage, Thos. H.
Hentz, Wm. A
Hetherington, George F.
Hillery, Harry M
Hogue, Rene
Holden, Dudley F.
Holm, George E.
Holmes, Raymond M.
Hooper, Noel J
How, Robert A
Howlett, Arthur E
Hughes, Dale C.
Hull, Edwin J
Jackson, Wm M
Jones, Spencer L.
Keller, Alexander W.
Kempton, Robert B.
Kins, John L
Klauber, Murray
Lane, Howard A
Latson, Frank W
Leavitt, Geo. F.
Lee, Elwood B
Leyden, Thomas Jr.
Lloyd, Edward C
Long, David R
Maer, onnell, John G.
Mahlman, osborne
Mansur, Charles A
Mayer, Gustave
Mayham, Ray F
McNeill, Winfield L.
Meeker, Lawrence
Merrill, Leslie M
Merryman, James R.
Miller, Elroy J.
Mitchell, John H.

FIRST LIEUTENANTS (*Concluded*)

Morawski, Frederick H.
Morgan, Arthur M.
Moulton, Paul B.
Mulford, Wm. J. (S. C.)
Murphy, Alfred
Murtfeldt, W. Scott
Nimick, Francis B.
Noble, Edson J.
Northrup, William C.
Pierce, Edward P.
Prentice, Philip B.
Proctor, William R.
Rammel, Chas. L.
Ransom, Wm. J.
Rapee, Frank J.
Rector, Thos. M.
Regan, Edward F.
Reiling, Howard A.
Riddell, John F.
Rodgers, Rollins W.
Romilly, Edgar P.
Sampson, Ernest (S. C.)
Scott, Henry P
Shaw, Guthrie
Smith, Lawrence W.
Staples, Scott D.
Stephenson, Morris L.
Talbot, John C.
Talcott, Harrison W.
Todd, Wm. T.
Towler, Thos. W.
Trenkman, Frederick
Trumbart, Geo
Vile, Norman D
Vincent, Max G.
Visscher, Raymond
Walsh, James
Wangler, Albert W.
Wardin, Edward
Watson, Warren
Wemple, Holland R
Whitfield,
Wilson, Otto
Winter, Edwin M
Wiswall, Paul M.
Woodbury, Horace G.
Zimmerman, Joseph

DEVELOPMENT DIVISION

LIEUTENANT COLONELS

Bassey, F. M.
Wilson, W C

MAJOR

William, L. I

CAPTAINS

Barnebey, O L
Cover, L C
Cowan, L C
Duff, J R
Fulger, R C
Hering, E

CAPTAINS (*Concluded*)

McAdams, W H
Macrie, D
St. John, H M.
Silver, J R
Wright, B. B.

FIRST LIEUTENANTS

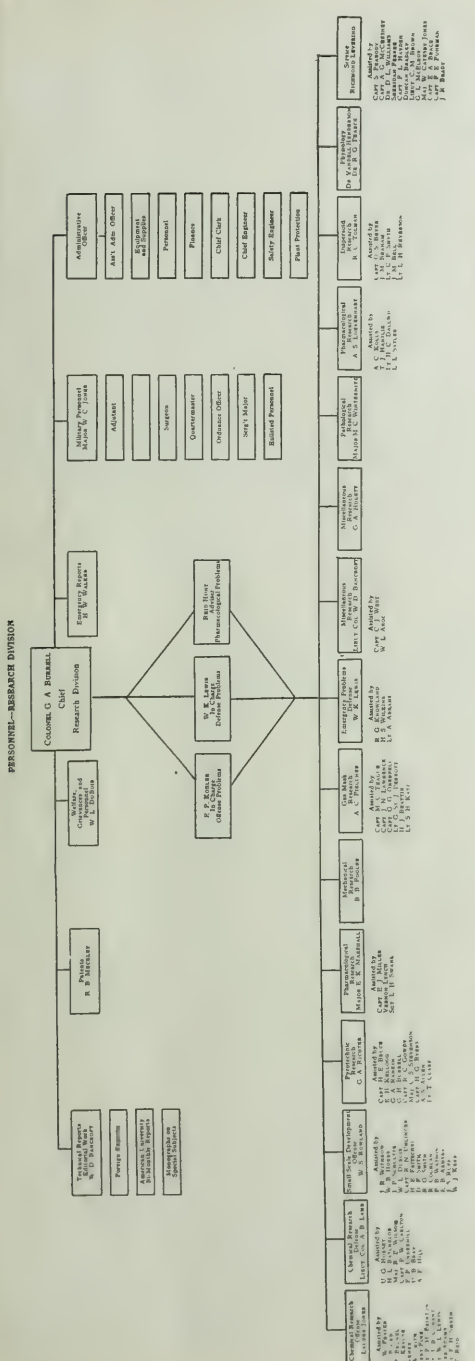
Eaton, T
Kurz, J F
Mecurdy, P R
Penfield, R

SECOND LIEUTENANTS

Calaghan, J O
Cheever, I P
Chenes, M R
Dabney, R. P.
Dobe, F
Fulks, B. F.
Graces, W
Randall, P.

SECOND LIEUTENANTS (*Concluded*)

Rice, W W
Royce, C.
Ryan, W P
Sotven, H.
Vanarnam, W.
Weber, L.
Westbrook, L.
Wilkins, W. P.


PERSONNEL—RESEARCH DIVISION
COLONEL G. A. BURRELL
Chief
Research Division
Assistant Officer
Adj't Adm. Officer
Equipment and Supplies
Personnel
Finance
Chief Clerk
Chief Engineer
Safety Engineer
Plant Protection
Military Personnel Matters & Records
Adjutant
Surgeon
Quartermaster
Ordnance Officer
Sergt. Major
Enlisted Personnel
Engineering Research Section
Physiology Dr. Yandell Henderson
Histology & Pathology Dr. H. T. Marshall
Pharmacological Research
Physiological Studies of Respiration
Histopathology of Respiration
Physiological Studies of Circulation
Asphyxiating Gases
Irritating Gases
Lachrymators
Vesicants
Gas Masks
Personnel
Pharmacological Research
Physiology
Chemical Research
Analytical Chemistry
Small-Scale Development
Technical Reports
Physics
Publications
Secretary
Assistant Secretary
Stenographers
Messenger
Telephone Operator
Mail Clerk
Files
Chief Draftsman
Assistant Draftsman
Tracers
Blue Printer
Photographer
Photographic Laboratory
Chief Mechanician
Assistant Mechanicians
Machinists
Carpenters
Glass Blowers
Helpers
Chief Chemist
Assistant Chemists
Analytical Chemists
Laboratory Assistants
Chief Engineer
Assistant Engineers
Draftsmen
Tracers
Blue Printers
Chief Physicist
Assistant Physicists
Chief Physiologist
Assistant Physiologists
Chief Pharmacologist
Assistant Pharmacologists
Chief Bacteriologist
Assistant Bacteriologists
Chief Pathologist
Assistant Pathologists
Chief Histologist
Assistant Histolog

6. Are you married? 7. Is your wife living?
8. How many people are dependent upon you (a) wholly? (b) partially?

II—Training

9. Give the names of the schools, colleges, universities, graduate schools or technical schools which you have attended, with dates of attendance, courses pursued and degrees granted.

Institution	Dates	Courses Pursued	Degree

10. State any other training you have had.
11. State fully the courses of study in which you have specialized.
12. What foreign languages do you (a) speak?.... (b) read?.....(c) write?..
13. Of what technical societies are you a member?

III—Practical Experience

14. In what foreign countries have you had experience, and how much?
15. How many years of continuous experience have you had?..... (a) Industrial (b) Teaching (c) Other
16. What experience have you had along executive and administrative lines?...
17. State in detail your duties in your various positions

From—To	Employer	Title	Nature of Work	Salary Statement optional and confidential)

18. Publications

Title	Publisher	Date

19. State specifically the kind of work you do best.
20. In the present emergency how and where, in your opinion, could you be of most service to your country?

IV—Service

21. Do you desire to enter the service of the United States at once (a) in a civilian capacity? (b) in a military capacity?

Note—*If you answer this question in the affirmative, answer the rest of the questions in this section in so far as they apply to your case: Otherwise, skip to Section V.*

22. What rank (or salary, if you desire a civilian appointment) would you accept?
23. What has been your total military experience?
24. Are you registered in the draft?
25. What is your Order Number? 26. What is your Serial Number?
27. Have you received the draft questionnaire?
28. How have you been classified?
29. Give names and addresses of three or four responsible persons (not relatives) or send letters of recommendation herewith:

Name	Address

V—Miscellaneous

30. State anything else which will aid us, or which you want us to know, which is not covered by the questions on this folder. (Answer this question last.)

Please Re-Read this Whole Questionnaire and Sign Below

Signature

. . . . . .

WAR DEPARTMENT

CHEMICAL WARFARE SERVICE, WASHINGTON, D. C.

SEPTEMBER 1, 1918

TO THE CHEMISTS OF THE UNITED STATES:

This is a chemical war; therefore the War Department must have immediately available all possible information regarding chemical materials and chemical man power. Of these two essential elements chemical man power has so far received less attention. The census of American chemists made by the American Chemical Society in 1917 has been of great assistance to the War Department. Without it the present state of progress of the United States in chemical warfare would have been impossible of attainment.

However, during the same period conditions have undergone rapid and radical changes. The old census, excellent as it was, is no longer completely adequate. With the organization of the Chemical Warfare Service as an independent branch of the War Department, unifying all the elements of chemical warfare, it is obvious that the War Department must have its own set of records on a matter so vital to its own success. Moreover, these records must contain information which a short time ago was apparently of little importance. The new census must be made primarily from the viewpoint of the military status of chemists.

The importance of a prompt return of the census blank, properly filled out, by every chemist of the country, cannot be overstated. American chemists are presented at this moment with one of the greatest opportunities to serve their country by the simple process of answering this questionnaire with all possible speed.

(Signed) William L. Sibert,
Major General, U. S. A.
Director, Chemical Warfare Service

. . . . . .

CHEMISTS IN CAMP

As the result of the letter from the Adjutant General of the Army, dated May 28, 1918, 1749 chemists have been reported on. Of these the report of action to August 1, 1918, shows that 281 were ordered to remain with their military organization because they were already performing chemical duties, 34 were requested to remain with their military organization because they were more useful in the military work which they were doing, 12 were furloughed back to industry. 165 were not chemists in the true sense of the word and were, therefore, ordered back to the line, and 1294 now placed in actual chemical work. There were being held for further investigation of their qualifications on August 1, 1918, 432 men. The remaining 23 men were unavailable for transfer, because they had already received their overseas orders.

The 1294 men, who would otherwise be serving in a purely military capacity and whose chemical training is now being utilized in chemical work, have, therefore, been saved from waste.

Each case has been considered individually, the man's qualifications and experience have been studied with care, the needs of the Government plants and bureaus have been considered with equal care, and each man has been assigned to the position for which his training and qualifications seem to fit him best.

Undoubtedly, there have been some cases in which square pegs have been fitted into round holes, but, on the whole, it is felt that the adjustments have been as well as could be expected under the circumstances.

Where readjustment is necessary, subsequent action will be taken.

AN ARMY WITHOUT RESERVES

Many letters have been received commenting upon the several points raised in the editorial "An Army without Reserves" printed in the July issue of THIS JOURNAL. In view of these comments it seemed desirable to make a wider canvass of views and to present these in the form of excerpts from letters.

Three points were discussed in the editorial: first, the responsibility of the War Department for instructional assistance in chemistry departments; second, intra-university readjustments; third, material assistance of universities by the chemical industries.

As the symposium was going to press news was received from Washington of favorable action by the War Department concerning the detailing of instructors. This is contained in the announcement below from Major Samuel Avery of the Relations Section, Chemical Warfare Service, at one time head of the chemistry department of the University of Nebraska, and later chancellor of that institution.

In the light of this action universities can now proceed promptly and effectively to the development of their plans for the approaching educational year. The action of the War Department, together with the letter from Major General Sibert, which leads the symposium, should constitute a powerful, patriotic appeal to those who have already begun the study of chemistry in our universities, and to the very brightest minds among the young men entering this Fall. We are confident that the response will be a blessing to America both in war and in peace.

The editorial, Major Avery's announcement, and General Sibert's letter will be reprinted in combined form. On request these reprints will be furnished free and in quantity to university executives and heads of chemistry departments who may desire to circulate them.—EDITOR.

. . . . . .

WASHINGTON, D. C., AUGUST 13, 1918

By recent ruling of the War Department, enlisted men may now be furloughed to approved institutions for the purpose of engaging in instruction in chemistry. Upon recommendation by the Director of Chemical Warfare Service, through the Relations Section, the War Department's Committee on Education and Special Training will administer such furloughs.

The new ruling provides that other enlisted men qualified to carry on the work of instruction in chemistry may be sent to approved institutions when these institutions are unable to secure the return of former instructors already in military service, or unable to fill vacancies in the teaching staffs from the ordinary sources of supply. This provision will do much to assist those institutions whose instructional staffs were very nearly depleted by the demands for chemists during the early stages of the war.

The organization of the Chemical Warfare Service has now progressed to such a stage that assignment of chemists to the various Bureaus of the War Department may be made without serious inconvenience to the sources from which these chemists have been drawn. Industries essential to the prosecution of the war have already been protected by the return on furlough of chemists previously employed by them. The provision for the return of a sufficient number of teachers insures sufficient instruction to provide the steady stream of chemical recruits necessary for war production and research.

Application for the return of men needed should be addressed by the heads of institutions affected to the Relations Section, Chemical Warfare Service, 7th and B Streets, N. W., Washington, D. C., Attention Major Avery.

(*Signed*) SAMUEL AVERY, *Major*,

Relations Section, Chemical Warfare Service

ARMY OFFICERS

It is of fundamental importance for the winning of the war that the chemical resources, in the shape of man power, be utilized at their maximum efficiency. Through the mobilization of the chemists, chemical supplies are becoming more available each day, but chemically trained men, necessary to meet the growing needs of the war, are constantly becoming more difficult to obtain.

The Chemical Warfare Service realizes to the utmost that men must be trained in the university laboratories, both for the necessity of the war and for the furtherance of the growth of the chemical industries that have been built up in this country since the European war began. To this end there has been established in the Chemical Warfare Service itself a division on University Relations, whose duties are, broadly speaking, to further the production of chemists for the future, as well as to supply the immediate demand.

The organization of the industrial and educational resources of the country is a matter of such import that it must be approached in a spirit of self sacrifice, each thinking only of securing the greatest good for all. In this spirit the Chemical Warfare Service cordially welcomes the coöperation of both the educator and the manufacturer; and through its divisions of University Relations and Industrial Relations, is prepared to assist both in meeting the difficulties in the chemical situation now confronting the country.—WM. L. SIBERT, Chief, Chemical Warfare Service.

Many of the matters with which this editorial deals are receiving very careful consideration at our hands, and considerable progress has already been recorded along these lines.—MARSTON T. BOGERT, Colonel, Chemical Warfare Service, N. A.

PRESIDENT, AMERICAN CHEMICAL SOCIETY

No one realizes more than I do the need of chemists and engineers at the present time, or the anxiety which we all feel as to filling up the ranks for after-war conditions. The only way to provide reserves for the army you have in view is to educate men for the job, and this takes a long time in each case. Our educational institutions have been sadly drawn upon as regards the teaching staffs, and I very much fear that our future output of chemists and engineers will not only be smaller in number than is needed, but in many cases will not be properly fitted for the tremendous work they will have to undertake. I sincerely trust that some means will be devised to keep our educational institutions going to the fullest extent, as without large successes in this direction I fear we will find ourselves by and by with a smaller army and no reserves at all.—WM. H. NICHOLS, President, American Chemical Society, New York City.

UNIVERSITY EXECUTIVES

You have put your finger on something that is troubling us very much here at Columbia. I am sending your editorial to Dean Pegram in order that he may study and discuss it with some of our colleagues.—NICHOLAS MURRAY BUTLER, President, Columbia University, New York City.

The universities are certainly in a very serious condition in regard to instruction in chemistry. So many of our instructors have been taken off into war work that we have barely enough to go on, and some institutions must be wholly unable to carry on their instruction. The difficulty is not money but men. Your article will do good.—A. LAWRENCE LOWELL, President, Harvard University, Cambridge, Mass.

I have read with interest your article on "An Army without Reserves," with its interesting application to the study of chemistry, and sympathize most heartily with your line of thought. Of course it is hard to know how to apply it in each individual case, but of the general importance of what you say there can be no doubt whatever.—ARTHUR T. HADLEY, President, Yale University, New Haven, Conn.

I have read your editorial with care and interest as it discusses directly the problem that institutions of this kind are facing in connection with their departments of pure and applied science. The problem, as you say, is a difficult one and I know that the authorities at Washington are giving it careful consideration.—DEXTER S. KIMBALL, Acting President, Cornell University, Ithaca, N. Y.

We are very much obliged to you for writing the editorial in behalf of chemistry in the universities. I wish you would send me a number of the reprints of this article. I shall be very much obliged to you indeed and shall use them where they will help the cause.—CHARLES W. DABNEY, President, University of Cincinnati, Cincinnati, Ohio.

Your recent editorial is a strong and timely presentation of the facts of a situation which is fortunately rapidly becoming better recognized. The first great rush to gather, equip and train from the most available portion of our population an army of fighting men has now settled down to steady and effective procedure. The next step is obviously to look a year or two into the future and plan to continue the support of the great army in France, and to overtake and pass our enemy in all measures of military effectiveness, which at the present time means largely to beat the Germans in the production and utilization of those materials and military appliances for the manufacture and operation of which trained technical men are necessary. Therefore the training of these men must continue.

It appears that the only effective way in which the resources and organizations represented by our colleges and universities can be kept in operation to produce a reserve of trained men is by enlisting students in colleges and technical schools who are studying subjects essential to the conduct of the war in a reserve organization which shall be fully recognized as a part of our army. Young men of intelligence and vigor are not going to attend our universities in large numbers in any work that is not definitely taken over by the War or the Navy Department as part of their program. Consequently it is most gratifying to all those concerned with this problem to learn, since the appearance of your editorial, that through the efforts of the War Department Committee on Education and Special Training provision is almost certain to be made at once for an enlisted reserve of scientific and technical students and for retaining in the universities the necessary instructors of these men.

The next step which I hope and believe the War Department Committee on Education and Special Training will, conjointly with such valuable agencies as your Journal and other general and technical publications, soon take is to give wide publicity to the exact facts as to the number of students there will be graduated from scientific and technical schools next year and as to the demand for graduates at the present time and the prospective demand as the war proceeds by the Army, the Navy, the Shipping Board, and the civilian concerns.

If the action of the War Department succeeds in filling our institutions this Fall it may be necessary still to call upon the War Department for help in returning instructors to the institutions if there are any that can be spared from their present posts. As to the financial support of the universities at this time, it appears to be difficult to do very much in the way of getting contributions until the new Federal Tax Law shall have been enacted and corporations and individuals shall have learned where they stand under the law. After that it should be possible to count on continued support for our educational institutions whose value and effectiveness were never so evident as now.—GEORGE B. PEGRAM, Dean, Columbia University, New York City.

PROFESSORS OF CHEMISTRY

There can be no question but that the training of chemists in our universities for positions with the Government or with the chemical manufacturers is at the present time one of our most important "war industries."

***I understand that a plan is now being worked out in Washington under which adequate staffs of instruction in the various universities will be ensured for the four branches above mentioned [physicians, engineers, physicists and chemists] and students of good standing in these four branches will be permitted to continue their university work until the completion of their courses.—L. M. DENNIS, Cornell University, Ithaca, N. Y.

I have read with interest your editorial which I am heartily in accord with and congratulate you on writing.

If you have them yet left for distribution, I would like to have 25 or 30 copies, as I wish to place them in the hands of some people who have influence and have to do with educational matters.—C. S. WILLIAMSON, JR., Tulane University, New Orleans, La.

Your editorial discloses a condition which thoughtful men have been facing for some time with serious apprehension. It must be met and the solution found without delay. Otherwise the injury and loss will be hard to repair.—FRANCIS P. VENABLE, University of North Carolina, Chapel Hill, N. C.

From the reports which have come to my attention, the situation with regard to instructors in chemistry in many of our colleges and universities is almost desperate. I sincerely hope that the War Department, especially, may come to a realization of the need and may authorize the return of some of the enlisted chemists to our colleges and universities as assistants and instructors. In any case, I hope that no further calls for men of this class will be made upon the depleted chemical staffs of the institutions of the country. At best, there is a very great temptation for the young chemists of the country to get into some form of active service for the prosecution of the war. Some of us believe that an equally important service may now be rendered in giving instruction to the young men and women who remain in the universities. Such service may seem rather tame and unattractive in these stirring times, but it is nevertheless of vital importance for the future.—W. A. NOYES, University of Illinois, Urbana, Ill.

It should be of some service to have the seriousness of the situation so forcibly pointed out. Being myself a university teacher, I am especially concerned with university conditions.

I am much pleased with some of the suggestions that you make and hope they may bear fruit. I have seen my own staff depleted until I have left one assistant professor and two of the younger instructors. I have been trying in vain all summer to fill four important positions; so far I have only "prospects."

I think your suggestions in regard to detailing enlisted men back to the university, is a valuable one, and as far as I can see this is the only way in which the situation can be handled. Many of the men are leaving because they feel there is some reflection on their zeal if they remain in university work. Until university work is given some recognition by the War Department, this situation will continue. I, myself, have had a strong feeling that I ought to be getting into active war work; at the same time my good judgment tells me the importance of keeping up the supply of trained chemists. Your article has helped reassure me in this.—FRED W. UPSON, University of Nebraska, Lincoln, Neb.

I have for some time been considering the advisability of doing an unprecedented thing as a public duty, in view of the unusual conditions as to our scientific reserve; that is, the making of an appeal to my most promising students of last year to continue their scientific work in college the coming year. A little consideration showed that any such appeal should be enforced by authoritative and official statements as to the need of the hour and the immediate future. Such statements would be hard to get or put in adequate and manifold form.

Two days ago your editorial "An Army without Reserves" reached me. It gave me an idea which I shall dare to place before you for what it may be worth.

You are the one man in the best strategic position to help us in the colleges and universities, the sources of the supply. It seems to me the way is open for you to do a hugely important thing by taking the leadership in making a wide appeal to the students themselves.

Secretary Baker is much interested in the "scientific reserve." So is Professor Bogert. If you could work over that editorial so as to make it specific for the purpose, the three of you and perhaps others of great prominence sign it, and rush it in quantity to the colleges and universities in time for use before the beginning of the academic year I have no doubt that it would have a very great effect.

Of course you might prefer to start anew, without regard to this editorial, making a statement of the need, and an appeal to the colleges and universities, students, industries, as may seem best.

If you and the other gentlemen such as I have named are willing to certify the need, you will strengthen the hands of us in the colleges in several ways. The need of explanations and arguments addressed by us to faculties, registrars, students, would be almost obviated. I, for instance, with such a document in hand could with confidence appeal to men of means to help promising students who are over-burdened by work for support, and can find little time for laboratory work or money to pay for the extra expense. It would remove the possibility of any charge of special pleading.—W. S. HENDRIXSON, Grinnell College, Grinnell, Iowa.

Your editorial deals excellently with a number of considerations which have given me great concern. The need of chemists in the future is so great that it can hardly be exaggerated; and I feel very strongly that not only must our all too few chemists be conserved, but also that young men of chemical promise must be favored in every possible way, in order to complete their training. We all agree that every conceivable effort must be made to win the war and complete the victory of our just cause —but it would be indeed short-sighted to put out of the running our young prospective chemists, upon whom so much must depend in the future, by assigning to them tasks, however important, which could be undertaken by others.

If the new draft proposition to lower the age limit (obviously needed in the present crucial emergency) goes into effect without any provision for continuing the education of young men who desire to be chemists, clearly our universities and colleges will be entirely depleted of able-bodied young chemical students. The provision for a Chemical Engineer Reserve Corps, excellent as it is, does not seem to be elastic enough to cover all types of necessary chemists. If we do not take care, there will be no more chemists just at a time when chemists are needed more than ever before in the history of the country. Therefore it seems to me highly necessary that some provision should be made for assigning able boys interested in chemistry back to their universities, after their enrollment in the Army, to continue their academic work in approved and appropriate studies. This they should do with the utmost seriousness, realizing that in this way they are serving their country and civilization fully as much as if they were in the firing line.

It is because of this conviction that I have continued my service to the University in spite of intense longing, at times, to do something more obviously (but perhaps less really) contributing toward our cause.—T. W. RICHARDS, Harvard University, Cambridge, Mass.

I would like to call your attention to two sources of help in the university teaching situation. The first is the high school teacher.

Most colleges and universities are located in or near large cities. Most teachers of chemistry in the high schools of large cities have taken special courses in the subject; many have one or more graduate degrees; many are members of the A. C. S. These teachers have stayed in the high school field preferring its independence and larger salary.

In these high school teachers, the university and college can find a corps of enthusiastic men and women, *trained in teaching* as well as in chemistry, anxious to do intensive work, with more or less experience on the executive side as well. They would be glad to *give* their free time to the university if programs can be adjusted. They could take night classes, Saturday classes, afternoon classes satisfactorily. They should find it easy to change to a lecture system.

The teacher of chemistry in a city high school knows industrial chemistry at first hand as well as from a book; he has studied food chemistry in the school of home experience as well as in the laboratory. Such teaching can be drafted for the period of the war, permitting the return of regular instructors after the Government is through with them. Not least important in this connection would be the growth in understanding and appreciation between teachers of college-preparatory chemistry and directors of university work.

My other suggestion takes in the men who graduated from schools of chemistry in the "lean years," men who went into other lines of business, who if residing near their Alma Mater might be induced to give part time. I should think the lists of alumni might be worth looking over.—JESSIE CAPLIN, West High School, Minneapolis, Minn.

My staff of eight was cut in two and I have had a very difficult time indeed to fill the vacancies, in fact, I was on the point of taking women until by good chance I secured enough men to bring my numbers to normal. It is very certain that if further drafts are made upon the staff, it will be practically impossible at this late day to fill their places, and unless we receive aid from the Government in the shape of returning to us men whom they have taken, our work will be very seriously crippled. Naturally, those men who would be returned to us would come in uniform and serve as detailed men.

It may interest you if I tell you of a small matter that happened of late and which illustrates the odd way in which some people look at the matter covered by the editorial. A number of recent recruits chanced to be in Troy of late and during their progress around the city were driven through our campus. There they noticed a number of our students and inquired who they were. They were told, whereupon they expressed surprise that such men were not training for the firing line. Upon being informed that they were getting ready for work behind the lines, of chemical character, they expressed strong disapproval and requested that they be driven elsewhere as they didn't care to see any more of them. In discussing the matter, I had an opportunity to dwell upon the fact that when our enemies first developed a gas attack it would have been pretty disastrous if those on our side who were opposed to them had consisted only of such men as are technically known as soldiers. Fortunately for us and our Allies there were available trained chemists who knew what to do to meet the unexpected procedure of the Germans, and it was not difficult to persuade those to whom I was speaking that matters would go pretty seriously for us if specialists, trained technical men, were not behind the lines ready for emergency calls.—W. P. MASON, Rensselaer Polytechnic Institute, Troy, N. Y.

Referring to your timely and interesting editorial, the suggestions therein outlined deserve the thoughtful consideration of every one of the 15,000 that make up our chemical army.

What is needed mostly to-day to arouse intelligent public interest in chemistry is a well directed chemical propaganda that will reach the man in the street as well as the man at the directors' table. We need more enthusiasts who can interpret chemistry to the public.

With few exceptions, the backbone of chemical education to-day is the State University. Unfortunately, its fate is too often left to legislators of the Siwash breed or the Tammany type. However, even these worthies may be educated and shown the light. Granted this, needful appropriations will follow; and where there are sufficient funds, the right men can always be found.

Equal in importance to focussing the attention of legislators on the training places of chemists should come the reminding of certain corporations of their great debt to these institutions. There are scores of corporations that can and will follow the fine example of the du Pont Company. They will do so not only out of gratitude for past benefits, but also because their business foresight will tell them that their future must be protected.

A general and persistent propaganda, then, should implant the chemical germ in many hopeful young men, and if a certain portion of this propaganda could be concentrated upon legislators and corporations alike, the future would take care of itself, and the country could be assured of an oncoming and unfailing supply of chemical reserves.—W. A. WHITAKER, University of Kansas, Lawrence, Kansas.

I note with gratification your plans for a symposium upon this vital matter. Naturally, I was most deeply interested in your comprehensive analysis of the university conditions.

Like many others, I have been confronted with the difficult task of enlisting and reorganizing a chemistry faculty and have been successful in filling four out of five important vacancies with teachers not now subject to draft but who have been drawn from other universities where their services were also greatly needed. Truly, something must be done to re-establish the depleted ranks of the teachers.

It is reported that some of the chemists now engaged in governmental research work are primarily teachers whose past records do not indicate that they are altogether qualified to pursue original investigations. Furthermore, many able teachers are engaged continuously in governmental routine laboratory work of such character that it could and should be delegated to men of undergraduate calibre. I note these reports with no intention whatever of disparagement, but, if they are correct, it seems to many of us whose faculties have been unduly depleted that men who have already established themselves as able teachers of chemistry in the universities, would undoubtedly be of greater service to the Government if they could be officially returned to their positions and vocation as teachers.

There is another condition connected with the maintenance of chemistry departments and their courses deserving note, namely, the indispensable services of clerical help versed in

chemical terminology, chemical stock-keepers, and lecture assistants. For instance, a lecture assistant, a specialist in the assembling of lecture experiments, will shortly be removed by the draft. There are many such men in our universities. They are not classed as indispensable teachers but their services are just as indispensable and important as the teachers themselves Will it be possible to conserve men of this description, as well as teachers, through the selective draft system, or otherwise?—H. S. Fry, University of Cincinnati, Cincinnati, Ohio.

Let me use this opportunity to express to you how thoroughly I agree with you in your plea for the protection of our chemist reserves. In spite of our efforts of some months with the War Department, no progress has been made in securing protection for the students studying chemistry in our universities and colleges that have no engineering department proper. I understand that the problem is being considered with a larger problem of utilizing all university men, but it should be consistently and intelligently pushed the way you are doing it. I should be very glad to be of assistance in the effort if you see any possibility of making more rapid progress toward the goal. From the outset I have foreseen that we should have an extraordinarily severe shortage of chemists by this autumn, unless we could keep up the supply from our universities and colleges. With this in mind, we at Chicago have kept up our full teaching staff, having lost only one assistant professor and one instructor of draft age. We have felt that we were doing war service in preparing for the demand for chemists exactly as others in preparing munitions and other supplies. It will interest you to know that at our request the faculty has given us a free hand in regard to the amount of chemistry which we may require of undergraduate students, and we intend concentrating their work to such an extent that in their fourth year they will receive some research training and will be able to replace men who in normal times would have had at least two years of graduate training. It is our plan to include in their work only courses in mathematics, physics, and English, and such optional courses as demand chemistry as a prerequisite and which are in fact forms of applied chemistry.—Julius Stieglitz, University of Chicago, Chicago, Ill.

I find myself in hearty sympathy with your editorial. Its timeliness is emphasized by the contents of nearly every mail which comes to my office. There are no young men of ability with chemical training available to fill positions. The salaries which are offered to inexperienced men are beyond the dreams of avarice of a few years ago, and they tell their own story. They also point clearly to increasing perplexities in the future, unless the problem of training chemists and chemical engineers is squarely met. Thoroughness must not be sacrificed, but specialization should be. Courses and subjects of instruction must be overhauled with courage and a forgetfulness of traditions. Many so-called "expedients" will be found to be actually better than the subjects or methods which they replace. It is often a surprise (not always agreeable) to find how much can be left out without harm.

All that you say of the difficulties encountered by administrative officers in retaining, to say nothing of securing, instructors is abundantly true. Even if fairly convinced, in some cases, that an individual is not the man best qualified for a particular national service, the administrator must give the instructor the benefit of the doubt. It seems probable that the time may come when it will be wise for those connected with the Government to examine courageously the list of college men in service and return to college work some who are not needed in the positions they are occupying because of their specific knowledge or ability.

Some missionary work needs to be done among the freshmen and sophomores, and especially with their parents, to bring home the fact that there is a very real need of curbing the natural tendencies of the youth of eighteen to turn to what he conceives to be the more immediate and certainly the more spectacular forms of service. The better and more virile the lad, the greater is this tendency. Something needs to be said to them from sources outside the institutions, to let them know that there is a very real duty toward the Nation, not for the duration of the war alone, but for many days after, to persist in the training for the chemical contests ahead.—H. P. Talbot, Massachusetts Institute of Technology, Cambridge, Mass.

Your editorial calls attention to a matter of very serious import which has doubtless been in the minds of many thoughtful men for some time.

The chemical situation will be a serious one throughout the period of the war and, it seems to me, even more serious for American chemical industry under post-war conditions. To establish on a permanent basis the vast chemical enterprises begun during the present emergency will mean that the wasteful methods of the past and present must give place to the most highly developed scientific methods and will require the services of a very large number of highly trained chemists.

Have we the requisite number of such men? Are our universities and technical schools giving the kind of training which best fits their students for work in the industries? Do the industries themselves understand fully the kind of training their chemists should have had in order to be of the highest value?

These and similar questions are of vital importance at the present time and I am writing to suggest that steps be taken to bring about a general discussion of the whole subject of the training and work of the industrial chemist. Is it too late to arrange for such a discussion at the Cleveland meeting in September? If so, could not the Journal of Industrial and Engineering Chemistry conduct such a symposium as that held by the Faraday Society about a year ago? An interchange of views between chemical manufacturers, works managers, industrial chemists and university professors, under the auspices of the American Chemical Society or your Journal, it seems to me would be of very great value at the present time.—B. F. Lovelace, Johns Hopkins University, Baltimore, Md.

The conditions here at the Worcester Polytechnic Institute are even more serious than they were in the spring when I wrote a letter to the Chairman of the National Research Council urging that immediate action be taken to relieve the situation. This letter was dated April 17 and was as follows:

"The situation as regards instruction in chemistry in universities and technical schools is rapidly becoming serious. The restricted financial resources of educational institutions in general prevent any increase in the salaries paid to educators so that with the rapidly increasing cost of living many of them are being tempted away into the industries where at the present time there is such a great demand. Numerous others are volunteering their services to the Government in various capacities. Ordinarily the places of these older men would be filled more or less satisfactorily by younger men. Unfortunately, however, the same causes are at work with them, but to an even more intensified degree and in addition they are of draft age. The result is that at the present time there are almost no young men entering the graduate schools in chemistry and none available for teaching the subject. From our own department we are losing one full professor, one instructor, and an assistant, and I am unable to find anyone to take their places. We have in our institution between fifty and sixty young men in process of training as future chemists. It seems to me that something should be done immediately by such organizations as the National Research Council to counteract this crisis. For example, it would materially help the situation if all young men desiring to enter the profession of teaching chemistry and having the necessary qualifications were given deferred classification. Possibly your Council is now acting on this question or has already done so."

This was answered by John C. Merriam, who expressed his gratification at receiving such statements, as the Council was busy in assembling data regarding the exact situation and hoped to be useful in working out the proper balance of instruction and research for educational institutions.

Personally I think this war will be won as quickly, as surely, and as permanently if we give some time and thought to devising means for keeping our educational institutions running as nearly as possible along normal lines.

Upon the declaration of war by this country, what do we find—a universal, and it seems to me somewhat hysterical, haste to give up scientific research and study and devote this time and energy to warfare work. This impulse was highly commendatory and important results have been achieved. Necessarily, however, there has been a great deal of wasted effort and my appeal is to return a part at least of this energy to normal scientific investigation.

The situation is well stated by Alexander Findlay in the preface of a recent publication entitled, "The Treasures of Coal Tar," in which he calls attention to a quotation of a prominent German industrial chemist to the effect that "England talks now not only of holding her own in war, but beating us in our chemical industries. She cannot do it, because the nation is incapable of the moral effort to take up an industry like that—which implies study, which implies concentration, which implies patience, which implies having one's eye on the distant consequences and not considering merely the momentary profit." Commenting on this, Findlay says, "That is a challenge which this country cannot refuse to take up, but in taking it up, let us realize that

success can be achieved only by a more general appreciation of science, by the cultivation and encouragement of chemical research in an enormously higher degree than in the past, and by the continual coöperation between science and technology. And it is important, also, to realize that it is not merely science in its immediate applications to industry that we must cultivate and encourage, but also, and more especially, pure science or experimental research motivated solely by the desire to increase knowledge. The acquisition of knowledge must precede its application; chemical invention must follow chemical discovery. All the great discoveries, all the great advances have been made, not as a result of effort to achieve results of immediate industrial importance, but as the result of a patient and persevering pursuit of knowledge."

It strikes me the general public and its representatives in the Government do not appreciate these facts and even many of our educators in the higher institutions of learning have temporarily lost sight of them. What is it that is emptying our colleges and technical schools? The answer, as given by the student himself, finds a partial explanation in the resentment which he feels to some conditions existing in many colleges. He remarks the great number of college presidents, deans of colleges, and faculty members who have sought greater emolument in war service, forsaking the class-room and students. He believes that the consequent change in faculty members leads to demoralization of standards, interest, and results, and a general lowering of scholarship. He will have to be convinced of a more sincere altruism on the part of educators at Washington and elsewhere before he will cease enlisting for immediate active service.

I think this student viewpoint, be it conscious or unconscious, should be given thoughtful consideration for it depicts the situation in all the educational institutions with which I am familiar.

I feel that to save the situation the Government should make it obligatory on all students, who have the necessary qualifications, to stay in their respective institutions until their education is completed; that measures should be provided to retain and keep up an ample supply of trained instructors; and, furthermore, provision should be made that will prevent our graduate schools from atrophy and keep the torch of research alight.—WALTER LOUIS JENNINGS, Worcester Polytechnic Institute, Worcester, Mass.

All who teach chemistry throughout the United States are viewing with alarm the decimation in the ranks of chemistry teachers and chemistry students which the war has entailed. This disorganization is going to be more disastrous than it appears even now. It is well known among the profession that the men who have just an elementary training in chemistry are really of minor importance in the industrial world to-day; it is the men of extensive training and of research ability who are needed, and who alone can aid and enable our country to do the high type of industrial work which our modern civilization requires. Yet it is particularly the advanced work, even down into the senior class of the undergraduate college, which has been disturbed, and in many schools entirely done away with. Here at the University of Texas we will have two graduate students who have just received their B.A. degree, and four seniors, where we have had about ten or more graduates and about fifteen seniors. There is considerable likelihood that we will lose some of these and, with the new draft age, we will lose all of these and all of our junior class even. If the war lasts until January 1, 1920, there will be not only a lack of chemists, due to the absence of advanced students during a period of three years, but at least four more years will be required for the students in colleges, who have had only sophomore work, to be trained sufficiently extensively to do a high quality of chemical work. Thus a period of seven years will have passed in which no chemists will have been trained.

If the war should last longer, the present shortage of chemists will make itself felt even in the conduct of the war.

The seriousness of the situation would be recognized much more readily if the term "chemist" were defined somewhat. In the recent enrolling of the soldiers who had had chemical training, men who have had only high school training were enrolled even, and it is likely that, in many instances where so-called chemists were detailed by the Government to do certain work, and where firms have tried to secure chemists, men were put in charge of work which they were wholly unable to do; but, since mistakes are often covered up as much as possible, the shortage of competent chemists—that is, of men with sufficient training—has really not become apparent at present; yet the future is sure to reveal it.

The draft provisions are not the only causes which are affecting the training of the reserves for our chemical army. Many of the brainiest men in the teaching profession, impelled by patriotic motives, have left the colleges to serve the country in positions in which they were more greatly needed than in teaching. The industrial world has suddenly recognized its great need for men possessed of the highest type of scientific training, and by dint of offering large salaries, has drawn many of the brightest minds out of the teaching profession. While many good men remain at the post of teaching, yet it must be admitted that, on the whole, the teaching staffs are decidedly weakened and will be still further weakened by men leaving the teaching profession to go into governmental or industrial work, as long as the present great need for chemists continues. If we are to train a reserve army of chemists, we must make an effort to retain faculties capable of doing the teaching of, not merely elementary work, but particularly the advanced work. It should be represented to members of faculties that they can do no more patriotic work than to strive to do effective teaching, and that they should carry on and stimulate work in the advanced courses particularly, even though the number of students in these courses may be only a small fraction of those present under normal conditions. Furthermore, presidents and governing boards of colleges should be urged to meet the high offers of industries by making liberal increase in salaries to competent men and by urging them to stay and carry on the work.

I would suggest that your symposium of expressions on the subject, as well as your original editorial, be printed in a separate leaflet and sent to the presidents and governing boards as well as teachers of chemistry throughout the United States.—E. P. SCHOCH, University of Texas, Austin, Texas.

Having the responsibility of providing a teaching staff for chemistry in the University of Pittsburgh, I fully appreciate the significance of your article. Five of the twelve regular members of our chemistry staff are at present in the service. A number of these would have remained at the University had it not been that they felt they would be called by the draft and could better serve the country by enlisting in the chemical service. At the time when our teaching staff was being depleted I wrote to various officials in Washington and suggested that our men be drafted in the regular fashion and detailed to instructional service in the University. This was during the early period of the war and the request met with no sympathetic response.

I am at present trying to secure three men for assistant professorships and one for an instructorship. While I may meet with success, I am afraid that the salaries offered by our institution will not be a sufficient inducement, though these are already far in excess of offers that we have made in past years. The University suffers from a reduction of available funds through the loss of a large number of students in the draft. It is necessary to pay good men from $3,000 to $5,000 per annum, and I believe it would be wise for the Government to subsidize this work in universities. Furthermore, I believe it would be well for the Government to detail men to instructional service, if necessary placing the chemistry students of our colleges and universities under the chemical warfare division of the War Department.

Uncle Sam already has several thousand draftees in the institutions of higher learning in this district. Why would it not be appropriate to commission members of a teaching staff and have them do the regular work in the chemistry department together with some of the instructional work necessary for the training of the draftees? We have very few students doing graduate work. It is the graduate student who will have to look after research problems in Government departments, industrial plants, and universities after the war. This branch of the "reserves" will determine our supremacy in the field of chemistry during the reconstruction period.

As chairman of the Employment Committee, Pittsburgh Section, American Chemical Society, I realize perhaps more than any other man in the district what the demand for chemists really is. I feel certain that there are not less than fifty openings in our own region which cannot be filled by competent men. Undergraduates are leaving us and going into industrial laboratories where they are entitled to industrial exemption. Such students should be told that they are to remain in educational institutions and strive for records sufficiently high to entitle them to deferred enlistment in the Chemical Warfare Service.

We have already utilized our laboratories to the greatest possible extent, running sections every morning and every afternoon. Our universities need greater facilities and I cannot

conceive a better plan than that of sending an official letter from the American Chemical Society to manufacturers in various districts, urging them to endow new laboratories and research funds in the institutions in their district.

I enclose a copy of a letter (not reprinted) which is being sent to every chemist in the Pittsburgh district and to all chemistry alumni of the University of Pittsburgh. This will show you what we are doing to help build up the chemical reserves.—ALEXANDER SILVERMAN, University of Pittsburgh, Pittsburgh, Pa.

I note your reference to the editorial which appeared in the July issue of the INDUSTRIAL JOURNAL. Any professional man who is interested in chemistry would have been stimulated by that article. I am now taking the opportunity to express certain views which appear to me very important and give you liberty to reconstruct them in a manner that is suitable to you in order to bring before the public the necessary information.

I think it well to remember that, no matter what view may be held as to the real value of our universities as a national asset, the young men who are graduates of these institutions are today the rulers of our country, its diplomats, its judges, its governors, lawyers, professors, scientists, and leaders in almost every branch of human thought and endeavor. There is no subject, therefore, in these serious times which deserves more immediate and earnest consideration than that of the maintenance and reconstruction of these institutions to meet the conditions that prevail at the present time.

The world has finally awakened to a realization of the real value of the fundamental sciences and it is the duty of our educational forces to see to it that our own nation takes full advantage of opportunities which are unique in the history of the world. What we need to-day, as never before, in order to take a prominent lead in the period of reconstruction are college trained men who have been taught to think for themselves. Such men are a valuable asset and it is our duty as university teachers to see to it that greater emphasis is laid upon educational methods which will lead to the greater production of this type of recruits or reserves.

Never before in the history of our country has the important and real value of the chemist been so appreciated as at the present time. The war has created an excessive demand for men of this profession and if we are to triumph successfully in the carrying out of principles to which we have dedicated ourselves, we shall need to organize immediately an educational program which will provide not only for the present, but also give serious consideration to the matter of specialized training in the natural sciences for the future. Under any circumstances the constructing of reserves from our raw material will be a slow and difficult process.

In the first place only about 2 per cent of our American youths of eighteen desire to go to college and, secondly, it takes time and patience to produce the right kind of finished product. Especially is this true with respect to the training of chemists. While the American youth is naturally resourceful, and has courage and intelligence of a high order, it does require special effort of enthusiastic and experienced teachers to develop in him that initiative that is absolutely essential before he, as a chemist, will ever make a success of his profession.

After this war is over and the reconstruction period commences, our industries will need technical assistance as never before and will be dependent to a large degree upon the product of our schools of chemistry and chemical engineering. Not only will attention be directed by manufacturers and capitalists to old industries which were successful before the war, but also to the establishing of new ones. Many such have already been brought to notice, including particularly those concerned with the manufacture of chemicals, drugs, dyes, metals, cements, etc. In all these developments well trained chemists will be needed in the organization of more efficient methods of manufacture and in designing better equipment for successfully carrying on chemical operations.

In the majority of gainful occupations success requires continuous and painstaking application of many years. There is no profession where this is more true than in that dealing with the application of chemistry to industrial problems. Therefore, it is essential that every means be provided whereby men can be kept in training to meet the exacting demands which necessarily will be made upon them in the future. How are we to provide these reserves and give the necessary instruction if we are not permitted to operate and continue with what we already have. It would be a sad mistake to curtail at the present time this educational work, and it is to be hoped that the Government in its educational policy will in every way provide means whereby we can retain in our training courses a maximum number of first-class reserves.—TREAT B. JOHNSON, Sheffield Scientific School, New Haven, Conn.

MELLON INSTITUTE

Your editorial expresses exactly my views and experience as Acting Director of the Mellon Institute of Industrial Research and Dean of the School of Chemistry of the University of Pittsburgh.

This terrible war has demonstrated that there exists for each large nation a certain number of vital industries which it cannot neglect without exposing itself to the danger of some day being at the mercy of its enemies. The nature of the problem changes. Scientific and technical instruction becomes necessary and this should be taken up by the universities of the country. Also life becomes more and more difficult even for the most prosperous nations such as ours, and the problem becomes singularly complicated when it is no longer simply a question of supplying a national market, largely open, but of entering into commercial competition from within and from without, with new industries strongly organized.

It becomes necessary then to have a large number of highly trained specialists to carry out this work, which means searching out the most rapid and most economical processes, allowing no loss of anything which represents any value. We can only hope to obtain this class of men from the universities that have a strong teaching staff, therefore, it is absolutely essential that the universities should be provided with the necessary men of ability, and in most cases they will not be able to compete for this class with the industries; therefore, they should receive assistance both from the industries and the Government if the best results are to be obtained for the future.—E. R. WEIDLEIN, Acting Director.

INDUSTRIALISTS

Your article "An Army without Reserves" should be submitted to the Secretary of War and to anybody who has anything to do with the draft. I hope that your warning may be heeded *before it is too late*.—L. H. BAEKELAND, Yonkers, N. Y.

I am, of course, in full sympathy with your desire to ensure that the forces of the country should be used in the most efficient manner and that we should not be misled by the fetish of numbers, putting every possible man in the army to the sacrifice of the specialists who must supply the support from the rear.—C. E. K. MEES, Eastman Kodak Co., Rochester, N. Y.

I am too busy repairing a fire damage to our plant to write in detail, but I am with you on the article, and I hope you can drive it home.—E. MALLINCKRODT, JR., Mallinckrodt Chemical Works, St. Louis, Mo.

The Panama Canal could not have been built in a hundred years were it not for the men at home building steam shovels, locomotives, dump cars, enormous dredges, and the other highly organized machinery necessary to the work. It would have been only a small job to have made picks, shovels and wheelbarrows at home, but the job at the Canal would have been so great under these circumstances that it would have taken many generations to complete it.

In all modern great undertakings machinery is becoming more and more a factor, and in the greatest test of power the world has ever known, now being made in Europe, the capacity of our plants at home when strained to the limit will be pitted against the utmost capacity of the corresponding plants of Germany and Austria, and the side that wins will give the men at the Front the same advantage that the man with machinery has over the man with more primitive equipment.—HERBERT H. DOW, The Dow Chemical Company, Midland, Mich.

The editorial is most timely and touches on one of the most vulnerable points in the situation of the chemical developments in this country.

The chemist is now an inseparable part of the machinery of war, but as important as his rôle is during these times it must be recognized that his services to the welfare of the country and to the industries cannot be underestimated when peace is finally established.

The new chemical industries that have developed in the United States during the last years must be continued as they are essential for our economic independence, and to maintain them successfully, among other conditions, we must be prepared with an army of trained chemists.

The importance of chemistry has been so thoroughly recognized that enrollment in the chemical courses at universities

and colleges is continually increasing and it needs no particular encouragement.

A competent staff of teachers is the most essential requirement. In consequence of inadequate compensation at the educational institutions many of the most able teachers have resigned for more lucrative industrial positions. As you suggest in the editorial, it is not only essential that teachers of chemistry be placed in the deferred list or assigned back to teaching by the Government, but it is also necessary that the educational institutions receive financial aid in order to make the position of the teacher more remunerative.

Uninterrupted progress of the chemical training of young men must be secured and means to this effect must be coördinated in an efficient system to obtain the substantial benefits which must accrue to this country in times to come.—GEORGE D. ROSENGARTEN, Philadelphia, Pa.

Your admirable and timely editorial sounds a warning which should be emphasized in every possible way. We have only to turn to Canada for an example of what may happen in this country if this warning is not heeded. After two or three years of war, the total number of students graduating in chemistry in the Dominion had fallen to eight for the year.

The situation which you define involves so many difficulties that its complete solution will make severe demands upon the coöperative effort of our educators and industrial leaders. Certain things may be done at once, however, to relieve the situation and to serve as initial steps toward the upbuilding of our chemical reserves. Corporations operating in the chemical industries have a unique opportunity to combine patriotism, altruism and self-interest by devoting a proportion of their war profits to the founding of adequately endowed chairs of chemistry. They can also do much in the factory itself to develop the latent capacities of subordinates on their chemical staff by the establishment of classes, reading courses and lectures, and by arranging the work of the factory in a series of graded jobs through which the younger chemists have opportunity to pass.

To relieve the situation in the universities, it should be possible to recall for temporary courses some of our older chemists of distinction, now retired. Possibly also some of the eminent teachers of chemistry now almost without pupils in Canada, could be persuaded to conduct courses for a time in our own universities and technical schools, which could at the same time extend their hospitality to Canadian students. I may even be permitted to suggest without in any way implying criticism, that some of our Government laboratories, and especially those devoted to war research, may possibly be over-manned, and that their working efficiency, which must first of all be maintained, might not be impaired by assigning a portion of their staff to teaching.—A. D. LITTLE, Cambridge, Mass.

Your well-timed article covers a subject to which I have given considerable thought from the manufacturer's standpoint.

There is no question but the present demand for chemical help in the army has curtailed laboratory forces in all directions. In some of our laboratories we are training young women to do the routine work, but that is not going to help us secure many chemists. We cannot follow out the practice of the past of securing promising young graduates from our universities and technical schools because the Government seems to have first mortgage on almost every one of them, and from present indications the next crop is going to be very small.

It has occurred to me that with the present scarcity of instructors the only sensible thing to do is to shut down as many of our smaller institutions as possible and combine the forces of instructors and professors in a few of our larger institutions and run them to their full capacity. In that way we can use our professors and instructors to better advantage than by having them scattered through many small institutions and be able to give better training to a much larger number of students than can be done in a multiplicity of smaller institutions with badly crippled faculties. I believe the matter is of sufficient importance to have special legislation, if possible, passed by Congress to see that the training of chemists is not interfered with by the draft,—it to be understood, however, that the Government has the first call on the services of chemists trained under these special conditions.

It certainly seems illogical for the Government to spend enormous sums in putting up vast chemical plants for the manufacture of explosives, poison gases, and other war materials, without making ample provision for the training of the men who are needed to manage and control these plants.—DAVID WESSON, The Southern Cotton Oil Co., New York City.

In Buffalo, on June 22, 1917, I started a discussion at the annual meeting of the American Institute of Chemical Engineers, and the Institute sent a long telegram to President Wilson asking the exemption of chemists, which speaks for itself. I had in mind that in the Fall of 1914 when we were still obtaining German journals, I noticed that among the casualties there were a large number of chemists, and after each name it simply stated "Hat den Helden-Tod erworben." In other words, it took one second to kill a man, but it took anywhere from four to ten years to make a chemist of him, and by January 1915, Germany withdrew all her scientific men from trench work. It took England about fifteen months to learn the same lesson, and even after the first gas attack at Ypres, England still kept her engineers and chemists in the front line trenches.

Now comes the appalling situation where the chemical instructors of the United States are leaving the colleges for Government and commercial work, and if this war keeps on, there will be no embryo chemists, for the students will have no professors. Something must be done, and done quickly, to alter the state of affairs.

You cannot expect a professor of chemistry to work for $3000 or $5000 per year when the industrial fields will pay him much more than that, and there is at least an outlook for the future. I have in mind the case of one institution in the city of New York, where the head professor of chemistry has been receiving about $5000 per year for the last twenty years, and if it were not for the fact that all his spare moments are put in on commercial work, he could not succeed in bringing up his family with anything like the station to which they are entitled, and this brings to my mind the oft mooted question which nobody has ever answered satisfactorily to me: "Is a college an altruistic institution, or is it a business institution?" The nearest answer I ever got to it was given by the president of one of our very large universities, who said a university was a little of both, which to my mind is the equivalent to the answer that it is "neither flesh nor fowl." If a college is an altruistic institution, then it must not practice its altruism at the expense of underpaid professors, and if it is a business institution, I should say it is very badly managed, if the brilliant heads of its departments must seek outside work in order to make both ends meet. I know of one man who for the last fifteen years has given very liberally of his money and his time to at least three institutions of learning in order to help the department of chemistry, and of course, if a large number of men did this, it might solve the problem partially because poor students could do post graduate work at the expense of successful manufacturers. But that will not mend the trouble, as I see it. The first thing that ought to be done is to conduct the chemical departments on a business basis, and if quite a number of nonessential studies were eliminated, it would give more money to the college so the professors could receive higher pay. The second thing that would help the matter, but it would only tide it over temporarily, is for a number of institutions, instead of establishing fellowships entirely, to establish them partially, and give to the professors who have charge of the fellows a little share of the money, for after all, no fellow in science could do much without the guiding hand, and the guiding hand should at least obtain a part of the subsidy. The third remedy would be in putting a number of our institutions on a business basis by having some active business men take a hand in the affairs of the management, and provide additional funds.

Something, of course, must be done. A committee from the American Chemical Society, the Electrochemical Society, The American Institute of Chemical Engineers and the Chemists' Club would make an imposing body, whose advice would carry weight.—MAXIMILIAN TOCH, Toch Brothers, New York City.

I doubt if I can add anything to what has been suggested at least in your editorial. Even if the machinery were intact and in good working order a difficulty is met with—the raw material.

Raw material must be taken as we find it. Chemists cannot be manufactured from imperfect material. The qualities which are necessary are present when the training begins but cannot be discovered until later, and therefore teachers of judgment and experience are necessary, for the right material is limited.

I think perhaps that all teachers of draft age should be placed in the Service, assigned to the various institutions and paid by the Government. No teacher should be encouraged to enter the army voluntarily unless with the understanding he might be assigned to educational work at the discretion of the authorities.

Industrial institutions might be encouraged to use educators as consultants, the privilege being subject to the approval of the governing school body.

Boys of draft age, majoring in chemistry, should be put in uniform and should be kept at school as long as their standing is satisfactory, otherwise they should be put into service in some active capacity.

Chemists in industrial occupations, where the vicinity of educational institutions permitted, should be selected by the faculties of such institutions for part time educational work, this being voluntary or paid for as seemed necessary or advisable.

Technical laboratories are not at present used by the Government to such extent as is possible for solving problems of a technical nature, research or inspection. Inspection and other technical work of the various war departments might be coördinated to a greater extent, thus economizing ability and personnel.

Many chemists, equipped with experience, ability and training, discretion and loyalty, are anxious to be employed part time, at least, on Government problems, or to aid the cause in some way, if they but knew what the problem or other work was. If this force could be put to work, economy of ability and personnel would also result. To give time to build up our reserves, we must relieve the pressure as much as possible by fully utilizing our present capacity.

Perhaps our colleges and universities have been too heavily drawn upon, I sometimes think so at least, and the practicing technologist has not been utilized to the extent of his possibilities. It will certainly be a pity if the country finds itself overstocked by and by with mediocre chemists. It would be better to have trained fewer men thoroughly.

There are, no doubt, many women available at least as laboratory assistants and there is no good reason why girls should not be educated as chemists as well as boys, though it may not be fashionable to recognize the fact and to make allowances uhtil the novelty of their employment wears off.—Wm. Hoskins, Chicago, Ill.

In my estimation it is much harder for a chemist to stay out of a uniform than to get into a uniform. The man who gets into a uniform is right away considered a hero who is doing his part for his country, while the man who does not enter the uniform is easily looked upon as a slacker, whereas in reality he is in many cases doing much more vital work and accomplishes much more important work, due to the fact that he is not tied down by military red tape.

My impression is that many college professors, shortly after we entered the war and when Washington began to realize the importance of chemistry, were carried away by their patriotic enthusiasm and with one of the human weaknesses that is so apparent in everybody—the desire to do something he is not doing and feeling that he could do more if he were just doing something else from what he is doing at present. These professors, and there are many of them all over the country, dropped their work suddenly and disappeared in the maelstrom of khaki clad men. The result is that the chemical faculties have disintegrated. In some cases, I have been told, record registration to the chemical department has taken place, and no teachers to teach the students—a condition which is hurtful if not fatal to our future chemical developments; and in many cases there is immediate need of chemical skill in large chemical industries.

As I can see it, there are two principal ways by which this lack of teachers at the universities can be overcome.

Many of the college professors, after the first exhilaration of appearing in khaki uniform has worn off, have found themselves, I am sure, mentally circumscribed; and they have had assigned to them problems which are not congenial to them and have found conditions of work which are exceedingly unsatisfactory; and if a general order was issued by the War Department, suggesting that professors could be assigned back to their universities if they so desired, many of these would certainly avail themselves, I believe, of this opportunity. It would not take them out of the immediate field of research, which should continue. They only transfer their activities from the present location to their universities. A suitable number of assistants from the Army could be assigned to them and the professors would turn out better and quicker work, due to the fact that they were in home and congenial surroundings.

The equipment necessary for the work has to be assembled in the new laboratories created, while in the university laboratories, the equipment may already be in and standing idle. Consequently the using of same would be the saving of both time and money.

A professor would be able to guide his students and give them the instruction necessary, without materially interfering with the work he is doing for the Government.

Again, the industries hold in their personnel a very strong factor in the development of the new generations of chemists which have to be reared. In these days of coöperation and in these days when we are planning for the time after the war, there is no doubt in my mind but that men in practical chemical work would be pleased to coöperate with the universities in such a way that they would be willing to give a series of lectures covering the special field of activity they may be interested in. As an example, men in the sugar industry would be pleased to give a series of lectures on sugar manufacture, accompanied by a visit, in some cases, to a sugar refinery. In other cases, an expert along sulfuric acid lines would be glad to do the same thing, and so on. The result would be that the students would obtain a vastly superior industrial chemical instruction than they could possibly get through their college professors, who in most cases never have had any practical experience in the operation of any of these plants.

We might not develop in this way the best theoretical chemists (and they are badly needed, too) but we would at least develop a chemical embryo which has good, common-sense chemical knowledge; and from what I learn, the industries are to-day clamoring for men who have good, common-sense chemical knowledge that makes it safe to place them out in the operating departments of the industries.

It was, I believe, a short-sighted policy on the part of the Government to permit the large number of college professors to enter the uniform early in the war; and I think the reassignment of men with their chemical problems to work out to their universities will help us to train a chemical field army which is absolutely essential if we want to hold our place in the chemical industries after the war.—John Woods Beckman, Berkeley, California.

EFFECT OF THE WAR ON AMERICAN CHEMICAL TRADE

By O. P. Hopkins, Washington, D. C.

Four years of war have wrought tremendous changes in American foreign trade. Shipments of foodstuffs and munitions to Europe and increased sales of manufactured articles to countries cut off from accustomed European supplies have raised export totals from 2,330 million dollars in the fiscal year 1914 to 5,928 million dollars in 1918. A most thorough scouring of the whole world for raw materials, on the other hand, has increased the value of imports from 1,894 millions in 1914 to 2,046 millions in 1918.

The increase in exports is 154 per cent; in imports, 55 per cent.

For imports, 1918 was the peak year, but for exports the total for last year was 362 millions below that of 1917, the loss of Russia's markets and the rationing of European neutrals accounting for the drop.

The changes wrought in America's chemical trade by the war are quite as astounding as in any other line. The Allies would have been much harder pressed much earlier in the war had it not been for the American chemist. Explosives and explosive materials have gone over in enormous quantities. To other markets, lying outside the fighting zone for the most part, have gone the finer chemical products that formerly were more frequently imported from Europe than from America. To other markets also have gone increasingly great quantities of such allied products as paper and glass, foreign trade in which was not well developed by American manufacturers before the war started. Some increases in sales of heavy chemicals are to be noted in districts outside of Europe, but this trade is limited by the fact that such districts are not largely industrial.

To give an approximate idea of how the war has affected trade in the various chemical branches a summary table has been especially compiled, revealing

a jump in imports from about half a billion dollars in the last normal year to somewhat more than a billion dollars in 1918, and a leap in exports from half a billion to a billion and a half. The increase in imports is attributable mainly to heavy purchases of rubber, copper, and mineral and vegetable oils, as will be shown in later tables. The most spectacular gain in exports is, naturally, in explosives, the increase being from a mere 6 million to no less than 379 million dollars. This class is followed by metals, principally copper, by oils, principally mineral, and by heavy chemicals, principally explosive materials. These are the showy headliners. From the point of view of future foreign trade, however, some of the less showy results are quite as interesting, such as the gains in exports of drugs and medicines, paints, and paper, which have been achieved in markets formerly dominated by European competitors.

The summary table follows:

SUMMARY OF FOREIGN TRADE IN CHEMICALS AND ALLIED PRODUCTS

CLASSES	IMPORTS 1914 Million Dollars	IMPORTS 1918 Million Dollars	EXPORTS 1914 Million Dollars	EXPORTS 1918 Million Dollars
Chemicals	61	97	15	129
Drugs, medicines, etc	9	11	11	21
Dyes, dyestuffs, dyewoods	10	9	(a)	17
Explosives	1	8	6	379
Fertilizers	28	5	12	6
Gums, resins, etc	88	227	20	11
Metals, ores, earths	132	286	175	327
Oils, fats, waxes	79	200	194	378
Paints, pigments, etc	2	1	7	17
Tanning materials	5	7	1	4
Paper and pulp	30	66	6	30
Miscellaneous products	120	253	44	132
Miscellaneous materials	8	6	2	3
TOTAL	573	1176	493	1454

(a) $400,000.

These are rough groupings, as such groupings are bound to be, but will serve the present purpose. A definite idea of the articles included in each group can be obtained by a study of the detailed tables occurring later in the article. No perfectly satisfactory grouping can be devised. As an illustration, the official statistics include under fertilizers only such materials as are used exclusively for fertilizing. Sodium nitrate, therefore, goes under chemicals, although the total for fertilizers is misleading without it. It is also puzzling to decide what manufactures should be included as allied chemical products. The foregoing table includes in the total some lines that might for one reason or another have been omitted, and excludes others that might have been considered. The importance of the item "Miscellaneous products" is due to the inclusion of sugar.

A clear enough idea of the changes wrought in our chemical trade by the war can be obtained from the detailed analyses of each class that follows. The statistics are compiled from official bulletins issued by the Bureau of Foreign and Domestic Commerce, and cover the fiscal years ended June 30, 1914 and 1918; that is, the last normal year before the war and the fiscal year just closed.

CHEMICALS

Of all the imports under the heading "Chemicals" the most valuable is nitrate of soda, the only important source of which is Chile. Purchases of this material tripled in quantity in 1918 as compared with 1914, while the value was quadrupled. It is Chile's most vital contribution to Allied success. The practical cessation of imports of chloride of lime is an interesting feature. England formerly supplied about three-fourths of the total, Germany being the other important source. Creosote oil also shows a heavy falling off. It was imported from the same sources as was the chloride of lime, in about the same proportions. The drop in the receipts of magnesite is explained by the fact that it came principally from Austria-Hungary. The falling off of 14 million pounds in receipts of nonfertilizer potash needs no comment. A study of the following table will disclose further details as to the import trade in chemicals:

IMPORTS OF CHEMICALS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Acids:				
Carbolic, lbs	8,392,995	$ 532,211	127,574	$ 11,198
Carbolic (phenol), lbs	.....	.....	498,264	58,314
Oxalic, lbs	8,507,850	420,409	792,383	327,785
All other	.....	261,106	.....	1,847,691
Ammonia, muriate, lbs	9,176,729	465,429	1,120,074	103,334
Argols, lbs	29,793,911	3,228,674	30,267,388	5,443,628
Coal tar and pitch, bbls	.....	.....	25,540	47,645
Coal-tar distillates, N. E. S. (a)	.....	1,126,400	.....	510,941
Creosote oil, gals	60,900,435	3,839,062	3,857,869	329,846
Fusel oil, lbs	5,802,369	910,759	1,606,528	346,589
Lactarene, lbs	10,798,614	705,264	12,133,855	1,765,653
Lime, chloride, lbs	47,423,651	416,740	4,285	184
Lime, citrate, lbs	3,097,265	493,738	4,253,686	879,199
Magnesite, not purified, lbs	289,494,316	1,473,207	23,499,789	549,727
Potash (not for fertilizers):				
Carbonate of, lbs	20,603,593	614,926	14,468,211	3,166,043
Cyanide of, lbs	808,721	113,199	144,225	48,323
Hydrate of (containing not more than 15% of caustic soda), lbs	8,450,402	326,668	11,732	4,398
Nitrate of, lbs	3,546,580	115,344	8,820,367	955,018
All other salts of	5,775,588	537,592	1,662,153	803,627
Soda:				
Cyanide, lbs	.....	.....	84,652	39,405
Nitrate, tons	564,049	17,950,786	1,607,020	70,129,026
All other salts of	.....	487,038	.....	389,384
Sulfur, or brimstone, tons	19,389	355,450	282	8,677
All other (b)	.....	8,000,000	.....	9,000,000

(a) Not elsewhere specified.

(b) Includes all other chemicals, drugs, dyes, and medicines than those mentioned in this article.

Less than half a million dollars' worth of acids was exported from this country before the war; in 1918 more than 35 million dollars' worth of picric acid alone was sent abroad. This, of course, is a war business. The big increase in the sales of soda preparations, as shown in the next table, may, on the contrary, be attributed to a wide distribution in markets that formerly were supplied from Europe. Fine beginnings of a trade in coal-tar products are indicated in the exports of "Coal-tar products, N. E. S.," which includes such products as are "not elsewhere specified." (Coal-tar dyes will be found under the section of this article headed "Dyes, dyestuffs, and dyewoods.") The destination of the copper sulfate in 1918 is not yet available. In 1917 France was the principal purchaser, while in 1916 Greece and Spain took the bulk of the shipments. The comparatively heavy shipments of acetate of lime in 1914 went chiefly to Germany, Belgium, and the Netherlands. The export trade in chloride of lime is new, but the destination will not be known until more detailed figures are available. Table of exports follows:

EXPORTS OF CHEMICALS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Acids:				
Carbolic, lbs.	(a)	(a)	8,688,554	$4,236,288
Nitric, lbs.	.....	.....	961,494	101,040
Picric, lbs.	.....	.....	56,193,952	35,387,010
Sulfuric, lbs.	12,131,750	$ 125,892	67,654,722	1,119,907
All other	.....	357,038	.....	5,623,707
Alcohol, wood, gals.	1,598,776	652,486	2,538,001	2,070,026
Calcium carbide, lbs.	32,845,649	962,040	28,869,686	1,328,437
Coal-tar, bbls.	22,130	43,148	53,935	147,765
Coal-tar distillates, N. E. S.:				
Benzol, lbs.	.....	.....	25,400,852	2,152,315
All other	.....	.....	.....	5,620,851
Copper, sulfate, lbs.	7,375,775	330,007	15,164,078	1,431,262
Lime, acetate, lbs.	68,160,224	1,560,933	15,490,032	797,996
Lime, chloride, lbs.	.....	.....	13,060,401	588,066
Potash:				
Chlorate, lbs.	.....	.....	1,564,662	681,128
All other salts of	.....	.....	.....	961,989
Soda:				
Caustic, lbs.	.....	.....	134,729,691	8,629,086
Sal soda, lbs.	.....	.....	14,076,264	205,489
Silicate, lbs.	.....	.....	26,127,870	375,110
Soda ash, lbs.	.....	.....	198,902,457	6,074,879
All other salts of	.....	.....	.....	7,421,521
Sulfur, or brimstone, tons	110,022	2,018,724	140,525	3,842,904
All other (b)	.....	9,000,000	.....	40,000,000

(a) Some items in this table were not given separately in the official statistics for 1914, as the trade was not then important enough for particularization.

(b) Includes all other chemicals, drugs, dyes, and medicines than those mentioned in this article.

DRUGS, MEDICINES, PERFUMERIES, ETC.

The most interesting developments in the foreign trade in lines included under this broad head are the decreased receipts of licorice root as the result of Turkey's stand in the war, the increased sale abroad of American medicinal preparations, the exportation of more perfumery and cosmetics than was imported, the development of a foreign business in infants' food, and the increase in prices. The persistence of the Chinese demand for ginseng and the willingness of Americans to meet it in spite of the questionable exploitation methods a few years back, are interesting points. The grouping in the following table is arbitrary but convenient:

IMPORTS AND EXPORTS OF DRUGS, MEDICINES, PERFUMERIES, ETC.

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Arsenic and sulfide of, lbs.	4,432,793	$ 178,388	9,260,768	$ 804,889
Cinchona bark and products	.....	.....	.....	.....
Barks, cinchona, or other, from which quinine may be extracted, lbs.	3,648,868	464,412	3,273,628	810,775
Quinia, sulfate of, and all alkaloids or salts of cinchona bark, oz.	2,879,466	624,125	1,445,702	656,945
Iodine, crude or resublimed, lbs.	195,087	433,498	268,281	580,538
Licorice root, lbs.	115,636,131	2,047,182	26,982,932	1,853,927
Medicinal preparations	.....	1,031,054	.....	519,558
Opium, 9% or more morphia, lbs.	455,200	1,810,429	157,834	2,443,228
Perfumeries, cosmetics, etc	.....	2,309,027	.....	3,497,695
Exports				
Formaldehyde	(a)	(a)	.....	866,038
Infants' food	(a)	(a)	.....	1,908,141
Medicinal and pharmaceutical preparations	.....	6,721,928 (b)	.....	10,190,188
Petroleum jelly	.....	661,889	.....	1,278,658
Roots, herbs, barks:				
Ginseng	224,605	1,832,686	289,892	1,717,548
All other	.....	513,071	.....	784,514
Perfumeries, cosmetics, etc	.....	1,620,872	.....	3,965,465

(a) Not stated separately in 1914.

(b) Stated as "medicines, patent or proprietary" in 1914.

DYES, DYESTUFFS, AND DYEWOODS

The establishment of an American dye industry as the result of shutting off German supplies has received more attention in the public prints than any other development in the chemical industry, and, making due allowance for the exaggerations of sensational writers, the general impression gained by the man in the street is not far wrong; namely, that whereas formerly we depended almost entirely upon Germany for dyes, now we are supplying our own needs and exporting more than we formerly imported.

The following table shows that in 1914 we imported about 10 million dollars' worth of dyes, dyestuffs, and dyewoods, but also reveals the surprising information that in 1918 imports still amounted to 9 million dollars. A second glance, however, will show that increased prices account for this puzzling fact. For instance, nearly three times as much indigo was imported in 1914 as in 1918, yet the total value was only about a fourth of what it was last year. The small consignment of dyes recorded as coming from Germany in 1918 was probably a batch ordered before we entered the war and held up through some technicality or other in some neutral country.

That exports have increased from less than half a million dollars' worth in 1914 to nearly 17 million dollars' worth in 1918 is the outstanding fact that has given so much satisfaction to the American public in general and the chemist in particular. It is the fact that shows that the industry has delivered.

Thanks to a new feature in the official statistics, the destination of the dye exports is now ascertainable. Japan led in imports of our dyes in 1918 with a total of more than 3 millions, followed by the United Kingdom, India, France, Canada, Brazil, and Italy, in the order named.

The following table shows details of both imports and exports, so far as they are available:

FOREIGN TRADE IN DYES, DYESTUFFS, AND DYEWOODS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Alizarin and alizarin dyes, lbs.	2,633,414	$ 845,459	329,323	$ 130,722
Aniline salts, lbs.	3,184,467	222,728	21,273	3,250
Indigo, lbs.	8,125,211	1,093,226	3,126,497	3,895,114
Natural, lbs.	.....	.....	2,113,912	3,276,557
Synthetic, lbs.	.....	.....	1,012,585	618,557
Colors and dyes, N. E. S.	.....	7,241,406	.....	2,507,296
From Germany	.....	5,965,537	.....	3,048
Switzerland	.....	767,783	.....	1,675,609
United Kingdom	.....	239,480	.....	589,758
Other countries	.....	268,606	.....	268,881
Dyewoods, crude state:				
Logwood, tons	30,062	378,064	52,027	1,066,455
All other, tons	7,663	108,928	35,449	951,667
Exports				
Aniline dyes	.....	.....	.....	7,298,298
Logwood extract	.....	.....	.....	2,339,480
All other	.....	.....	.....	7,284,110
Total	.....	356,919	.....	16,921,888
To—France	.....	.....	.....	1,630,131
Italy	.....	.....	.....	1,181,931
Russia	.....	.....	.....	142,156
Spain	.....	.....	.....	785,618
United Kingdom	.....	.....	.....	2,569,298
Canada	.....	.....	.....	1,419,162
Mexico	.....	.....	.....	381,488
Argentina	.....	.....	.....	503,092
Brazil	.....	.....	.....	1,281,758
British India	.....	.....	.....	1,947,668
Japan	.....	.....	.....	3,233,333
Other countries	.....	.....	.....	1,846,233

EXPLOSIVES

Increased exports of explosives are perhaps the most spectacular feature of our war trade. Sales to our associates in the war amounted to almost 379 millions in 1918, as contrasted with total foreign sales of about 6 millions in 1914. The total for 1918 is the highest since the war started, showing our ability to provide for our own needs without interfering with supplies to the Allies. It should be borne in mind

that shipments to our expeditionary force are not entered in our official export returns.

Imports of explosives also show a big percentage of increase, but the total involved is not large. These imports originate in Canada.

Such details as are available are shown in the following table:

FOREIGN TRADE IN EXPLOSIVES

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Fulminates, gunpowder, etc.	.....	$ 256,379(a)	.....	$ 7,860,139
All other	.....	600,958	.....	437,010
TOTAL	.....	857,337	.....	8,297,149
Exports				
Cartridges, loaded	.....	3,521,533	.....	13,672,371
Dynamite, lbs.	14,464,601	1,587,184	18,911,668	4,991,508
Fuses	(a)	(a)	.....	19,346,554
Gunpowder, lbs.	989,385	247,200	340,516,883	262,201,813
Shells and projectiles, loaded	(a)	(a)	.....	40,130,298
All other	.....	916,280	.....	38,559,249
TOTAL	.....	6,272,197	.....	378,901,793

(a) Not stated separately in 1914.

FERTILIZERS

Imports and exports of fertilizers both show a big falling off according to official figures, but it will be noticed that the group as given in the following table does not include sodium nitrate, which, because it is not used exclusively as a fertilizer, is included under "Chemicals."

The falling off of potash imports is the serious fact made plain in the table, for while good work has been done in developing a domestic industry, it is nevertheless true that the foreign potash is missed.

Exports of phosphate rock to Europe fell off immediately after the war started and have not been resumed on the old scale, although Spain has continued to make purchases on something like the scale of pre-war times. Of the total exports for 1918, four-fifths are included under the heading "All other fertilizers," and there is no way of throwing any further light upon the subject at present.

Both imports and exports of fertilizers are shown in the following table:

FOREIGN TRADE IN FERTILIZERS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Ammonia, sulfate, tons	83,377	$4,888,563	3,983	$ 467,999
Bone dust, ash, and meal, tons	41,450	1,034,636	8,511	286,764
Guano, tons	21,887	755,833	10,096	287,446
Kainit, tons	541,846	2,554,567	...	.....
Manure salts, tons	261,342	2,767,241	190	8,872
Potash, N. E. S.:				
Muriate of, tons	237,886	7,915,523	723	195,154
Sulfate of, tons	45,139	1,897,740	135	19,837
All other substances used only as fertilizers	.....	6,199,554	...	4,089,989
TOTAL	.....	28,013,657	...	5,356,061
Exports				
Phosphate rock:				
High-grade hard rock, tons	475,335	4,753,350	25,652	217,650
Land pebble, tons	1,000,630	5,857,969	110,909	456,383
All other, tons	1,906	6,516	25,798	336,880
Superphosphates, tons	.....	.....	6,155	202,268
All other fertilizers, tons	61,601	1,360,903	84,410	4,626,958
TOTAL TONS	1,539,472	11,978,738	252,924	5,840,139

GUMS, RESINS, ETC.

Increased imports of India rubber are the most noteworthy feature of the trade in this class of materials since the war started, the total receipts jumping from 132 million pounds in 1914 to 390 million pounds in 1918. The increase in direct imports from the East Indies is remarkable and is an encouraging circumstance. The tendency to import raw materials directly from the original source instead of through European middlemen will probably be an important factor in after-the-war trade. It is an interesting fact that although the quantity of rubber imported from Brazil has increased slightly the total value has decreased. The importation of varnish gums and of camphor has apparently not been affected materially by the war.

Imports are shown in the following table:

IMPORTS OF GUMS AND RESINS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Camphor:				
Crude natural, lbs.	3,476,908	$ 929,715	3,638,384	$ 1,451,050
Refined and synthetic, lbs.	566,106	182,790	1,189,932	819,431
Chicle, lbs.	8,040,891	3,012,458	6,408,093	3,454,193
Copal, kauri, damar, lbs.	32,693,412	3,354,679	30,003,549	2,868,863
Gambier, lbs.	14,936,129	571,067	8,964,832	955,352
India rubber, gutta-percha, etc.:				
Balata, lbs.	1,533,024	793,126	2,449,881	1,278,610
Guayule gum, lbs.	1,475,804	607,076	4,307,539	1,341,095
Gutta joolatong, lbs.	24,926,571	1,155,402	17,475,863	975,816
Gutta-percha, lbs.	1,846,109	323,567	1,151,312	147,323
India rubber, lbs.	131,995,742	71,219,851	389,599,015	202,800,392
From Belgium	11,005,246	6,481,901	.....	.....
France	2,629,287	1,124,629	508,017	225,803
Germany	7,052,767	3,595,369	.....	.....
Netherlands	2,016,440	1,134,060	.....	.....
Portugal	556,560	176,687	538,076	220,133
United Kingdom	48,279,674	31,152,336	21,926,945	12,793,606
Central America	565,487	297,849	736,014	287,247
Mexico	640,448	333,327	1,033,087	451,915
Brazil	40,641,305	16,319,048	41,277,914	14,307,158
Peru	1,016,566	427,002	3,565,094	1,471,823
Other South America	828,856	379,886	3,182,605	1,299,351
British East Indies	16,597,105	9,675,709	258,245,724	138,324,996
Dutch East Indies	.....	.....	53,663,857	30,504,525
Other countries	166,001	121,048	4,921,682	2,913,835
India rubber scrap, lbs.	25,958,261	2,063,198	13,980,303	1,019,222
Shellac, lbs.	16,719,756	2,689,269	22,913,256	9,514,651

America's export trade in the class of gums and resins is confined to the items included under the heading "Naval stores," and foreign sales in this line have been cut nearly in half as a result of the war. This is to be accounted for by the fact that some of the best customers under ordinary circumstances have been entirely cut off and by the fact that the

EXPORTS OF NAVAL STORES

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Naval stores:				
Rosin, bbls.	2,417,950	$11,217,316	1,073,889	$7,876,718
To Austria-Hungary	68,158	284,715	.....	.....
Belgium	111,735	463,464	.....	.....
France	128	726	.....	.....
Germany	799,185	3,465,723	.....	.....
Italy	109,380	508,648	10,056	63,570
Netherlands	247,339	1,058,963	.....	.....
Norway	2,409	12,490	.....	.....
Russia	144,653	584,076	.....	.....
Sweden	180	980	.....	.....
United Kingdom	504,400	2,310,373	274,976	2,021,339
Canada	77,064	471,511	132,070	876,077
Cuba	24,032	127,886	34,455	223,349
Argentina	102,028	506,260	149,536	1,068,153
Brazil	99,632	687,480	158,824	1,169,447
Uruguay	18,982	106,295	23,041	181,798
Dutch East Indies	2,252	13,092	27,628	233,092
Japan	14,413	94,004	103,081	843,663
Australia	61,682	366,561	72,284	561,926
Other countries	30,278	154,069	87,884	634,304
Tar, turpentine, and pitch, bbls.	351,352	568,891	82,030	598,211
Turpentine, spirits of, gals.	18,900,704	8,095,958	5,100,124	2,697,305
To Austria-Hungary	7,650	3,300	.....	.....
Belgium	1,027,355	420,595	.....	.....
France	490	215	.....	.....
Germany	3,275,929	1,368,616	.....	.....
Netherlands	4,393,902	1,870,304	.....	.....
United Kingdom	7,109,851	2,930,870	1,413,732	659,989
Canada	1,114,863	488,138	978,125	424,520
Argentina	512,544	271,000	321,797	186,661
Brazil	301,912	154,398	222,339	139,851
Australia	499,248	249,935	851,328	528,428
Other countries	657,060	338,997	1,312,803	757,856
TOTAL NAVAL STORES	.....	19,882,165	.....	11,172,234

belligerents that still have access to supplies do not need the quantities formerly purchased. Sales to neutrals outside of Europe and to non-participating associates of the Allies have increased to some extent, as will be seen by examining the preceding table.

METALS, ORES, EARTHS, ETC.

Copper is the principal item in both imports and exports of metals, and purchases and sales of that essential have increased wonderfully since the war started. Imports have jumped in value from about 55 millions to more than 122 millions, the augmented supplies coming largely from Latin-American sources. Exports have increased in the meantime from 149 to 244 millions as the result of war demands in Europe.

Tin imports have more than doubled, totaling 85 millions in value in 1918. The importation of 10 million dollars' worth of Bolivian ore for smelting in the United States indicates the importance of one of our newest industries. There have been increased importations of all the important metals except iron.

Aside from copper, the only important increases in metal exports are recorded for iron and lead. A summary of the foreign trade in the important metals is contained in the following table, which relates only to metals in the form of ore, concentrates, pigs, bars, etc.:

SUMMARY OF TRADE IN PRINCIPAL METALS

ARTICLES	1914	1918
Imports		
Antimony	$ 696,000	$ 4,435,000
Chromate of iron	737,000	1,543,000
Copper	54,506,000	122,450,000
Iron	11,879,000	9,652,000
Lead	2,057,000	11,970,000
Manganese	1,841,000	11,948,000
Nickel	6,110,000	9,120,000
Platinum	3,976,000	4,575,000
Tin	39,422,000	84,834,000
Tungsten-bearing ore	114,000	5,794,000
Zinc	616,000	2,560,000
Exports		
Aluminum	1,102,000	8,746,000
Bauxite concentrates	616,000	1,465,000
Copper	149,480,000	244,328,000
Ferrovanadium	503,000	2,578,000
Iron	6,261,000	20,579,000
Lead	2,610,000	17,376,000
Nickel	9,404,000	7,681,000
Tungsten and ferrotungsten	.....	4,056,000
Zinc	995,000	19,193,000

IMPORTS OF METALS, ORES, EARTHS, ETC.

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
METALS AND ORES:				
Antimony:				
Ore, regulus, or metal (antimony content), lbs.	2,664,425(a)	$ 145,917(a)	.....	.....
Ore, gross tons	555 (b)		5,280	
Ore, antimony, lbs.	865,565 (b)	24,121(b)	6,526,292	$ 495,953
Matte, regulus, or metal, lbs.	9,633,639(b)	526,324(b)	33,934,515	3,939,174
Cobalt and ore, and zaffer, lbs.	197,009	115,038	161,705	306,310
Chromate of iron, tons	78,842	737,127	77,781	1,542,761
Copper:				
Ore, gross tons	444,907		377,124	
Ore, copper, lbs.	87,588,730	10,137,244	104,691,803	18,318,781
Concentrates, gross tons	(c)	(c)	160,998	
Concentrates, copper, lbs.	(c)	(c)	39,093,081	9,492,501
Matte, regulus, etc., gross tons	33,772		21,658	
Matte, regulus, etc., copper, lbs.	24,682,744	3,559,740	22,869,596	5,279,976
Pigs, bars, etc., lbs.	281,536,836	40,624,598	362,494,391	89,221,607
All other	.....	184,672	.....	136,927
Iron:				
Ore, tons	2,167,662	6,984,577	837,546	3,116,109
Pig, tons	136,444	4,894,201	54,776	6,535,525
Iridium, osmium, palladium, etc., and native combinations thereof with platinum, etc., oz. troy	2,960	207,832	4,759	488,596
Lead:				
Ore, gross tons	55,807		93,322	
Ore, lead, lbs.	23,127,210	740,058	39,054,690	2,098,045
Bullion, gross lbs.	37,795,279		158,509,646	
Bullion, lead, lbs.	37,059,518	1,247,567	149,575,356	8,719,554
Pigs, bars, and old, lbs.	236,691	9,002	19,082,922	1,138,757
All other	.....	60,849	.....	13,841
Manganese oxide and ore, tons	288,706	1,841,451	558,018	11,944,515
Monazite sand and thorite, lbs.	1,002,300	52,329	4,975,975	329,711
Nickel ore and matte, gross tons	36,420		58,776	
Nickel ore and matte, nickel, lbs.	43,549,303	6,109,547	73,095,770	9,120,269
Platinum:				.....
Unmanufactured, oz. troy	40,634	1,489,208	48,745	4,308,518
Ingots, bars, etc., oz. troy	54,189	2,404,364	3,117	264,096
Retorts, etc., for chemical use	.....	82,000	.....	2,547
Sulfur ore as pyrites, over 25% sulfur, tons	832,134	3,695,335	810,075	4,522,335
From—Spain	638,711	2,966,682	596,583	3,709,368
Canada	79,141	312,575	205,163	765,429
Other countries	114,282	416,078	8,329	47,538
Tin:				
Ore, tons	.....	.....	14,816	10,291,261
Bars, pigs, etc., lbs.	100,177,962	39,422,479	136,519,310	74,543,006
Tungsten-bearing ore, tons	187	113,534	5,646	5,793,698
Zinc:				
Ore and calamine, gross tons	18,280		102,234	
Ore and calamine, zinc, lbs.	14,484,802	251,479	78,770,011	2,499,468
Pigs and old, lbs.	2,145,089	90,481	303,505	15,289
Dust, lbs.	4,807,664	223,010	407,546	44,625
All other	.....	50,981	.....	564
CLAYS, EARTHS, ETC.:				
Cement:				
Portland, Roman, etc., 100 lbs.	364,141	160,737	8,426	6,020
All other	.....	82,819	.....	30,682
Chalk:				
Unmanufactured, tons	128,842	102,907	107,391	122,592
Ground, etc.	.....	53,618	.....	42,822
Clays or earths:				
China, or kaolin, tons	238,802	1,577,747	194,225	1,322,603
Blue, and bauxite, tons	33,041	228,207	2,292	11,649
All other, tons	73,576	440,853	37,553	316,407
Fluorspar, tons	13,655	50,851	10,935	117,279
Gypsum, crude, tons	416,599	482,529	151,415	256,294
Mica:				
Unmanufactured, lbs.	1,611,207	524,454	706,706	543,289
Cut, split, manufactured	.....	312,361	.....	998,460
Plumbago, tons	24,868	1,846,126	25,825	6,127,887
Talc, ground or prepared, lbs.	29,537,111	148,523	27,425,987	265,979
Minerals, crude, n. e. s.	.....	271,882	.....	1,232,613

(a) Covers period from July 1 to October 3, inclusive.
(b) Covers period from October 4 to June 30, inclusive.
(c) Not stated separately in 1914.

Further details as to the imports will be found in the foregoing table, which also includes, as a matter of convenience, such items as cement, chalk, clays, plumbago, and talc. Imports of these latter articles are not comparatively important.

Exports of metals, ores, cement, clays, etc., are shown in detail in the table that follows:

EXPORTS OF METALS, ORES, EARTHS, ETC.

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
METALS AND ORES:				
Aluminum, ingots, etc., lbs.	.....	$ 1,101,920	21,256,641	$ 8,746,451
Copper:				
Ore, matte, regulus, tons	77,410	3,257,080	.....	.....
Ore, tons	.....	.....	51,545	984,709
Concentrates, matte, regulus, tons	.....	.....	4,376	216,941
Unrefined black, etc., lbs.	.....	.....	26,550,026	6,920,687
Pigs, bars, etc., lbs.	974,791,676	144,895,519	839,904,470	235,717,071
All other	.....	1,327,037	.....	488,837
Babbitt metal, lbs.	1,010,651	181,958	2,290,878	610,979
Bauxite concentrates, tons	13,792	616,327	21,339	1,464,933
Ferrovanadium, lbs.	626,641	503,389	2,089,347	2,577,670
German silver	.....	38,691	.....	270,703
Iron:				
Ore, tons	1,004,547	3,401,156	1,185,769	4,877,380
Pig, tons	201,995	2,859,830	377,012	15,701,846
Lead:				
Pigs, bars, etc.	.....	2,610,207	.....	17,377,031
From domestic ore, lbs.	.....	.....	130,303,394	10,411,539
From foreign ore, lbs.	22,237	1,295	84,260,273	6,965,492
Nickel, oxide and matte, lbs.	28,895,242	9,403,709	18,818,212	7,680,502
Platinum:				
Unmanufactured, oz. troy	273	12,977	468	50,697
Manufactures of	.....	71,172	.....	33,557
Quicksilver, lbs.	64,190	32,241	502,088	679,414
Tin, pigs, bars, etc., lbs.	.....	.....	209,391	127,219
Tungsten and ferrotungsten, lbs.	.....	.....	2,184,769	4,056,437
Zinc:				
Ore, tons	14,294	559,785	1,203	64,873
Dross, lbs.	572,477	29,084	31,104,163	2,283,843
Spelter, etc.	.....	406,208	172,333,718	16,844,449
CLAYS, EARTHS, ETC.:				
Cement, hydraulic, bbls.	2,391,453	3,382,282	2,575,205	5,898,081
Clays:				
Fire, tons	.....	57,581	50,529	310,527
All other, tons	.....	249,335	22,267	188,055
Lime, bbls.	285,749	200,437	142,525	150,197
Mica and manufactures	.....	65,102	.....	71,285
Plumbago:				
Unmanufactured, lbs.	5,376,880	387,075	4,912,730	331,369
Manufactures of	.....	269,499	.....	716,538

OILS, FATS, AND WAXES

Exports of mineral oils in 1918 exceeded the total for the last normal year by 137 million dollars. That and the increase in the imports of vegetable oil and oil-bearing materials are the most interesting changes wrought by the war in the foreign trade in oils. The following summary table will show at a glance the salient features of the trade in this class of materials:

SUMMARY OF TRADE IN OILS

ARTICLES	1914	1918
Imports		
Oils:		
Animal	$ 1,034,000	$ 3,678,000
Mineral	13,666,000	21,926,000
Fixed vegetable	28,829,000	87,986,000
Essential	3,492,000	4,338,000
Oil-bearing materials:		
Castor beans	1,139,000	2,641,000
Copra	2,395,000	26,946,000
Flaxseed	10,571,000	33,850,000
Peanuts	1,899,000	4,771,000
Exports		
Oils:		
Animal	822,000	1,155,000
Mineral	152,174,000	289,037,000
Fixed vegetable	15,624,000	23,930,000
Essential	628,000	1,091,000

Details of the import trade are set forth in the table on page 698. It will be seen that the increased imports of mineral oil came almost entirely from Mexico. The most impressive increases in vegetable oils are recorded for coconut oil, 7 to 31 millions in value, and soya bean oil, 1 to 31 millions, while purchases of copra rose from 2 to 27 millions, and imports of flaxseed mounted from 11 to 34 millions. This will give some idea of the search American manufacturers have made for food and industrial oils. As is well known, coconut fat has entered largely into the manufacture of butter substitutes that have recently appeared in such large quantities in the market.

Mineral oil has long been one of America's most valuable contributions to the world's trade. The American oil can is recognized affectionately by our tourists in the most remote corners of the world. But the war has given a new significance to the exports, for enormous quantities are now going forward for war service in Europe. A study of the table of exports on page 698 will show that the increases have been restricted to fuel and lubricating oils and to the light distillates. Illuminating oil has fallen off by half in quantity.

Exports of cottonseed oil have fallen nearly half in quantity. but the total value has increased, as is also the case with oleo oil. Our exports of oil-bearing seeds and nuts are not of particular importance.

PAINTS, PIGMENTS, VARNISHES, ETC.

American imports of this class of chemical products have fallen off more than half since the war started, but never were of much importance. About a million dollars' worth came from Germany in 1914.

Exports have increased from about 7 millions in value to 17 millions, a result of pushing such goods in markets abandoned by European manufacturers. It is an interesting departure and one that should be watched carefully with a view to retention of the present gains and still further expansion in the

IMPORTS OF OILS, FATS, AND WAXES

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Oils, animal:				
Cod and cod liver, gals	1,393,706(b)	$ 563,600(b)	2,021,636	$2,111,489
All other	1,488,973	470,251	2,906,473	1,566,366
Oils, mineral:				
Crude, gals	773,052,480	11,776,737	1,347,543,144	17,916,737
From—Mexico	737,712,569	10,971,613	1,346,666,866	17,901,639
Trinidad and Tobago	14,597,633	297,603		
Peru	20,710,023	506,535	907	77
Other countries	32,255	986	875,371	15,021
Refined:				
Benzine, gasoline, naphtha, gals	16,139,912	1,400,740	11,069,899	1,473,033
All other, gals	1,945,007	488,463	45,114,581	2,536,600
Oils, fixed vegetable				
Chinese nut, gals	4,932,444	1,962,389	4,815,740	4,038,072
Cocoa butter or butterine, lbs	2,838,761	793,451	405	74
Coconut, lbs	74,386,213	6,703,942	259,194,853	30,919,783
Cottonseed, lbs	17,293,201	1,044,834	14,291,313	1,629,111
Linseed, gals	192,282	91,555	50,827	32,203
Olive, non-edible, gals	763,924	477,210	114,324	94,629
Olive, edible, gals	6,217,560	7,916,980	2,537,512	3,873,311
From—France	949,858	1,512,324	227,617	576,602
Italy	4,319,567	5,552,098	200,403	467,692
Spain	362,483	370,053	2,091,400	2,783,691
Other countries	589,652	482,505	18,092	45,226
Palm, lbs	58,040,202	3,858,001	27,405,231	2,527,301
Palm kernel, lbs	34,327,600	3,087,343	18,618	2,583
Peanut, gals	1,337,136	918,614	8,288,756	7,311,824
Rape-seed, gals	1,464,265	704,655	3,056,438	2,702,920
Soya bean, lbs	16,362,452	830,790	336,824,646	32,827,460
From—China	5,983	363	12,470,720	1,456,172
Japanese China	6,150,000	288,320	237,442,917	23,104,484
Japan	6,427,307	313,795	86,830,583	8,255,001
Other countries	3,779,162	228,312	80,426	11,803
All other		439,009		2,027,137
Oils, distilled and essential:				
Birch tar and cajput				25,981
Lemon, lbs	385,959	858,220	628,057	427,318
All other		2,633,789		3,884,287
Glycerin, lbs	36,409,619	4,486,415	1,875,531	804,618
Oleostearin, lbs	5,243,553	459,989	6,575,379	1,118,422
Paraffin (except oil), lbs	7,495,459	326,966	8,997,023	672,518
Wax:				
Beeswax, lbs	1,412,200	476,364	1,826,618	632,356
Mineral, lbs	8,086,422	543,103	1,708,514	135,920
Vegetable, lbs	4,255,686	1,049,126	8,707,396	2,693,258
Grease and oils, N. E. S	22,322,492	1,251,997	28,000,428	3,343,565
Oil seeds and nuts:				
Castor beans, bu	1,030,543	1,139,311	1,222,934	2,640,902
Coconuts in shell		2,133,416		2,788,635
Copra, lbs	45,437,155	2,395,013	486,996,112	26,945,569
From—Australia	1,851,741	86,473	96,397,324	6,104,493
Other British Oceania			46,206,768	3,220,227
Philippines	27,542,443	1,497,358	219,555,171	9,949,785
Other countries	16,042,971	811,202	124,836,849	7,671,064
Flaxseed, bu	8,653,235	10,571,410	13,187,609	33,850,054
From—Canada	8,647,168	10,561,662	5,501,391	16,375,622
Argentina			7,253,501	16,471,798
Other countries	6,067	9,748	432,717	1,002,634
Peanuts:				
Not shelled, lbs	17,472,631	660,010	3,150,747	153,054
Shelled, lbs	27,077,158	1,239,227	73,362,215	4,617,560

EXPORTS OF OILS, FATS, AND WAXES

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Oils, animal:				
Fish, gals	448,366	$ 155,535	464,936	$ 448,710
Lard, gals	110,199	87,364	91,585	126,672
All other, gals	891,035	609,294	442,496	579,631
Oils, mineral				
Crude, gals	146,477,342	6,812,672	186,672,778	9,107,519
Refined or manufactured:				
Fuel and gas, gals	475,143,205	13,747,863	1,224,807,405	61,339,504
Illuminating, gals	1,157,283,310	74,600,162	328,805,501	47,488,425
Lubricating, gals	196,884,696	27,852,959	269,667,145	66,146,827
Gasoline, gals	151,611,537	21,699,475	260,300,337	61,447,382
Other naphthas, gals	40,840,730	5,653,210	207,905,009	52,408,330
Residium, gals	113,370,245	1,907,715	1,879,475	206,940
Oils, fixed vegetable:				
Corn, lbs	18,281,576	1,307,204	1,831,114	306,219
Cottonseed, lbs	192,963,079	13,843,179	100,008,074	18,142,938
Linseed, gals	239,198	134,540	1,187,850	1,532,307
All other		338,956		3,948,483
Oils, volatile or essential:				
Peppermint, lbs	117,809	397,050	76,247	233,899
All other		230,557		857,044
Glycerin, lbs			21,045,991	10,587,531
Grease:				
Lubricating		2,394,918		2,986,815
Soap stock, etc		5,046,959		2,612,488
Oleo oil, lbs	97,017,065	10,156,665	56,648,102	12,166,482
Oleomargarine, lbs	2,532,821	263,453	6,404,896	1,631,267
Paraffin:				
Unrefined, lbs	186,357,728(a)	6,516,338(a)	84,657,140	4,857,931
Refined, lbs			162,003,480	13,683,597
Stearin:				
Animal, lbs	2,724,182	234,121	10,252,522	2,180,485
Vegetable, lbs	(a)	(b)	1,293,327	293,591
Wax				
Beeswax, lbs	96,215	37,292	189,871	68,117
Manufactures of		112,193		717,181
Oil seeds and nuts:				
Cottonseed, lbs	16,342,384	215,115	1,565,052	57,693
Flaxseed, bu	308,546	436,874	21,481	101,165
Peanuts, lbs	8,054,817	421,367	12,488,209	1,517,831

(a) Not stated separately in 1914.

future. Available details are shown in the following table:

FOREIGN TRADE IN PAINTS, PIGMENTS, ETC.

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Paints, pigments, etc....	.....	$2,325,222	.....	$ 961,047
Exports				
Dry colors:				
Carbon, bone, and lampblack.....	.....	421,548	.....	1,111,265
All other.....	.....	690,836	.....	1,907,667
Lead:				
Red, lbs.....	(a)	(a)	4,792,330	567,854
White, lbs.....	16,845,154	1,013,506	18,235,783	2,072,352
Ready-mixed paints, gals.	852,910	1,096,335	1,521,588	2,399,638
Varnish, gals.....	1,069,501	1,038,864	736,949	1,209,762
Zinc, oxide, lbs.....	29,197,790	1,215,360	25,862,063	2,750,610
All other.....	.....	1,779,863	.....	4,875,006
TOTAL.....	.....	7,256,312	.....	16,894,154

(a) Not stated separately in 1914.

TANNING MATERIALS

Quebracho is the only important tanning material imported into the United States, and the war seems to have stimulated this trade to a slight extent. Argentina and Paraguay are getting an important share of the business.

Exports of tanning extract have increased from less than 1 million to nearly 4 millions since the war started, practically all of the consignments going to England and Canada, as will be seen in the table entitled "Foreign Trade in Tanning Materials."

PAPER AND PULP

Imports of printing paper have doubled in quantity and tripled in value since the war started, and at the same time exports have increased threefold in quantity and nearly fivefold in value, although the import trade is the more important. Probably recent restrictions will effect some changes in the trade for 1919.

Imports of pulp fell off 65,000 tons in 1918 as compared with the receipts in 1914, but the value of the imports nearly doubled. Canada made up for the failing supplies from Scandinavia, but at greatly enhanced prices. More pulp was exported than in 1914, but this trade is not important.

Details of the trade will be found in the table given below:

FOREIGN TRADE IN TANNING MATERIALS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Extracts:				
Quebracho, lbs	93,329,087	$2,543,302	101,523,282	$4,917,212
All other, lbs.....	8,710,040	306,934	4,573,925	219,993
Materials:				
Mangrove bark, tons.	7,689	196,891	3,529	72,956
Quebracho wood, tons	73,956	900,880	45,440	718,567
Sumac, lbs.....	10,770,340	258,738	14,046,662	467,663
All other.....	.....	468,230	.....	496,070
Exports				
Bark, tons.....	(a)	(a)	.....	5,857
Extracts.....	.....	639,941	.....	3,804,563
Germany.....	.....	11,776	.....	.....
Netherlands.....	.....	1,474	.....	.....
Norway.....	.....	1,874	.....	17,810
Sweden.....	.....	909	.....	.....
United Kingdom.....	.....	214,151	.....	2,357,272
Canada.....	.....	353,833	.....	1,094,330
Japan.....	.....	19,561	.....	750
Other countries.....	.....	36,363	.....	334,401

(a) Not stated separately in 1914.

MISCELLANEOUS PRODUCTS

Under this heading has been included sugar, which perhaps could just as well have been excluded from

FOREIGN TRADE IN PAPER AND PULP

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Printing paper:				
Not over 5 cents lb , lbs	536,815,288(a)	$10,785,129	1,203,762,118	$34,192,845
All other, lbs	6,053,429	290,530	278,367	41,377
Surface-coated paper, lbs	6,925,505	620,061	380,153	85,675
Wrapping paper, lbs	36,515,554	1,028,500	6,150,942	375,592
Wood pulp:				
Mechanically ground, tons	177,484	2,733,595	189,599	6,138,831
From—Canada	176,169	2,704,901	178,130	5,814,419
Other countries	1,315	28,694	11,469	324,412
Chemical, unbleached, tons	302,963	10,136,707	296,465	23,314,875
From—Germany	55,844	1,035,267	.....	.....
Norway	43,970	1,538,788	3,235	287,046
Sweden	117,914	3,761,637	40,420	3,900,494
Canada	79,327	2,862,943	251,265	18,949,696
Other countries	5,908	938,072	1,545	177,639
Chemical, bleached, tons	88,917	4,153,036	18,044	2,135,384
From—Germany	18,638	886,604	.....	.....
Norway	46,292	2,168,173	4,316	627,248
Sweden	14,165	614,227	1,368	172,202
Canada	6,630	340,673	11,464	1,225,492
Other countries	3,192	143,359	896	110,442
TOTAL PULP, TONS	569,364	17,023,338	504,108	31,589,090
Exports				
Printing paper:				
Newsprint, lbs	88,966,738	2,177,483	220,080,301	9,559,849
To—United Kingdom	4,017,011	90,901	8,274,963	468,719
Canada	7,544,600	151,783	453,611	27,244
Mexico	417,401	13,218	8,230,196	343,177
Cuba	11,955,503	266,257	19,667,822	708,298
Argentina	17,688,296	447,908	48,177,451	1,983,472
Chile	1,493,973	37,141	15,593,731	626,429
Australia	36,583,363	947,185	20,520,633	839,342
Other countries	9,266,589	223,090	99,161,894	4,563,168
All other printing paper, lbs	28,602,134	1,612,370	90,353,235	7,702,090
To—United Kingdom	4,014,625	296,231	1,750,864	146,897
Canada	10,379,029	601,909	8,334,122	722,944
Mexico	522,388	32,111	3,192,276	258,961
Cuba	5,104,725	263,157	9,521,768	885,907
Argentina	356,150	25,618	10,037,691	870,846
Brazil	45,534	2,724	10,361,919	872,320
Chile	913,419	40,665	4,442,904	388,369
Japan	855,960	33,651	9,731,534	816,946
Australia	2,828,669	132,498	13,041,834	1,084,481
Other countries	3,581,635	183,306	19,918,323	1,654,419
TOTAL PRINTING	117,568,872	3,789,853	310,433,536	17,261,939
Wrapping paper, lbs	14,133,097	532,657	59,350,946	4,489,287
Writing paper and envelopes	.....	1,179,232	.....	4,560,084
Wood pulp, tons	13,481	529,741	34,805	3,531,639

(a) Not over 4 cents per pound.

FOREIGN TRADE IN MISCELLANEOUS PRODUCTS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Collodion, and manufactures of		$ 569,763		$ 53,637
Glass and glassware		8,191,833		1,723,014
Glue and glue size, lbs	22,714,877	1,805,543	2,048,543	348,241
Matches		882,812		3,856,961
Oilcloth and linoleum for floors:				
Linoleum, sq. yds	3,724,086	1,762,896	38,584	28,080
Oilcloth, sq. yds	340,288	66,700	5,060	1,934
Photographic goods:				
Dry plates	(a)			33,857
Motion picture films:				
Sensitized, not exposed, lin. ft	44,717,323(b)	889,560(b)	47,462,715	739,135
Negatives, lin. ft		402,704(c)	713,363	166,033
Positives, lin. ft	20,087,144	1,009,469	3,374,497	177,148
All other films and plates		264,655		203,719
Soap:				
Castile, lbs	4,622,082	360,128	1,016,399	147,149
All other		460,485		211,149
Sugar and molasses:				
Molasses, gals	51,410,271	1,744,719	130,730,861	9,177,833
Sugar:				
Beet, lbs	2,367,708	70,829	750	73
Cane, lbs	5,061,564,621	101,365,561	4,898,277,025	236,105,886
Exports				
Baking powder, lbs	2,725,964	790,274	6,046,455	1,840,251
Blacking and polishes		649,395		1,009,100
Candles, lbs	3,047,756	283,018	6,761,767	1,031,184
Celluloid and manufactures of		1,387,541		3,744,745
Chewing gum		178,630		1,896,135
Flavoring extracts and fruit juices				1,018,102
Glass and glassware		3,729,623		14,012,656
Glucose and grape sugar:				
Glucose, lbs	162,680,378	3,766,284	80,970,744	4,949,159
Grape sugar, lbs	36,850,496	799,635	16,887,557	1,045,512
Glue, lbs	2,381,770	258,611	4,935,250	839,197
India-rubber manufactures:				
Belting, hose, and packing		2,372,887		4,578,396
Boots and shoes, pairs	1,735,619	1,113,495	2,803,768	5,774,341
Tires		4,068,639		15,128,294
All other		4,886,199		6,194,816
Ink:				
Printers'		443,377		882,062
All other		181,697		407,093
Matches		77,236		471,385
Metal polish		162,504		192,691
Mucilage and paste		95,013		399,295
Oilcloth and linoleum:				
For floors, sq. yds	163,214	60,608	1,259,805	655,175
All other		666,479		1,277,777
Photographic goods:				
Motion-picture films:				
Not exposed, lin. ft	155,359,550	4,264,722	57,995,064	1,385,291
Exposed, lin. ft	32,690,104	2,282,924	84,557,376	5,132,528
Other sensitized goods		1,348,216		2,938,756
Soap:				
Toilet or fancy		2,141,633		2,246,258
All other, lbs	58,547,763	2,797,369	82,726,757	6,894,454
Sugar and molasses:				
Molasses, gals	1,002,441	175,498	3,811,341	847,692
Sirup, gals	11,630,528	1,491,639	7,690,074	4,823,912
Sugar, refined, lbs	50,895,726	1,839,983	576,415,850	38,756,680
Vulcanized fiber and manufactures of		854,642		950,029
Washing powder and fluids, lbs	12,761,958	535,635	4,754,084	243,184

(a) Not stated separately in 1914.
(b) From October 3, 1913, to June 30, 1914.
(c) Stated as "All other" motion-picture films in 1914.

consideration entirely. Sugar imports were not quite so high in 1918 as in 1914, considering quantities, but the value was more than doubled. Exports, on the other hand, increased from 51 to 576 million pounds, the values increasing from 2 to 29 million dollars. The refining of Cuban sugar for export to Europe is a war development.

Exports of rubber goods have increased from 12 to 32 millions in value, although what percentage of increase has been due to high prices would be difficult to determine.

Imports of matches have increased in value, as, to a lesser extent, have the exports. Japan has built up a good business in matches as a result of difficulties in Sweden.

In the above table will be found a number of export increases that, while comparatively unimportant, are significant because they represent new business in non-fighting countries, business that may possibly be retained when the war is over.

MISCELLANEOUS MATERIALS

Grouped under this head will be found a number of materials that will interest some branches of the chemical industry, but which could not well be included in any of the previous groupings and are not important enough to be treated individually.

FOREIGN TRADE IN MISCELLANEOUS MATERIALS

ARTICLES	1914 Quantity	1914 Value	1918 Quantity	1918 Value
Imports				
Asphaltum and bitumen	180,689	$ 918,387	139,899	863,476
Blood, dried		391,816		462,703
Bones, hoofs, and horns		1,061,466		1,324,546
Fish sounds, lbs	(a)	(a)	331,248	77,499
Gelatin, unmanufactured, lbs	2,341,317	738,731	365,586	133,057
Hide cuttings, raw and other glue stock, lbs		2,158,514	21,710,205	936,393
Moss and seaweed				
Crude		301,259		230,163
All other		54,376		8,514
Rennets, raw or prepared		129,720		62,173
Salt, 100 lbs	3,076,071	423,322	1,028,231	307,036
Vanilla beans, lbs	897,100	2,277,675	914,668	1,475,676
Exports				
Asphaltum:				
Unmanufactured, tons	49,831	1,131,086	22,052	548,271
Manufactures of		362,347		488,892
Moss		51,006		99,793
Salt, lbs	148,931,265	542,783	267,045,840	1,416,798

(a) Not stated separately in 1914.

THE CHEMICAL MARKETS OF SOUTH AMERICA(*)

By O. P. Hopkins, Washington, D. C.

THE CHEMICAL MARKETS OF ARGENTINA, BRAZIL AND URUGUAY

Received July 29, 1918

The region in South America which embraces Argentina, Brazil, and Uruguay is famed chiefly for its agricultural and pastoral products. Brazilian rubber is a forest product, but as a whole the forests of the region, although rich in material, have been little exploited. The mineral resources of some parts of the district are beyond calculation, but they have been worked only very superficially.

The lack of one mineral, however, is the factor that keeps the region definitely pastoral and agricultural rather than industrial—there is very little coal. It is the lack of fuel that holds in check the present tendency to manufacture at home the articles that formerly were imported from Europe and the United States, but which now are almost unobtainable on account of the scarcity of tonnage and the dislocation of trade caused by the export restrictions of the belligerent countries.

As would be expected, chemicals and allied products are not imported in comparatively important quantities. The finer chemical products, however, such as pharmaceutical products, perfumes, patent medicines, and soaps are in demand and are purchased to a large extent from foreign manufacturers. Such products as paper and glassware are imported also. Before the war Germany had the lion's share of the trade in most of the imported articles, but American manufacturers have not been slow to take advantage of the German's absence and have learned so much about the business that they never knew before that it is very unlikely they will ever lose their grip. Lack of shipping and export restrictions stand between them and a complete conquest of the markets.

The statistics contained in this article have been compiled with the primary object of showing the extent of the market for chemicals and allied products which exists in the three countries treated. The principal table in each case shows details of imports, including the chief sources of origin, and is a compilation from the original official statistics, published in Spanish or Portuguese. Official detailed statistics in most of the South American countries are always several years behind time, but these figures will give an adequate idea of the demand for imported goods. Tables are also given showing the trade of each country with the United States for the fiscal years 1914 and 1917, based on statistics published by our own Bureau of Foreign and Domestic Commerce. These will show how the war has affected our trade with the three countries, and will also indicate what those countries have to export in the way of raw and manufactured chemical products.

It should be borne in mind that South America was at first much harder hit by the war than we were and that the period of depression lasted much longer. Recovery was finally effected through the European demand for foodstuffs and other raw materials and a period of unexampled prosperity has now set in.

(*) First of a series of articles on South American Chemical Markets.

ARGENTINA

Cereals and meat products in mighty volume have given Argentina her rank among South American nations and are almost the sole cause of her present prosperity. Manufacturing industries have never thrived in the face of such obstacles as the lack of coal and iron and the high price of labor. Mineral resources are comparatively unimportant and the forests have not been extensively exploited.

A variety of chemicals are imported, but only a few in anything like important quantities. Sheep dip is not manufactured at home and foreign purchases of this Argentine essential amount to more than $2,000,000 a year. Since the Uruguayan Government established its domestic sheep-dip industry, some imports have come from that source, but normally England gets the bulk of the business.

Tartaric acid, an essential in Argentina's rapidly developing wine industry, was formerly imported from Europe, but short supplies have resulted in establishing the industry at home, which in turn has cut down Argentine exports of argols and wine lees. American firms have taken an active part in stimulating the new industry. The largest wine producers have installed apparatus for making the high-priced crystallized acid from their own raw materials.

Aluminum sulfate, formerly imported largely from Germany, and used in water-purification plants, is now being manufactured at home to some extent with the assistance of the Government. Eight thousand tons were required in 1917. The kaolin used is found in the Sierra Chica, Province of Buenos Aires.

The ammonia required in the meat-freezing plants was formerly imported from Austria and the United States, but now American exporters do all of the business.

The Argentine paper market is an important one and will continue to be so, as there is no prospect of formidable competition from domestic producers. It is one of the markets that Germany cultivated most carefully, but American exporters have recently taken over the best of the business. Germany's success, apart from price considerations, was due largely to the fact that the wholesale houses were controlled by Europeans who were not keen about pushing American products. Now there are at least two wholesale houses controlled by Americans and they are doing a big business. Other things being equal, these houses will favor American goods after the war.

Paints and glass are two other lines that have been developed by American exporters since the war started, as will be seen more clearly in the second table, which is based on American statistics.

The following table, based upon official Argentine statistics, shows chemical imports in considerable de-

tail. It should be used only as a general guide, however, as the Argentine customs returns are based upon arbitrary valuations that are seldom changed. They are lower than the actual values. (N. E. S. is an abbreviation for "Not elsewhere specified."

ARGENTINE IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

CHEMICALS, DRUGS, DYES, MEDICINES	1913	1915	1916
ACIDS:			
Acetic, diluted	$ 68,694	$ 47,080	$ [illegible]
Germany	26,262	13	
Netherlands	31,537	18,159	
United States	[illegible]	[illegible]	
Boric	28,960	13,072	[illegible]
France	9,720	6,552	
Germany	8,868	1,307	
United Kingdom	3,940	4,323	
Carbonic	6,593	5,207	632
France	268	2,260	
Germany	5,252	1,977	
United Kingdom	363	970	
Citric	79,310	65,627	[illegible]
France	17,806	24,035	
Germany	31,264	1,252	
Italy	207	[illegible]	
United Kingdom	23,367	15,971	
Hydrochloric	21,346	3,693	[illegible]
France	15,208	283	
Germany	3,117	[illegible]	
United Kingdom	2,289	2,824	
United States	7	378	
Hydrofluoric	4,425	8	21
France	3,351	8	
Germany	1,074	[illegible]	
Nitric	3,789	2,897	1,196
France	431	301	
Germany	2,109	[illegible]	
United States	31	1,478	
Phenol	6,671	2,535	5,159
Germany	3,952	[illegible]	
United Kingdom	2,555	1,683	
United States	7	694	
Sulfuric	51,900	11,484	12,297
Germany	13,656	2,264	
Netherlands	23,762	[illegible]	
United Kingdom	13,419	6,930	
United States	75	1,905	
Tannic	27,911	4,735	8,258
France	1,341	638	
Germany	24,747	3,239	
United States	[illegible]	773	
Tartaric	1,107,196	749,098	318,514
France	117,657	70,788	
Germany	418,579	148,719	
Italy	399,502	461,259	
United Kingdom	121,052	66,967	
United States	[illegible]	1,353	
All other acids	32,964	14,542	25,283
Germany	27,551	988	
United Kingdom	985	1,697	
United States	1,678	5,873	
ALUM	246,787	253,960	284,735
Belgium	188,917	[illegible]	
United Kingdom	53,113	61,701	
United States	1,861	129,364	
ALUMINUM SULFATE	107,475	54,626	125,655
Belgium	37,191	232	
Germany	55,993	13,037	
United States	[illegible]	37,090	
AMMONIA:			
Anhydrous	122,982	156,317	98,869
Austria-Hungary	35,556	[illegible]	
United States	56,654	152,147	
Carbonate of	18,061	14,986	15,132
Germany	4,004	209	
United Kingdom	13,110	13,276	
Liquid	14,744	7,840	2,405
Germany	5,198	[illegible]	
United Kingdom	9,070	5,061	
United States	82	2,158	
Muriate of	18,095	9,306	9,658
Germany	10,082	715	
United States	22	2,616	
Other	19,681	9,089	3,230
Germany	13,530	174	
United States	[illegible]	7,679	
ANILINE DYES	209,723	29,956	42,905
France	15,104	34	
Germany	174,728	2,016	
Switzerland	10,392	15,965	
United States	327	5,769	
ARSENIC FOR INDUSTRIAL USE	10,687	17,337	31,445
Germany	7,718	746	
United Kingdom	2,303	9,775	
United States	[illegible]	6,711	
CALCIUM CARBIDE	521,668	452,894	346,283
Norway	242,204	156,017	
Sweden	40,808	27,761	
United States	212,746	259,842	
CARBIDES WITH CARBONIC ACID	33,689	5,500	[illegible]
United Kingdom	33,466	5,481	

ARGENTINE IMPORTS OF CHEMICALS AND ALLIED PRODUCTS—*Continued*

CHEMICALS, DRUGS, DYES, MEDICINES	1913	1915	1916
CARBON SULFIDE	$ [illegible]	$ 27,698	$ [illegible]
France	[illegible]	3,792	
United Kingdom	59,400	[illegible]	
CHEMICAL PRODUCTS N. E. S.	809,889	[illegible]	
France	[illegible]	134,165	
Germany	[illegible]	28,940	
United States	[illegible]	299,637	
CHLORAL	1,349	[illegible]	[illegible]
CHLOROFORM AND ETHER	14,304	18,811	9,528
Germany	8,897	1,340	
United States	93	11,997	
COTTON SEED OIL	206,856	190,132	[illegible]
United Kingdom	[illegible]	[illegible]	
United States	[illegible]	172,462	
CRESOLIN	19,878	3,536	4,072
United Kingdom	17,079	1,214	
CYANIDES	13,219	4,851	[illegible]
Germany	7,481	1,064	
United States	[illegible]	2,013	
CREAM OF TARTAR	6,981	3,170	5,719
EXTRACT OF TANNIN	[illegible]	10,131	
France	82,133	[illegible]	
United States	[illegible]	[illegible]	
EXTRACTS, MEDICINAL	Not shown	[illegible]	36,569
EXTRACTS, INDUSTRIAL	Not shown	[illegible]	[illegible]
FORMALIN	13,207	7,569	17,387
Germany	7,771	695	
United States	[illegible]	4,560	
GLYCERIN	43,229	9,616	15,643
Germany	25,035	263	
United States	[illegible]	3,283	
GUMS:			
Adhesive	11,787	5,059	5,191
United Kingdom	4,650	[illegible]	
United States	[illegible]	[illegible]	
Camphor	19,615	12,765	27,101
Japan	[illegible]	5,603	
Other	141,827	134,305	113,620
France	31,885	32,642	
United States	1,853	9,511	
HYDROGEN, PEROXIDE OF	29,170	14,497	[illegible]
France	22,536	8,657	
United States	1,503	2,741	
IODOFORM	8,940	2,810	2,810
IRON, SULFATE OF	11,085	3,111	1,645
United States	8,584	[illegible]	
LIME, CHLORIDE OF	41,112	25,208	[illegible]
France	18,903	1,264	
United States	[illegible]	8,711	
LIME, HYPOCHLORIDE OF	14,304	18,527	9,361
LYSOL	9,096	2,878	[illegible]
MAGNESIA SULFATE OF	3,865	7,167	6,391
MANGANESE PEROXIDE	138,923	8,500	9,391
Germany	124,433	6,096	
United States	16	[illegible]	
MEDICINES, PREPARED	1,924,716	1,416,500	1,621,444
France	1,080,402	791,138	
United States	220,073	[illegible]	
MORPHIA AND ITS SALTS	6,128	4,005	[illegible]
PHARMACEUTICAL PRODUCTS, N. E. S.	323,673	208,100	164,254
Germany	[illegible]	14,143	
United States	[illegible]	51,932	
PERFUMERY	1,238,850	765,620	Not shown
France	948,987	544,873	
United States	[illegible]	30,055	
PHOSPHORUS	[illegible]	1,438	178
PHOSPHORUS SESQUISULFIDE	[illegible]	46,487	[illegible]
Switzerland	[illegible]	[illegible]	
United Kingdom	[illegible]	44,470	
PEPSIN	[illegible]	1,583	[illegible]
POTASH	23,302	9,194	13,941
Bicarbonate	[illegible]	1,092	44
Bichromate	[illegible]	18,992	4,586
Carbonate	9,661	3,217	1,107
Caustic	[illegible]	1,726	[illegible]
Chlorate	34,091	42,884	12,035
Nitrate	[illegible]	29,507	28,280
United States	[illegible]	20,365	
Permanganate	[illegible]	2,169	698
Prussiate	[illegible]	1,018	497
POTASSIUM IODIDE	22,190	37,707	[illegible]
QUINIA SULFATE OF	[illegible]	6,612	[illegible]
ROOTS, LEAVES, BARKS, ETC. MEDICINAL	[illegible]	68,952	[illegible]
Germany	[illegible]	[illegible]	
United States	404	966	
SHEEP DIP	2,040,643	2,301,094	[illegible]
United Kingdom	1,891,143	2,234,127	
United States	97,044	47,632	
SODA ASH	[illegible]	136,139	[illegible]
United Kingdom	[illegible]	128,156	
United States	[illegible]	[illegible]	
SODA:			
Bicarbonate	[illegible]	[illegible]	[illegible]
United Kingdom	[illegible]	[illegible]	
United States	[illegible]	1,784	

ARGENTINE IMPORTS OF CHEMICALS AND ALLIED PRODUCTS (*Concluded*)

CHEMICALS, DRUGS, DYES, MEDICINES	1913	1915	1916
Bisulfite	$ 9,843	$ 12,114	$ 3,479
Borate	4,225	2,928	2,571
Carbonate, crystals	152,403	83,890	41,129
United Kingdom	140,339	79,759	
United States	.....	2,797	
Caustic	375,768	308,987	336,590
United Kingdom	325,717	151,133	
United States	14,375	155,596	
Hyposulfite	17,151	8,790	13,050
Nitrate of	18,776	47,352	17,365
Salicylate	24,582	1,503	6,232
United States	10	1,063	
Solvay	186,500	180,787	145,453
United Kingdom	177,161	170,441	
United States	838	2,326	
Silicate	143,711	134,983	83,486
United Kingdom	136,661	131,262	
United States	1,073	1,859	
Sulfide	36,608	49,227	20,768
Germany	28,945	843	
United States	.....	39,951	
SULFUR	97,067	85,975	135,181
Italy	91,000	78,213	
United States	693	6,040	
SUMAC	360	510	1,049
OILS AND GREASES:			
Total Imports	22,946,654	34,875,377	18,527,909
Italy	2,664,495	2,120,068	
Mexico	1,285,227	14,544,651	
United States	15,188,993	15,856,670	
Cottonseed Oil	1,141,668	1,480,186	432,256
United States	1,129,282	1,459,560	
Olive Oil	4,153,451	3,753,360	3,394,291
Italy	2,577,166	2,050,663	
United States	171,271	182,901	
Kerosene	1,975,220	1,361,990	1,247,453
United States	1,974,446	1,361,964	
Lubricating oils	2,465,213	1,824,438	
United States	1,400,894	1,472,266	
Naphtha; raw petroleum	11,514,226	24,706,323	8,280,672
Mexico	1,280,160	14,544,651	(incomplete)
United States	9,857,766	10,145,593	
Paraffin	93,018	837,363	453,983
United States	36,248	802,572	
Vaseline	48,082	51,214	59,393
United States	35,432	48,393	
MISCELLANEOUS:			
EXPLOSIVES:			
Blasting powder	52,559	16,768	8,939
United States	7,634	5,744	
Dynamite	55,776	26,128	41,363
United States	3,939	272	
Gunpowder	670,703	243,733	.....
United States	303,629	166,411	
GLASS:			
Sheet and plate	2,037,529	725,730	734,442
United States	17,478	190,734	
Other manufactures	2,603,046	495,493	462,012
United States	142,531	77,878	
PAINTS, ETC.:			
Varnishes	461,164	307,259	392,045
United States	71,695	65,258	
Paints, colors, dyes, lacs, inks, varnishes:[1]	2,446,697	1,392,897	1,658,371
United Kingdom	1,047,723	727,070	
United States	276,638	388,720	
PAPER:			
Paper and cardboard	5,800,948	3,800,475	5,006,201
Germany	2,792,937	499,523	
United States	828,488	1,324,426	
Manufactures of paper	3,754,468	1,818,987	1,977,645
Germany	1,140,869	209,117	
United States	164,213	195,628	
SOAP:			
Common	225,218	203,541	221,077
United States	25,540	21,664	
Medicated	312,608	127,382	140,583
United States	223,654	116,101	
Perfumed	98,855	75,485	116,049
United States	8,099	17,247	

[1] This confusing total includes aniline dyes, indigo and varnishes stated separately above.

AMERICAN PRODUCTS SOLD IN ARGENTINA

ARTICLES	1914	1917
Asphaltum:		
Unmanufactured	$ 90,043	$ 16,453
Manufactures of	1,148	9,698
Blacking, shoe paste, etc	49,187	86,893
Candles	.....	21,772
Celluloid, and manufactures of	7,836	74,575
Chemicals, drugs, dyes, medicines:		
Acids:		
Sulfuric	.....	1,035
All other	271	180,905
Alcohol, wood	.....	109
Baking powder	40,819	54,309
Bark, extract for tanning	.....	17,032
Calcium carbide	242,784	197,986
Copper sulfate	73,244	124,128
Dyes and dyestuffs	.....	262,563
Lime, acetate of	.....	4,500
Medicines, patent or proprietary	382,135	502,705
Petroleum jelly	36,127	39,108
Roots, herbs, etc	15,719	16,326
Soda salts and preparations of[1]	.....	684,905
Sulfur (brimstone)	1,176	53,007
All other	257,734	1,853,017
Chewing gum	4,068	6,839
Explosives:		
Cartridges	194,555	265,445
Dynamite	10,671	11,664
Gunpowder	2,656	82,600
All other	12,573	86,153
Fertilizers	.....	210
Glass and glassware	91,173	605,476
Glucose and grape sugar	140,998	93,170
Glue	392	5,490
Grease:		
Lubricating	102,345	57,231
Soap stock and other	17,789	21,330
India rubber, manufactures of	120,520	1,818,511
Ink:		
Printers'	17,506	166,282
All other	2,790	20,921
Leather, patent	338,805	336,128
Metal polish	23,833	8,715
Naval stores:		
Rosin	506,260	808,809
Turpentine, spirits of	271,000	200,271
Oilcloth and linoleum	39,668	109,686
Oils:		
Animal	934	4,852
Mineral:		
Crude (including all natural oils)	593,594	542,012
Refined or manufactured:		
Gas oil and fuel oil	102,442	253,865
Illuminating	1,687,358	1,559,989
Lubricating and heavy paraffin	789,185	1,266,175
Naphthas:		
Gasoline	3,337,647	720,118
All other	310,889	2,479,760
Residuum (including tar)	7,035	4,372
Vegetable:		
Corn	9,412	38,336
Cottonseed	1,168,127	404,782
Linseed	718	5,599
All other	104,460	62,339
Volatile:		
Peppermint	.....	632
All other	.....	25,143
Paints, pigments, colors, varnishes:		
Dry color	9,301	165,949
Ready-mixed paints	78,024	35,492
Varnish	22,253	55,902
White lead	5,945	148,118
Zinc, oxide of	.....	21,222
All other	54,896	203,581
Paper and manufactures	584,669	3,331,254
Paraffin and paraffin wax	21,483	186,469
Perfumeries, cosmetics, etc	67,239	111,382
Photographic goods:		
Motion-picture films	19,492	373,472
Other sensitized goods	35,033	174,751
Soap:		
Toilet	261,712	183,369
All other	58,377	94,339
Wax, manufactures of	1,611	47,832

[1] Not stated separately in 1914.

The progress made by American exporters in the Argentine chemical markets can be traced readily enough in the following table, which is compiled from official American statistics. These are based upon wholesale values in this country at time of shipment, which means, of course, that the increases shown are due in part to advanced prices. The most striking increase has been in paper. While the sales of soda were encouraging in 1917, it should be noted that this item was not stated separately in 1914. These figures are for the fiscal years 1914 and 1917:

The only Argentine contributions of prime importance to America's present chemical needs are quebracho and flaxseed. About 117,000 metric tons of tanning extract were produced in Argentina and Paraguay during the calendar year 1917, practically all of which was exported. The potential output was estimated at 230,000 tons, shipping difficulties and low prices being assigned as the reasons for low actual production. One company exported 102,000 tons of extract. Ninety-five thousand tons of logs, equal to 25,000 to 30,000 tons of extract, were shipped

to the United States during the calendar year 1917, according to advices from Argentina.

A recent attempt, originating in the United States, to stimulate the production of linseed oil in Argentina and thus economize in the tonnage now required for flaxseed, has apparently failed. Several reasons are assigned for the inability to increase the oil output, the most important of which are lack of machinery, lack of containers, and the absence of any important local demand for the cake. The small quantity of oil now produced is sold most profitably in Argentina, Brazil, Chile, and South Africa. Some of the small mills prefer to take advantage of the present demand for edible oil. These reasons seem conclusive enough.

The following table of imports from Argentina covers the fiscal years 1914 and 1917:

ARGENTINE PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Antimony ore	$	$ 10,600
Bismuth	.....	16,757
Blood, dried	96,373	313,785
Bones, hoofs, and horns	469,077	398,893
Chemicals, drugs, dyes, medicines:		
Argols	.....	230,301
Extracts for tanning:		
Quebracho	2,441,083	5,198,667
All other	.....	14,799
Glycerin, crude	39,811	289,476
Lactarene, or casein	129,538	948,635
All other	63	3,943
Copper ore	6,126	26,416
Dyewoods in crude state	.....	15,680
Fertilizers	330,040	346,159
Hide cuttings and other glue stock	116,548	234,101
India rubber	.....	130,619
Mica	.....	10,530
Oils, essential	.....	10,987
Oleo stearin	185,596	82,269
Oil seeds:		
Castor beans	.....	26,282
Flaxseed	.....	7,309,161
Tanning materials, crude:		
Quebracho wood	899,603	1,180,447
All other	840	817
Wax, beeswax	.....	17,968

BRAZIL

The great wealth of Brazil lies principally in her coffee and rubber, although cotton, sugar, tobacco, matte, rice, cacao, cereals, nuts, gold, diamonds, iron, manganese, monazite sand, marble, and live stock all represent industries that have an important part in the economy of the nation. The mineral resources are apparently without limit, but have barely been scratched.

There are no great manufacturing industries in the sense that we know them, but the war has greatly stimulated the domestic production of textiles, soap, sugar, and a number of other products. Water power seems in some districts to have solved the fuel problem, and has even made possible a rather important calcium carbide industry. The impossibility of getting supplies of caustic soda has recently threatened some of the growing industries and the Government has come to the rescue by subsidizing the production of that chemical. Factories will probably be operated in Rio de Janeiro, Bahia, and Santos, where electric power and ample supplies of salt are available.

A study of the following table will reveal the more interesting facts about the Brazilian demand for chemicals and allied products and about the normal sources of the supplies imported. The insignificant part played by the United States before the war is at once apparent.

Of the articles usually classified as chemicals, soda in various forms, but particularly caustic soda, is the most important import. It is used in a number of growing industries, especially in soap making, and was formerly imported chiefly from England. Recently it has been purchased almost exclusively from the United States, but export restrictions and other difficulties have interfered with supplies to such an extent that the Government is endeavoring to establish a domestic industry, as already stated.

Imports described as "Chemical Products and Medicines Unenumerated" were valued at nearly $5,000,000 in 1913 and at considerably more than $6,000,000 in 1916, but there is no way of finding out just what items make up the class. Patent and proprietary medicines are undoubtedly the most important item, and the United States has obtained a fair share of that business.

Brazil followed the lead of other countries in purchasing dyestuffs from Germany before the war, but now depends upon the United States. As the second table shows, more than $1,200,000 worth of dyes were purchased from the United States during the fiscal year 1917. This demand will grow as the dye-using industries, especially the textile industry, expand.

More than a million dollars worth of perfumes was purchased in 1913, practically all from France, but in this connection there is a most interesting item entitled "Perfumery for Carnivals," purchases of which amounted to more than $400,000 in 1913. Swiss manufacturers had a monopoly on the business, but inability to deliver cut down the imports to $41,000 in 1916. Can "carnival perfumes" be made in America?

Brazil needs important quantities of paper and this is one line in which the United States has effectively supplanted the German business, for the time being at any rate. It is gratifying to state that American exporters have on the whole made a good impression and have rapidly adapted themselves to the conditions of the market. It is to be hoped that circumstances will permit their carrying on the business throughout the war so that they will be in an advantageous position when the old competition returns.

Mineral oils are imported in considerable quantities, and in that line America, as usual, is supreme.

In studying the accompanying table it should be borne in mind that the Brazilian Government does not compute import values on the same basis on which we compute export values; hence there will be discrepancies between values in the first and second tables. The first table should be used as a guide for determining the relative importance of imports and of the principal sources of supply.

BRAZILIAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

CHEMICALS, DRUGS, DYES, MEDICINES	1913	1914	1916
Acids:			
Acetic	$ 53,823	$ 33,440	$ 123,754
Germany	24,193	15,702	
United States	141	303	
Nitric	2,996	2,492	1,668
Germany	1,207	289	
United States	36	191	
Sulfuric	57,645	23,171	25,617
Germany	26,387	12,007	
United States	193	393	
Tannic	11,872	4,781	13,998
Germany	8,336	2,285	
United States	54	119	
All other	137,534	74,639	116,332
France	33,372	7,682	
Germany	57,600	29,132	
United States	1,364	6,235	
Aniline Dyes	572,355	169,155	114,924
Germany	517,753	154,500	
United States	1	101	
Calcium Carbide	426,568	335,777	85,000
Norway	235,586	158,404	
United States	35,801	58,308	
Capsules, Pills, Globules, Medical	50,931	29,377	26,049
France	14,899	7,902	
United States	26,658	13,171	
Chemical Products and Medicines, Unenumerated	4,903,654	3,087,189	6,337,578
France	1,706,481	1,098,884	
United States	427,919	314,097	
Chloride of Lime	59,500	26,689	185,113
United Kingdom	41,563	17,514	
United States	525	1,115	
Essences and Oils, N. E. S., Fixed Liquid, Volatile	147,728	91,074	162,838
Germany	78,390	50,272	
United States	105	790	
Ethyl Chloride	3,804	939	150
France	1,520	939	
Germany	2,247	.....	
United States	36	.....	
Extracts, Vegetable, N. E. S.	119,090	48,827	135,450
Italy	79,455	27,326	
United States	299	2,266	
Gums, Resins, Natural Balsams	136,704	89,579	217,740
Germany	42,448	23,585	
United States	3,032	1,330	
Glycerin	5,646	2,738	3,293
United Kingdom	2,331	1,412	
United States	789	.....	
Indigo and Ultramarine Blue	90,015	55,807	140,297
Germany	37,971	19,595	
United States	105	.....	
Perfumery for Carnivals	484,131	328,637	40,983
Switzerland	423,747	284,786	
Perfumery, Other	1,141,553	570,844	874,543
France	928,979	484,512	
United States	55,296	25,328	
Potash, Caustic	1,149	1,420	3,013
Germany	507	510	
United States	53	11	
Soda Ash	250,448	154,720	251,170
United Kingdom	236,989	133,208	
United States	662	6,136	
Soda, Caustic	512,402	398,012	1,561,483
United Kingdom	491,820	368,980	
United States	3,437	21,776	
Soda, Nitrate of	271,540	108,711	268,119
United Kingdom	111,283	45,731	
United States	17	.....	
Sulfur	87,302	64,356	235,365
Italy	65,147	49,171	
United States	851	606	
OILS AND WAXES			
Benzine	18,537	3,994	1,871
France	4,603	2,642	
United States	5,586	244	
Cod-liver oil and emulsion	24,984	13,588	44,366
Norway	10,099	3,413	
United States	7,413	6,242	
Cottonseed oil	298,109	267,991	183,681
United States	256,015	220,569	
Gasoline	2,506,067	711,381	2,646,549
United States	2,476,987	689,536	
Kerosene	4,719,418	3,741,027	5,838,493
United States	4,614,342	3,647,212	
Linseed oil	829,670	462,390	712,825
United Kingdom	730,296	403,740	
United States	1,863	5,445	

BRAZILIAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS (*Concluded*)

OILS AND WAXES	1913	1914	1916
Lubricating oils, mineral and vegetable	$1,591,470	$1,065,488	$1,851,751
United States	1,065,144	803,242	
Mineral fuel oil	208,646	451,785	1,370,659
Mexico	114,789	322,316	
United States	89,907	128,597	
Olive oil	1,788,941	1,585,747	1,794,890
Italy	638,950	692,525	
United States	80	9	
Palm oil	201,968	149,598	105,618
British India	56,464	42,243	
United States	812	1,264	
Paraffin	79,266	64,997	142,374
United Kingdom	35,460	33,815	
United States	15,628	16,478	
Vaseline	48,102	27,688	55,604
Germany	13,145	6,595	
United States	13,134	9,482	
GLASS AND GLASSWARE			
Sheet and plate glass	750,662	292,687	771,692
Belgium	437,416	154,380	
United States	6,490	2,456	
Manufactures of glass	1,995,800	727,913	511,154
Germany	1,083,064	327,890	
United States	120,602	56,942	
PAPER AND MANUFACTURES OF			
Total imports	7,342,182	4,321,000	8,062,971
Germany	2,540,920	1,469,808	
United States	516,933	283,296	

The principal chemicals exported to Brazil by the United States are dyes, soda, medicines, acids, and copper sulfate. Only time can tell whether our present hold on the market for these products is to be permanent. Of the products sometimes classed as "allied chemical products," the United States is at present supplying in considerable quantities mineral oils, paper, naval stores, india-rubber manufactures, explosives, and glass.

The following table, compiled from official American statistics for the fiscal years 1914 and 1917, will give an idea of how the war has affected the chemical trade between the United States and Brazil. Some of the increases may be ascribed to the present prosperity of Brazil, but for the most part they represent gains that have been made as the result of the withdrawal of European competitors.

AMERICAN PRODUCTS SOLD IN BRAZIL

ARTICLES	1914	1917
Aluminum and manufactures	$ 5,595	$ 106,227
Asphaltum and manufactures	80,291	11,612
Babbitt metal	21,413	19,093
Blacking, shoe paste, etc	25,235	41,330
Celluloid and manufactures	5,498	51,800
Cement, hydraulic	200,337	426,166
Chemicals, drugs, dyes, etc.:		
Acids:		
Sulfuric	1,363	17,437
All other	4,569	144,497
Baking Powder	6,456	19,913
Bark extracts, tanning	.....	8,136
Calcium carbide	32,236	31,743
Copper sulfate	2,448	126,254
Dyes and dyestuffs	65	1,203,140
Lime, acetate	.....	4,600
Medicines, patent or proprietary	248,617	315,392
Petroleum jelly	9,595	42,191
Roots, herbs, barks	.....	10,569
Soda salts and preparations[1]	.....	1,063,476
Sulfur (brimstone)	.....	53,273
All other	84,579	2,519,396
Explosives:		
Cartridges, loaded	287,600	570,824
Dynamite	14,835	45,944
Gunpowder	.....	51,730
All other	3,726	304,803
Flavoring extracts and fruit juices	1,634	14,413
German silver	.....	4,695
Glass and glassware	70,492	455,872
Glucose	498	18,248
Glue	731	8,173
Grease		
Lubricating	33,903	67,044
Soap stock, and other	1,120	9,990

[1] Not stated separately in 1914.

AMERICAN PRODUCTS SOLD IN BRAZIL (*Concluded*)

ARTICLES	1914	1917
India rubber, manufactures of	$ 119,272	$1,154,381
Ink	14,743	69,501
Leather, patent	41,612	382,318
Metal polish	26,925	13,357
Naval stores:		
Rosin	673,687	975,044
Tar, turpentine, pitch	3,302	3,153
Turpentine, spirits	154,288	165,523
Oil cloth and linoleum:		
For floors	142	10,597
All other	5,644	30,155
Oils:		
Animal	2,216	2,613
Mineral:		
Gas and fuel	54,412	95,451
Gasoline, etc	1,311,024	1,429,143
Illuminating	3,231,668	2,942,326
Lubricating, etc	699,382	886,842
All other	2,630	2,214
Vegetable:		
Cottonseed	191,781	70,080
Linseed	2,793	154,272
Volatile or essential	3,108	31,593
All other	601	59,687
Paints, pigments, etc.:		
Dry color	5,642	35,001
Ready-mixed paints	44,679	85,393
Varnish	30,057	82,738
Zinc, oxide		64,522
All other (including crayons)	45,641	197,322
Paper and manufactures	499,393	2,419,287
Paraffin and paraffin wax	18,498	72,213
Perfumery	15,818	133,350
Photographic goods:		
Motion-picture films:		
Exposed	1,900	122,006
Unexposed	10,575	9,533
Other sensitized goods	32,417	110,229
Plumbago and manufactures	1,259	21,475
Salt	1,050	77
Soap:		
Toilet	37,322	22,637
All other	3,728	12,573
Sugar and molasses:		
Syrup	65	405
Refined sugar	284	159,207
Vulcanized fiber and manufactures	109	8,082
Wax and manufactures	4,043	5,777

Brazil is making only two important contributions to our war-time industries—rubber and manganese—but they are vital. The demand for rubber has meant a great deal to Brazilian prosperity, as pre-war competition from the cultivated East Indian rubber had placed the Brazilian industry in a precarious position. The active demand for rubber has counteracted to some extent the depression resulting from the diminishing demand for coffee.

BRAZILIAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Aluminum, crude	$	$ 1,665
Chemicals, drugs, dyes, etc.:		
Glycerin, crude		292,597
Gums		594
Lactarene		10,248
Soda, cyanide of		38,059
All other		145,390
Copper		164,941
Dyewoods in crude state:		
Logwood		7,339
Other		356
Glue and glue size		49,467
Hide cuttings and other glue stock	4,382	4,381
India rubber, etc.:		
Balata		4,296
India rubber	16,319,048	25,654,924
India rubber scrap		11,802
Manganese oxide and ore	466,125	8,965,110
Mica:		
Unmanufactured	430	44,164
Cut, split, etc		10,468
Monazite sand and thorite	54,329	54,519
Oils, vegetable	94	120,387
Paper and manufactures		1,234
Platinum and manufactures		9,097
Seeds:		
Castor beans	12,644	202,758
All other	16	348
Wax		
Beeswax	629	212,117
Vegetable	671,296	1,330,290

The preceding table shows in some detail the exports of chemicals and allied products from Brazil to the United States for the fiscal years 1914 and 1917.

URUGUAY

In size, Uruguay is the least of the South American republics, but it is prosperous and progressive, for the population is intelligent and wide awake. The country is pastoral, however, with a recent leaning toward wheat growing, and offers a limited market for chemicals and allied products, as the following table will show.

Most of the fluctuations noted in the table can be traced readily enough to the war, but the falling off in foreign purchases of sheep dip must be attributed to the establishment of a local industry and the setting up of standards that are rather difficult for outsiders to attain. The Government is lending every encouragement to the domestic industry, as the product is a very important one in a country that depends so largely upon stock raising.

Statistics are given for the latest normal year for which official Uruguayan figures happen to be available in this country and for the latest war year. The valuations for these years are purely arbitrary and should be used only as a general guide. The statistics now being compiled for 1917 are based upon actual values and are said to be 30 to 150 per cent higher than the arbitrary values heretofore used.

URUGUAYAN IMPORTS OF CHEMICAL AND ALLIED PRODUCTS

ARTICLES AND PRINCIPAL SOURCES	1911	1915
ALCOHOL	$ 1,934	$ 141,605
Argentina	1,448	140,939
Germany	276	
CHEMICALS, DRUGS, EXPLOSIVES	752,490	823,548
Argentina	55,600	64,322
France	128,768	101,182
Germany	175,759	17,033
United Kingdom	228,948	205,979
United States	40,671	314,557
GLASS AND GLASSWARE	494,459	156,426
Belgium	203,590	12,232
France	37,986	12,450
Germany	162,768	14,469
United Kingdom	56,530	40,829
United States	10,123	22,817
OILS, EDIBLE	733,670	965,322
Italy	332,467	256,517
Spain	191,181	465,951
United States	158,375	198,751
OILS, INDUSTRIAL NOT INCLUDING KEROSENE	544,566	1,260,239
United Kingdom	43,308	63,360
United States	405,057	1,065,682
KEROSENE	902,150	1,132,163
United States	887,019	1,094,275
PAPER AND PAPER WARES	1,023,028	808,849
Belgium	220,389	27,381
Germany	317,255	35,238
United Kingdom	156,462	100,674
United States	98,468	189,850
MEDICINES, PROPRIETARY	76,595	91,335
France	22,657	38,673
United States	21,794	19,857
PERFUMERY	153,696	86,681
France	98,515	52,723
Germany	13,646	2,060
United Kingdom	29,831	11,105
SHEEP DIP	844,710	125,785
Argentina	60,485	17,778
United Kingdom	669,681	59,356
United States	36,330	8,400

American statistics show that the sales of certain chemical lines to Uruguay have increased since the war started, but comparatively they are unimportant, as a glance at the following figures for the fiscal years 1914 and 1917 will show:

AMERICAN PRODUCTS SOLD IN URUGUAY

ARTICLES	1914	1917
Asphaltum	$	$ 66,290
Blacking, shoe paste, etc.	9,003	17,014
Celluloid and manufactures	286	14,018
Cement, hydraulic	3,632	8,966
Chemicals, drugs, dyes, etc.:		
Acids	....	22,598
Alcohol, wood	....	5,413
Baking powder	13,735	9,013
Bark extract for tanning	....	23,639
Calcium carbide	21,413	8,538
Copper sulfate	4,338	39,367
Dyes and dyestuffs	....	52,647
Medicines, patent or proprietary	64,309	107,022
Petroleum jelly, etc.	2,707	5,592
Soda salts and preparations[1]	....	163,935
Sulfur (brimstone)	....	7,600
All other	56,610	269,372
Explosives:		
Cartridges, loaded	40,067	50,209
Dynamite	10,946	....
All other	2,612	5,731
Glass and glassware	10,948	81,271
Glucose	17,796	42,965
Grease:		
Lubricating	11,240	19,201
Soap stock, and other	....	1,462
India rubber manufactures	62,561	188,096
Ink	2,233	9,914
Leather, patent	6,105	15,432
Metal polish	62	3,853
Naval stores:		
Rosin	106,295	157,100
Tar, turpentine, pitch	....	50
Turpentine, spirits	24,527	19,366
Oils:		
Animal	....	467
Mineral:		
Gas and fuel	15,824	4,976
Illuminating	809,056	713,945
Lubricating, etc.	48,651	92,978
Gasoline	291,828	47,253
Other light	20,675	413,774

[1] Not stated separately in 1914.

AMERICAN PRODUCTS SOLD IN URUGUAY (*Concluded*)

ARTICLES	1914	1917
Vegetable:		
Corn	$ 13,978	$ 62,416
Cottonseed	334,381	147,425
Other fixed	....	6,806
Volatile	388	3,011
Paints, pigments, etc.:		
Dry colors	11,225	14,954
Ready-mixed paints	18,750	32,612
Varnish	5,678	25,839
White lead	426	13,112
All other	103	35,316
Paper and manufactures:		
Paraffin and paraffin wax	18,505	87,722
Perfumery, cosmetics, etc.	12,240	15,191
Soap:		
Toilet	6,021	12,418
All other	8,783	9,163

In chemical lines Uruguay makes no important contribution to the United States, as the following figures for the fiscal years 1914 and 1917 show:

URUGUAYAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Bismuth	$	$ 4,067
Blood, dried	12,751	50,803
Bones, hoofs, and horns	75,304	110,401
Fertilizers	88,141	124,684
Flaxseed	....	24,032
Glycerin	....	8,520
Grease and oils	....	16,520
Hide cuttings, and other glue stock	23,748	83,851
India rubber	....	53,015
Oleo stearin	....	28,705
Tin ore	....	70,078

ORIGINAL PAPERS

"JELLY VALUE" OF GELATIN AND GLUE

By A. WAYNE CLARK AND LOUIS DUBOIS

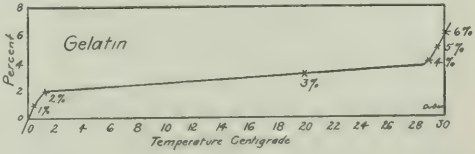
Received April 23, 1918

The examination of samples of glues and gelatins in this laboratory during the past ten or twelve years has included a test which we have designated as "jelly value." In making this test we have not followed the common practice of the makers of these products but have endeavored to improve upon it by following a procedure which produces results that can be expressed in absolute figures.

The system apparently in common use among the makers seems to be to make up a jelly of definite concentration and compare its physical strength with that of a standard sample.

The literature is exceedingly scant. Alexander[1] in an excellent paper has fully explained his methods and Fernbach[2] also goes into the subject in considerable detail. It seems to us, however, that our methods result in a more scientific presentation of the jelly-forming characteristics of these materials in that they can be expressed in per cent figures. Our practice has been to make up a series of glue or gelatin solutions of various known concentrations, cool them until well set, and then slowly warm them to a predetermined temperature and at that point note which concentrations are solid and which are liquid. We are then able to state that at a given temperature, the sample tested has a jelly value of, for instance, 6 per cent, meaning that the 3 per cent, 4 per cent, and 5 per cent trials were fluid, whereas the 6 per cent, 7 per cent, and 8 per cent trials were solid. This procedure obviates the use of all "shot tests" or weighed devices for testing the physical strength of a given jelly.

During the course of years in which these tests have regularly been made, we have used different temperatures for observing the setting of the water solution of the various percentages tried. The results have in many respects been quite unsatisfactory, until recently we have been able to carry out a considerable number of experiments to determine whether there might exist a trial temperature at which such mixtures show the best results. Our efforts have been rewarded by the discovery that there is in such mixtures a very plainly indicated temperature-range through which the "set" or "gel" of a definite concentration of solution is not changed. Our results, in general, as might be expected, are more satisfactory with gelatins than with glues and they are probably not as definitely useful in judging the strength of glues as in judging the quality of gelatin.

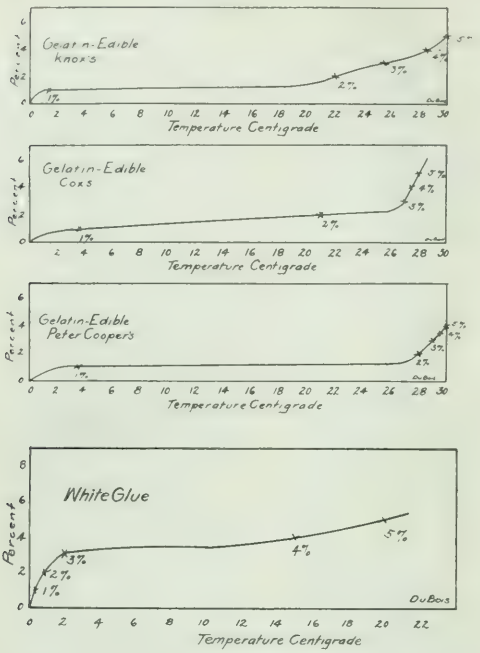


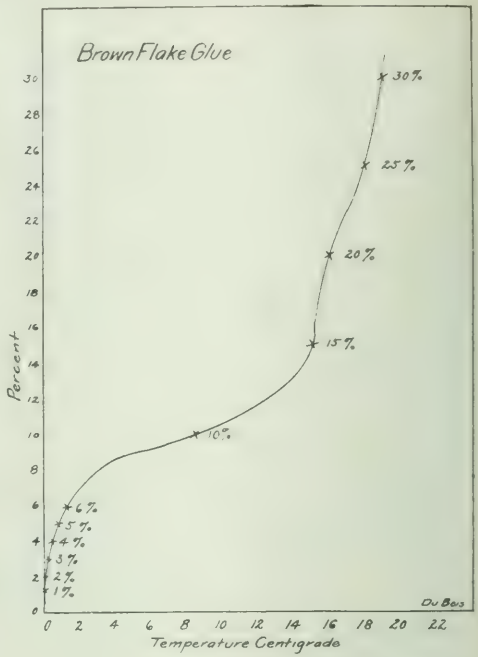
As to the character and sources of the samples used in obtaining the curves shown herewith, it will be necessary to state as follows:

The material designated "Gelatin" is a product

[1] "The Grading and Use of Glues and Gelatin," Jerome Alexander, *J. Soc. Chem. Ind.*, **25** (1906).

[2] "Glues and Gelatin," Fernbach, D. Van Nostrand Co., 1907.





regularly used in manufacturing processes and, as far as we have been able to ascertain, is of American manufacture. It is purchased from one of the most reputable of American manufacturers.

The "Gelatin Edible, Knox's," the "Gelatin Edible, Cox's," and the "Gelatin Edible, Peter Cooper's" were purchased in grocery stores for purposes of examination, as being reputable brands regularly on sale for household use.

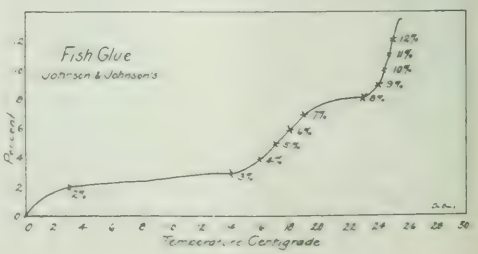
The so-called "White Glue" is simply a gelatin which might be called gelatin-glue, carrying a certain amount of white pigment.

The "Brown Flake Glue" is a common commercial variety used chiefly for the manufacture of paper boxes and other similar purposes where strength is not especially required.

The "Fish Glue" is a product about which we have complete information, as it is made in one of our own departments for use in coating court plaster and corn plasters where we are desirous of using a thoroughly standardized product well boiled for purposes of destroying pathogenic bacteria, etc. It is made from fish-sounds by thorough extraction with boiling water followed by protracted boiling in the steam kettle. This is then made into sheets and dried; in other words, it is straight first-class fish glue.

The method of procedure is to have on hand a sufficient number of ordinary 6-in. test tubes to include the range of percentages to be tried, each fitted with a cork and graduated for 10 cc. Into each tube is put a weighed amount of the granulated glue or gelatin sample and to these cool water is added up to the 10 cc. mark. A glass rod is now put into each tube and the contents stirred occasionally during several hours, after which the tubes are allowed to stand in boiling water until the sample is completely dissolved. The rod is now removed and the tubes tightly corked so as to avoid the formation of a skin on the surface of the solution when it cools. These tubes are then cooled considerably below the temperature at which the observation is to be made. They are then stood in water, which is allowed very gradually to come up to the desired temperature. Observation of the "set" is now made by tilting the tube to observe whether or not the jelly is solid. Naturally, this point is not absolutely accurate, but with tubes of uniform diameter the judgment of the "set" or "gel" is reasonably easy to make. It will be observed that this per cent is based on the weight of the solid and the volume of the liquid, as is usual under such conditions.

As a result of this investigation, it is evident that for practically all of this work a temperature of 10° C.



is the most valuable for comparative purposes. For instance, on the sample represented by the curve marked "Gelatin," it will be observed that the range of temperature between the points of liquefaction of the 1 per cent and the 2 per cent mixture is about one degree; also, that between 4 per cent and 6 per cent concentration it is about one degree, while between 2 per cent and 3 per cent the temperature range is about 18°. While in this particular instance the 10° point is no more valuable than the 16° point for a standard jelly-value temperature, yet taking this curve in conjunction with the others illustrated herewith, it will be seen that 10° C. is a good average working temperature-point for observation of the entire line of glues and gelatins.

RESEARCH LABORATORY
JOHNSON & JOHNSON
NEW BRUNSWICK, N. J.

A NEW METHOD FOR THE QUANTITATIVE ESTIMATION OF VAPORS IN GASES

A DIFFERENTIAL PRESSURE METHOD

By HAROLD S. DAVIS AND MARY DAVIDSON DAVIS

Received March 27, 1918

INTRODUCTION

In a former paper[1] a new form of tensimeter was described for measuring the partial pressure, in a mixture of inert gases, from any liquid or from its solution in a nonvolatile substance.

The ease with which these experiments could be carried out led us to experiment with modified forms of this apparatus, having in view the development of a method for the estimation of small quantities of vapors in inert gas mixtures.[2]

THEORY OF METHOD

According to the principle often referred to as Dalton's Law of Partial Pressures, the vapor pressure from a liquid is independent of the kind of gas above it, provided the gas is inert. Deviations from this law are well known, but it holds with surprising accuracy in the case of a mixture of benzene and air at atmospheric pressure, as has already been shown by one of us.[1]

Consider two closed flasks connected, as in Fig. I, by a manometer and filled with air at atmospheric pressure. If now a small sealed bulb containing a volatile liquid be broken in each, the liquid will partially evaporate, and if the temperatures of the flasks remain the same, the same additional pressure will be developed in each, so that the manometer connecting them will register no difference in pressure. Even if the temperatures of the flasks do vary, no difference in pressure will be recorded until there is a relative difference in temperature between them.

Now suppose that one of the flasks had contained a certain quantity of the vapor of the volatile liquid corresponding to a pressure less than the saturation pressure. When the small bulb of liquid was broken in this one, the liquid would not add all its vapor pressure to the pressure already in the flask, for part of that was already due to its vapor. It would add only the amount of pressure necessary to bring its pressure up to saturation; and since the total saturation pressure was added to the pure air in the other flask, the manometer connecting the two would register a pressure equal to the pressure of vapor in the original gas.

Two important points should be noted here:

1—The partial pressure of any particular vapor in a sample of gas is independent of the temperature of the gas, provided that the total pressure on the gas remains constant while the volume can change with the temperature, and provided the vapor remains always unsaturated and obeys the simple gas laws.

2—The difference in pressure developed between the two flasks, one of which contains air and vapor, and the other air free from vapor, will vary as the absolute temperature, provided the relative temperatures of the flasks remain the same; that is, for practical purposes, the difference in the pressure is independent of variations of temperature.

An apparatus constructed on this principle will, therefore, measure a definite quantity, *viz.*, the pressure of the vapor in a gas at any particular gas pressure.

The differential pressure which develops between the two flasks is equal to the original partial pressure of the vapor in the gas, when the total pressure on the gas is equal to the atmospheric pressure at the time of the experiment. This can be reduced to standard conditions in the following way:

Let P be the atmospheric pressure at the time of the experiment.

Let P_o be normal atmospheric pressure = 76 cm. of mercury.

Let X be the differential pressure developed between the flasks.

Then $\frac{XP_o}{P}$ is equal to the partial pressure of the vapor in the gas when the total pressure of the gas is P_o. As was pointed out before, the value $\frac{XP_o}{P}$ is independent of the temperature provided every component of the gas remains unsaturated.

In a similar way the total of the partial pressures of two or more vapors may be reduced to its value for a total standard pressure on the gas.

However, though this partial pressure of a vapor is independent of the temperature, the actual weight of the vapor contained in unit volume of the gas depends on the temperature. For one vapor this may be calculated from the partial pressure on the assumption that the vapor gives the same partial pressure as it would if it were a true gas at that temperature and molecular concentration.

SOURCES OF ERROR

1—The permanent gases in one of the flasks may dissolve in the liquid to a greater extent than those in the other flask and thus lower the pressure on that side.

[1] "The Extraction of Aromatic Hydrocarbons from Gases by Means of Liquid Absorbents," Harold S. Davis, University of Manitoba Publications, February, 1917.

[2] Most of the work was done during the early part of the summer of 1917 and the results under the same heading as that of this paper were given to the Canadian Advisory Council and to the Imperial Munitions Board of Canada. United States Patent No. 1,272,922 on this method was issued July 16, 1918.

2—The dissolved gases may lower the vapor pressure of the liquid to a greater extent in one flask than in the other and thus decrease the additional pressure developed in the former.

3—If there are other vapors present, these will partially dissolve in the liquid in the bottom of the flask, and thus their own partial pressure in the gas will be less, while, in addition, the vapor pressure from the liquid will be lowered.

If the gases in the two flasks are the same, these errors are negligible, for the only error is caused by the gas in one flask being at a slightly higher pressure than the gas in the other so that more of it will dissolve in the liquid. If, however, the gases are not the same, only careful experimentation will show the magnitude of the errors.

It is not necessary that the substance in the sealed glass bulbs should be in the liquid state, for, in the case of a substance which can exist as a solid under the conditions of the experiment, it is of course possible to estimate the amount of its vapor present in the gas by the same method. We have actually estimated quantities of benzene in gases at temperatures lower than 5°, using bulbs filled with frozen benzene. This will be described in another paper. A solution which has a vapor pressure of the particular substance to be estimated greater than that actually in the gas could be used under certain conditions.

EXPERIMENTAL PART

The apparatus used is of the form shown in Fig. I. Into the ground glass stopper of each of the flasks tubes are sealed; one of these terminates about 1 cm.

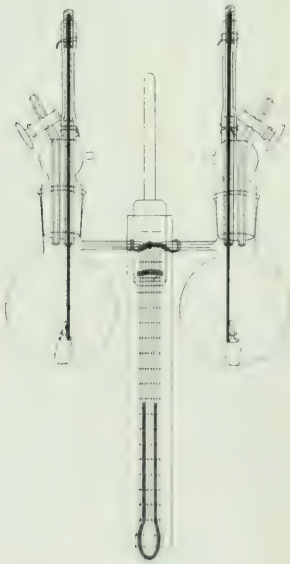


FIG. 1

above the stopper and through it a metal rod passes to the bottom of the flask, projecting above the stopper to a distance of 10 cm. The upper end of this rod is screwed into a short piece of metal rod of larger diameter. Over this rod, and extending down over the tubing which projects above the stopper, is slipped a piece of tightly fitting, rubber pressure tubing. The rubber joints are made tight by means of vacuum grease and wire. The second tube passing through the stopper is closed at the upper end by a stopcock. It simply provides a means for the passage of gases into or out of the flask and can as well be sealed into the side of the neck of the flask or the upper part of the manometer tube. In later work we have used it sealed into the manometer. To the bottom of the metal rod a small glass bulb is attached by means of small soldered supports and fine copper wire. This bulb, which has a thin bottom, contains sealed up inside some of the liquid whose vapor is to be estimated. By pushing down the rod at the proper time, or giving it a slight tap, the bulb at the end can be broken, thus liberating the liquid it contains. The rubber tubing then draws the rod back into place. The left flask is filled with the gas to be examined, at a pressure slightly above atmospheric. When the temperatures of the gases in the two flasks become the same, their pressures are equalized to that of the atmosphere by opening the stopcocks, which are then closed. This step is necessary if the temperature of the room or thermostat in which the experiment is being done varies to any extent.

Next, the small sealed bulbs containing the liquid are broken by pushing on the rods and the apparatus is allowed to stand, with an occasional shaking, until the manometer levels cease changing. The time required to reach equilibrium is 10 to 15 min. and 30 to 60 min. for flasks of 140 cc. and 340 cc. capacity, respectively. In routine work it is possible to hasten the evaporation of the liquid by heating the flasks, either gently with a flame or by immersion in a warm bath. In such a case it is necessary to guard against a leak through the extra pressure developed.

Two corrections must be applied to the difference in the mercury levels to obtain the true difference in pressure:

1—Reduction of the mercury height to 0° C. This can usually be neglected.

2—Correction for the increase in volume in the right-hand flask and the decrease in volume in the left-hand one, due to the movement of the liquid in the manometer tube. If, however, the flasks are fairly large and the bore of the manometer tube small, this correction can also be generally neglected.

Unfortunately it was impossible, at first, to obtain satisfactory apparatus and much of the following experimental work had to be done with flasks closed by corks instead of glass stoppers. Rubber stoppers cannot be used as they rapidly absorb benzene vapor and so cause serious errors. If the corks are boiled in soft paraffin they will hold a vacuum fairly well but are much inferior to glass stoppers. A little soft paraffin on the stoppers makes gas-tight joints, and to hold them securely in place thick rubber bands are slipped over their tops and fixed to small catches on the necks of the flasks.

In the first part of this work we introduced the gases into the flasks by simple displacement, but it is surprising how much gas is needed to completely displace the air from even a small flask and most of our troubles arose from overlooking this fact. About 5 liters will displace nearly all the air from a 300 cc. flask. We have since devised a slightly modified form of apparatus (Fig. II) which is filled by first evacuating the flask and then attaching to the gas supply. As will be seen, in this form the two flasks are close together, and the manometer tube is led out in front from them, so that the flasks may be placed in a bath of any kind while the manometer remains outside. Further, there is a stopcock above the mercury in the manometer tube on the side nearest the flask to be filled with the gas to be analyzed. This stopcock is closed before evacuating the flask. It allows the whole apparatus to be inverted without losing the mercury in the manometer tube.

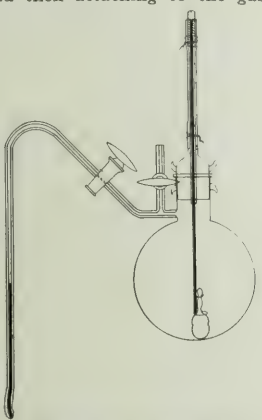


FIG. II—SIDE VIEW MODIFIED FORM OF DIFFERENTIAL PRESSURE APPARATUS (*Only One Flask Shown*)

The evacuation is carried out by a water pump which rapidly reduces the pressure to less than 1 cm. of mercury. The residual pressure is measured by a manometer in series with the pump. With this form of apparatus only a small quantity of gas need be collected for analysis. It can be kept, until required, in a small gas holder from which it is displaced into the apparatus by mercury. We have used gas holders of 300 cc. capacity with stopcocks at both ends. When one experiment is completed, the apparatus can easily and rapidly be cleaned for the next by drawing hot air through it.

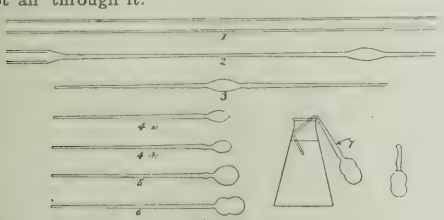


FIG. III

Naturally, in order to avoid fracture, the determination flasks should be of good uniform thickness, especially near the bottom where the little bulbs are broken. We have also lessened the danger of breakage by placing a thin piece of lead in the bottom of each flask. These precautions are useful when the bulb contains a solid, but when dealing with a liquid one need never break the bottom of a flask if the little sealed bulbs containing the liquid are made as shown in Fig. III.

The bulb is blown from a piece of glass tubing, preferably of a diameter not less than 0.8 cm. Our experience has been that if smaller tubing is used, bubbles form in the glass when it is blown; this may, however, be due to incorrect methods of procedure. This tubing, 1, is first drawn out as in 2 and a slight constriction made on each side, 3, for convenience later in tying the bulb to the bottom of the rod (see Fig. I). From 4 the round bulb 5 is blown and at once its bottom is heated in a mild flame and blown out in the form 6. Bulbs of this type will stand a wonderful amount of usage but can be broken on the bottom by a gentle pressure against any surface.

For filling, the neck of the bulb is bent in the form 7 and immersed in a narrow-mouthed vessel full of the desired liquid. On heating gently at intervals, the air is soon driven out, some liquid drawn over, vaporized, and the whole bulb filled with liquid. The liquid is now driven out from the capillary and the bulb full of liquid is sealed off with a small pointed flame at the point 7. In the case of benzene and toluene we have used a small naked flame for heating, and protected the flask by wrapping with asbestos paper. In this way a bulb can be filled in a few moments. Occasionally, one explodes and takes fire without serious results. If desired, one can work behind a glass screen. In the case of more volatile substances a liquid bath for heating and other such precautions could be used.

Another satisfactory method for filling the bulbs is as follows: The vessel containing the desired liquid together with a number of bulbs immersed in it, as shown in 7, are placed in a closed glass dish with a removable top, such as a desiccator. Next the air pressure in the desiccator is lowered by pumping out the air and is again brought to atmospheric by opening a stopcock. If this process is repeated a few times the bulbs will be completely filled with liquid.

We have given this description in detail, but when once mastered the manipulation is easy and two persons with only moderate experience in glassblowing can easily prepare twenty complete bulbs filled and sealed in an hour, casualties not being counted.

At first, we performed all the experiments in a thermostat with glass sides, the temperature of which remained constant to a few hundredths of a degree; but this is unnecessary. We have found it quite easy to obtain accurate results in a room where the temperature varied over several degrees.

Several samples of benzene obtained from well-known firms were used; on being distilled they boiled over constant to less than a tenth of a degree. Many of the preliminary results are omitted.

We attempted to check the benzene content in samples of air, containing known quantities of benzene, made up in the following way: Measured volumes of air, saturated with benzene vapor at a known temperature, were drawn from a 500 cc. flask and diluted with air over mercury. In the first 5 experiments given below, a 140 cc. determination flask was filled

by displacement of air with about 500 cc. of the sample of air and benzene vapor. This was a quantity far from sufficient to displace all the original air, and the results are low.

In Expt. 6, the flask was filled by displacement of mercury and the result is much better. In No. 7, a bulb containing a known weight of benzene was broken in a 5 liter flask slightly evacuated. Air was then admitted and the whole shaken up well by means of a small quantity of mercury in the bottom of the flask. After this, a 340 cc. determination flask was filled by displacement of air with the 5 liters of air and benzene vapor which were driven over by displacement with water.

PRELIMINARY RESULTS

Expt. No.	Difference in Pressure: Experimentally determined Cm. Hg	Difference in Pressure: Calculated Cm. Hg
1	0.67	0.85
2	0.94	1.06
3	2.40	3.00
4	2.30	3.00
5	2.00	2.60
6	1.38	1.50
7	2.31	2.45

In the final series of determinations a weighed quantity of benzene, less than that required for saturation, was introduced directly into the determination flask. This was accomplished by means of a second small, sealed bulb (Fig. IV) which contained a weighed amount of benzene. Its position could be regulated by means of the attachment screw A, so that on pushing on the rod the small bulb broke, leaving the larger one above it intact, to be broken later.



FIG. IV

In this way the actual pressure developed by the weighed amount of benzene could be measured, and the pressure could be checked by breaking the large bulbs according to the method already described.

FINAL RESULTS

Expt. No.	A: Wt. of benzene G.	B: Pressure calc. from gas laws Cm.	C: Pressure developed Cm	D: Pressure measured by new method Cm.	Percentage difference between B and average C and D	Percentage difference between C and D
1	0.0140	1.01	0.95	1.00	4.0	5.0
2	0.0204	1.43	1.46	1.46	2.0	0.0
3	0.0344	2.40	2.20	2.28	7.0	4.0
4	0.0618	4.32	3.79	3.80	12.0	0.2
5	0.0726	5.12	4.50	4.56	11.0	1.3
6	0.0763	5.34	4.48	4.54	16.0	1.3
7	0.0815	5.63	5.65	5.66	0.3	0.2
8	0.0819	5.64	5.11	5.29	8.0	3.6
9	0.0824	5.59	5.21	5.21	7.0	0.0
10	0.0839	5.91	5.50	5.41	8.0	1.7
11	0.0868	6.04	5.67	5.69	6.0	0.4
12	0.1015	7.02	6.42	6.41	8.0	1.4
13	0.1175	8.20	6.73	6.74	18.0	0.3
					Av., 7.4	Av., 1.5

DISCUSSION OF RESULTS

The agreement between the pressures of benzene actually developed and those determined by the new method is satisfactory. The average deviation is 1.5 per cent, but better agreement could undoubtedly have been secured by working in a thermostat, as the temperature of the room varied considerably.

The differences between the pressures actually developed and those calculated from the weights of benzene, the volume of the flasks being known, are fairly large; mean deviation, 7 per cent. In each case the pressure developed was less than the calculated.

These deviations may be attributed to two causes:

1—Impurities in the benzene and impurities collected from the interior surface of the flask. These impurities when dissolved in the last traces of benzene might lower its vapor pressure until it would cease to evaporate, being in equilibrium with the pressure in the flask. Naturally this tendency would increase as the amount of benzene pressure in the flask increased.

2—Divergence of the benzene vapor from the simple gas laws caused perhaps by polymerization, but the results show that this effect is not very large for pressures approaching saturation.

SUMMARY

I—A differential pressure method for the quantitative estimation of vapors in gases has been described.

II—Experimental results are given of the trial of this method for the estimation of quantities of benzene vapor in air.

DEPARTMENT OF CHEMISTRY, UNIVERSITY OF MANITOBA
WINNIPEG, CANADA

THE APPLICATION OF THE DIFFERENTIAL PRESSURE METHOD TO THE ESTIMATION OF THE BENZENE AND THE TOTAL LIGHT OIL CONTENT OF GASES

By HAROLD S. DAVIS, MARY DAVIDSON DAVIS AND DONALD G MACGREGOR

Received March 27, 1918

INTRODUCTION

It is unnecessary to dwell on the importance of the aromatic hydrocarbons, particularly benzene and toluene, at the present time, and on the necessity of increasing their output in every possible way.

A great need has been felt, by those engaged in the commercial production of these substances, for methods of analysis requiring only small samples of gas and giving a rapid estimation of the content of these vapors either collectively or individually. Such methods would make it possible to find the conditions of production necessary to obtain the maximum concentration of each aromatic substance and would also permit the efficiency of absorption processes to be tested at every point.

A method widely used at present for the estimation of these vapors requires the following steps:

1—Their absorption from a large measured quantity of the gas by means of a suitable solvent.

2—The distilling and fractionating of the solution thus obtained according to a definite scheme of operation.[1]

The absorption process most widely adopted for works purposes is the passage of the gas through a train of wash bottles filled with absorbing oils.[2]

The technique of this process as widely used in the United States has been fully described by F. W. Sperr.[3]

[1] H. G. Colman, *J. Gas Lighting*, **129** (1915), 314–315; H. W. James, *J. Soc. Chem. Ind.*, **35** (1916), 286.

[2] R. Lessing, *J. Soc. Chem. Ind.*, **36** (1917), 103.

[3] *Met. and Chem. Eng.*, **17** (1917), 548, 586, 642.

Absorption processes of a different kind have been proposed by R. Lessing[1] and H. H. Gray.[2]

Other methods[3] for the estimation of these vapors in gases are based on the fact that the vapors condense to liquids with negligible vapor pressures at low temperatures, while the permanent gases do not.

In the preceding paper there is described a differential pressure method for the estimation of a vapor in a mixture of inert gases.

The present paper[4] embodies the results of investigations on the application of this method to the estimation of a vapor in a mixture of other vapors and inert gases. In particular, we have studied the application of this process to the estimation of benzene and of the total light oil content in coal gas or coke oven gases.

RATE OF DEVELOPMENT OF THE DIFFERENTIAL PRESSURE

We have investigated more carefully the rates at which the vapor pressures are developed in the separate flasks, after the bulbs containing the liquid or solid are broken.

The rates of development of the vapor pressure from liquid benzene at 18° and from solid benzene at 0° were measured, with the results given below. About 1 g. of benzene was used in each case, in a 300 cc. determination flask, without shaking.

Benzene (liquid) 18.6°			Benzene (solid) 0°		
Time Min.	Pressure Cm. Hg	K	Time Min.	Pressure Cm. Hg	K
0	0	...	0	0	...
2	1.6	—0.054	5	0.67	—0.031
5	3.5	—0.058	10	1.23	—0.035
9	4.9	—0.055	15	1.54	—0.035
23	6.85	—0.056	25	1.90	—0.034
49	7.18(P_∞) (a)		35	1.99	—0.028
				2.21(P_∞)	

(a) P_∞ = saturation pressure at $t = \infty$.

If the rate of development of the pressure is proportional, at each instant, to the undeveloped pressure in the flask, and if we represent the time in minutes by t and the pressure in centimeters of mercury by p, then:

$$\frac{dp}{dt} = -K(P_\infty - p) \text{ and } \frac{1}{t}\log\left(1 - \frac{p}{P_\infty}\right) = K \text{ (a constant).}$$

The actual value of K would depend on the conditions of temperature, the surface of benzene exposed, the volume of the flask, etc., which conditions must approach constancy for any given determination.

As will be seen from the tables given above, the values of K calculated in each case from the experimental results are sensibly constant. It thus appears that the pressure is an exponential function of the time.

Consider a differential pressure apparatus containing air in each side, in which bulbs of benzene are broken at the same time. The pressures will develop exactly alike so that at no time is there any difference of pressure indicated. Now suppose, on one side, there is an original pressure of benzene. Then a difference of pressure slowly develops. This can be demonstrated to be an exponential function of the time similar to that of the pressure in either flask and it can be shown that at any time

$$\frac{\text{Difference in pressures}}{\text{Maximum difference in pressures}} = \frac{\text{Pressure developed in either flask}}{\text{Maximum pressure developed in that flask}}$$

This important result shows the great advantage of the differential pressure method. Consider the determination, at ordinary temperature, of the benzene pressure in a sample of gas containing 1 cm. pressure of benzene. When the benzene pressure on each side is 95 per cent developed, the differential pressure reading will be 0.95 cm. instead of the correct 1.00 cm., an error of 5 per cent. On the other hand, if instead of the differential pressure method, a method is used in which only one flask is employed, and the pressure obtained by breaking the benzene bulb is subtracted from the saturation pressure at that temperature, the error is much greater. For now at 95 per cent saturation, the numerical value of the error in the result is 5 per cent of the saturation pressure (about 10 cm.) or about 50 per cent of the original vapor pressure in the gas.

ESTIMATION OF BENZENE VAPOR IN THE PRESENCE OF TOLUENE VAPOR

Our next work on this subject concerns the estimation of benzene when toluene vapor is also present. A known amount of toluene vapor was introduced into the air of one of the flasks. Bulbs of benzene were afterwards broken on each side. If now the toluene did not dissolve in the benzene, the same benzene pressure would be developed in each flask and the manometer reading would not change. On the other hand, if the toluene dissolved in the benzene to any extent, the pressure developed in the flask containing the toluene would be less than in the other.

We were well aware that the toluene would dissolve in the benzene to some extent, but as the flasks used had a capacity of 150 cc. to 350 cc. and as the quantity of benzene used was less than 1 g. in each case, it

[1] *J. Soc. Chem. Ind.*, **36** (1917), 103.

[2] *J. Chem. Soc.*, **111** and **112** (1917), 179.

[3] St. Claire Deville, *J. des Usines a Gaz*, **1889**; Lebeau and Damiens, *Compt. Rend.*, **156** (1913), 144, 325; Burrell, Seibert and Robertson, U. S. Bureau of Mines, *Technical Paper* **104** (1915); Burrell and Robertson, THIS JOURNAL, **7** (1915), 669; H. F. Coward and F. Bailey, *Manchester Lit. and Phil. Soc.*, **34** (1916)

[4] After the work on the present paper was completed, the comprehensive article from the U. S. Bureau of Standards on the "Recovery of Light Oils and the Refining of Toluol" appeared in THIS JOURNAL, **10** (1918), 51. In the same number of THIS JOURNAL, p. 25, is an article by R. P. Anderson on the "Determination of Benzene Vapor." This contains a summary of the various methods which have been employed for the estimation of benzene vapor in gases and proposes a method on which he has done preliminary work. In this method the benzene content is to be estimated by measuring the increase in volume of the gas mixture when placed in contact with liquid benzene. He also points out that a similar method differing only in detail had been developed by the Société Roubaisienne d'Eclairage par le Gaz and R. R. L. H. Fortrieres. For an account of the specifications of the German patent on this method see *J. Soc-Chem. Ind.*, **33** (1914), 129.

seemed probable that the toluene would not appreciably dissolve out from the gas before equilibrium had been reached by the evaporating benzene. Otherwise, the toluene would first have to diffuse from all parts of the flask into the outer layer of liquid benzene and then from this layer through the main body of the liquid itself.

Experiment has shown that these ideas were erroneous; the toluene rapidly dissolved out from the gas in the flask into the liquid benzene. It seems impossible that this should be due to simple gas diffusion; it must rather be caused by convection currents in the gas. We attempted to prevent such currents by surrounding the liquid benzene with fine copper gauze, but without success.

Below are given summaries of a few of these experiments, some performed at ordinary temperatures and others at the temperature of melting ice.

The following points are to be noted in interpreting the results:

1—The benzene bulb in the flask containing the toluene was always broken first, so that the benzene pressure was always a little higher on that side at first. Accordingly, the toluene really dissolved out more quickly than would appear from the table.

2—The rates at which the difference in pressures developed in the several experiments are not strictly comparable, because it was impossible that the interval between the breaking of the bulbs should be the same in each case, and that the contents of the bulbs should be uniformly distributed on breaking.

3—In comparing the final differences in pressure, it must be remembered that the magnitude of these depended on the amount of liquid benzene left in the flask. If this was large, the lowering of its pressure caused by the dissolved toluene was small, and *vice versa*. This effect is discussed in detail later in the paper.

4—In the experiments in which solid benzene was used, there was sufficient toluene present in the flask to cause the benzene in that flask to melt.

No.	Temp	Kind of Material in Bulbs	V. P. of Toluene in Flask Cm	Difference in Pressures Developed between Flasks Time in Minutes 1 Cm.	3 Cm.	6 Cm.	7–10 Cm.	10–15 Cm.	20 Cm.	30 Cm.	60 Cm.	80 Cm.
1	22°	Liquid benzene	2.37	0.30	0.74	1.54	1.90	2.41	..	..		
2	24°	Liquid benzene surrounded by copper gauze	0.27	..	..	0.22	0.29	0.39	..	..		
3	22°	Liquid benzene	2.05	0.80	1.20	..	2.00	..	..	..	2.41	
4	24°	Liquid benzene	0.24	..	..	0.39	..	..	0.82	..		
5	23°	Liquid benzene	0.45	..	0.46	..	..	0.94	0.98	1.00		
6	0°	Solid benzene 0.075 G.	0.22	..	0.04	0.12	0.15	..	0.32	0.34		
		Toluene 0.006 G.	..	..	..	..	..	..	..	..		
7	0°	Solid benzene 0.090 G.	0.32	..	0.33	..	..	0.62	..	..		
		Toluene 0.009 G.	..	..	..	..	..	..	..	..		
8	0°	Solid benzene 0.98 G.	0.24	..	..	0.27	..	..	..	..		
9	0°	Solid benzene 0.81 G.	..	..	..	..	..	..	..	..		
		Toluene 0.008 G.	0.24	..	0.11	..	..	0.24	0.27	..		
10	0°	Air saturated with toluene	..	..	..	..	..	0.23	0.41	..		

In most of the observations recorded in this table, the difference in pressure had ceased to increase at the time of the last observation. The greater part of this pressure, however, was developed in the first 15 min., yet the flasks had not been shaken and the liquid benzene lay undisturbed on the bottom. When it is considered that the difference in pressure was due to toluene dissolved in the benzene and that this toluene had to be absorbed out of the gas in a 300 cc. flask into about 1 cc. of liquid benzene on the bottom, one cannot but be struck by the comparative speed of the process of absorption. It may well be that it is not so difficult to wash these aromatic hydrocarbons from gases as has often been supposed, a conclusion of great importance for industrial absorption plants.

VARIATIONS IN THE DIFFERENTIAL PRESSURE, DEPENDING ON THE QUANTITY OF LIQUID USED

If the gas to be analyzed contains only one vapor, together with inert gases which are insoluble in liquid of the same composition as the vapor, the differential pressure developed will not vary with the amounts of liquid used. On the other hand, suppose the vapors of two completely miscible liquids are present. If an attempt is made to estimate one of these vapors by the differential pressure method, with bulbs containing its liquid, the actual difference in pressure developed between the two flasks will depend on the amount of liquid used, as the following considerations show:

Consider a mixture containing inert gases and two vapors, benzene and toluene, for example. Let a bulb of pure benzene be broken in each of the flasks of the apparatus. Then in the one, A, containing pure air, the full pressure of benzene for that temperature is developed.

In the flask B, containing the vapors and inert gases, the following conditions exist at equilibrium:

1—The toluene has dissolved in the benzene until its solution in the benzene gives a vapor pressure of toluene equal to the residual vapor pressure of toluene in the gas.

2—The dissolved toluene has lowered the vapor pressure of the benzene.

Consequently a difference in pressure has been developed between flasks A and B, made up of the following factors:

(*a*) The original vapor pressure (unsaturated) of benzene in B.

(*b*) The original pressure of the toluene vapor which is now dissolved in the benzene in B.

(*c*) The lowering of the vapor pressure of the liquid benzene in flask B by the dissolved toluene.

Pressure developed between A and B = $a + b + c$.

Consider now the variations in the final differential pressure between A and B, caused by using different quantities of liquid in flask B. As these quantities are increased, Factor (*b*) becomes larger, and approaches a limiting value, which would represent the dissolving of all the toluene in the liquid benzene. At the same time, Factor (*c*) approaches a value infinitely small. The difference in pressure developed between the two

flasks at this limiting value P_∞ is equal to the sum of the original vapor pressures of benzene and toluene in the gas.

If now the quantities of liquid benzene are decreased, Factor (*b*) approaches a value infinitely small, which would exist if the quantity of liquid benzene used were so minute that only an infinitely small quantity of toluene could be dissolved from the gas. In this case, Factor (*c*) increases to a limiting value, equal to the lowering of the vapor pressure of benzene caused by the dissolving of sufficient toluene to give a vapor pressures of toluene from the solution equal to that originally present in the gas. The difference in pressure developed between the two flasks at this limiting value, P_o, is equal to the sum of the original vapor pressure of benzene in the gas and the lowering of the vapor pressure of benzene from a solution of toluene which gives a vapor pressure of toluene equal to that in the original gas.

The approximate form of this curve is shown in Fig. I.

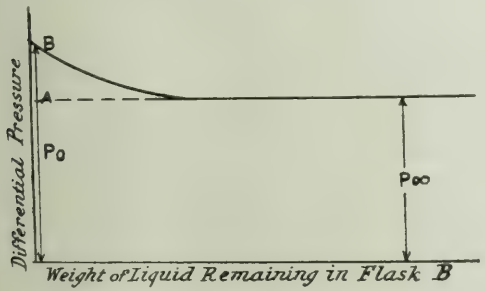


FIG. I

$P_o - P_\infty = AB =$ Limiting value of lowering of v. p. of benzene—Original v. p. of toluene in gas.

It is now necessary to obtain a relation between the two factors on the right-hand side of the equation, that is, a relation between the original pressure of toluene in the gas and the lowering of the vapor pressure of benzene in a solution of benzene and toluene which gives a vapor pressure of toluene equal to that in the original gas.

Let there be N_1 molecules of benzene and N_2 molecules of toluene in the solution

Let P_b be the saturation pressure of pure benzene at that temperature

P_t, the saturation pressure of pure toluene at that temperature

T, the original vapor pressure of toluene in the gas

$$\text{Lowering of v. p. of benzene} = \frac{N_2}{N_2 + N_1} P_b$$

$$\text{Lowering of v. p. of toluene} = \frac{N_1}{N_1 + N_2} P_t$$

$$\text{Or, v. p. of toluene from solution} = \frac{N_2}{N_1 + N_2} P_t$$

$$\text{Therefore, } \frac{\text{Lowering of v. p. of benzene}}{\text{v. p. of toluene from solution}} = \frac{P_b}{P_t}$$

Or substituting in the relation obtained above:

$$P_o - P_\infty = AB = T\left(\frac{P_b}{P_t} - 1\right)$$

At 25° the ratio of the vapor pressure of benzene to that of toluene is about 10 : 3, so that

$$AB = T\left(\frac{10}{3} - 1\right) \text{ or about } \frac{7}{3} T$$

Thus AB represents the vapor pressure of toluene originally present in the gas, magnified about $\frac{7}{3}$ times. Suppose that instead of toluene, the original mixture had contained the vapor of some less volatile liquid, a xylene for example. Then AB would represent the original vapor pressure of the xylene magnified to a still greater extent than was that of toluene. It is therefore evident that when the differential pressure method, employing bulbs of liquid benzene, is used for a gas mixture containing benzene vapor and the vapors of high boiling compounds, the vapors of these compounds will cause a sharp increase in the differential pressure in those cases in which minute quantities of benzene remain in Flask B.

We have tested these conclusions experimentally on a sample of illuminating gas collected in small gas holders. The gas was passed through them in series for a time sufficiently long to ensure a uniform sample.

The apparatus used was of the modified type described in a previous paper. In an apparatus of this form one of the flasks can first be evacuated and then filled with the gas to be analyzed. The flasks were of about 150 cc. capacity each. The results of these experiments are given in the table. The high values obtained in Nos. 6 and 9 are undoubtedly due to experimental error.

Expt. No.	Wt. of Benzene[1] Grams	Liquid Benzene[2] Grams	Differential Pressure[3] Cm.
1	0.0586	0.0066	2.83
2	0.0617	0.0087	2.34
3	0.0707	0.0177	2.33
4	0.0978	0.0448	1.20
5	0.1092	0.104	1.00
6	0.129	0.124	(1.29)
7	0.140	0.139	0.97
8	0.214	0.209	0.96
9	0.314	0.309	(1.11)
10	0.957	0.948	1.04
11	1.20	1.20	1.39

[1] Represents the weight of liquid benzene broken into Flask B.

[2] The calculated weights of benzene which remained at equilibrium some having evaporated into the flask.

[3] The pressure difference between the two flasks, with corrections for initial difference and manometer movement.

These results are plotted in Fig. II. It seems reasonable to suppose that the elevation of the curve from

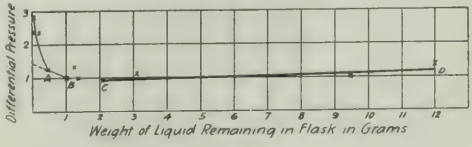


FIG. II

B to A is mainly due to toluene. This curve projected would meet the axis at a point corresponding to a vapor pressure of 1.4 cm. The constancy of the pressures in Nos. 7 and 8 would indicate that under these conditions all the toluene and other vapors had

dissolved in the liquid benzene. The average value of these pressures is about 0.97 cm.; or the limiting value of the elevation AB due to toluene is 1.35 — 0.97 = 0.38 cm.; that is, the original vapor pressure of toluene in the gas was about 0.15 cm.

The gradual elevation of the curve from C to D is undoubtedly due to increasing absorption into the liquid benzene of some constituents of the gas other than the light oils. As this effect was not very pronounced, it seems probable that in experiments done in this way when the volume of liquid benzene used is about 0.2 to 0.5 per cent of the volume of the flask, the difference in pressure developed represents the total pressure of the light oils in the gas.

The following experiment was carried out on illuminating gas, in order to test the solubility of the permanent gases in benzene:

A sample of illuminating gas was shaken up for a long time with two successive portions of straw oil (sp. gr. 0.87), such as is used in commercial works to remove the light oils from gases, until it seemed probable that these hydrocarbons had been removed from the gas. The left flask contained gas with the benzene, etc., removed by oil washing; the right, air.

The pressure developed was 0.02 cm. less in the left than in the right. This result indicates that the errors, caused by the permanent gases in coal gas dissolving in the benzene, are small. The experiment, however, should be repeated with more detail.

NEW METHOD FOR THE ESTIMATION OF BENZENE IN A GAS CONTAINING ALSO TOLUENE AND OTHER VAPORS

In a former paper it has been shown that the amount of benzene in an inert gas can be accurately estimated by the differential pressure method, using bulbs of liquid benzene. It has been shown above, however, that when the gas also contains toluene and other light oils, the following factors must be considered:

1—The toluene and other light oils dissolve in the liquid benzene so that their pressures are almost entirely removed from the gas, while at the same time these dissolved substances lower the vapor pressure of the benzene.

2—A less serious error is caused by the gases other than the light oils dissolving in the liquid benzene.

In order to eliminate these sources of error, we have conducted investigations on gases by the differential pressure method, using bulbs filled with solid benzene and immersing the apparatus in a bath below the freezing point of benzene, 5.48°. It is well known that the solubility of permanent gases in a solid, such as frozen benzene, is vanishingly small, so that the second source of error mentioned above is completely eliminated.

Again, the vapor pressure from the solid benzene, at any fixed temperature, is independent of the solution by which it is surrounded, so that while the solid benzene is present at equilibrium there can be no lowering of its vapor pressure.

Moreover, there are certain definite pressures of the light oil vapors which, at definite temperatures, can be in equilibrium with solid benzene. Any smaller pressures of these vapors will not be affected by the breaking of the bulb containing solid benzene. The following considerations make this clear:

Suppose that the light oil in the gas, besides benzene, is toluene. We are then to calculate the maximum quantity of toluene that can be in equilibrium with solid benzene, the temperature being known.

For each temperature there is a solution of toluene in benzene which would be in equilibrium with solid benzene. Its concentration can be calculated from the formula for the depression of the freezing point:

$$T = \frac{W_1}{M} \times \frac{K}{W_2}$$

Where T = depression of freezing point of solvent (benzene)

W_1 = weight of dissolved substance (toluene)

M = molecular weight of dissolved substance (92)

W_2 = weight of solvent (benzene)

K = molecular depression constant of solvent (4900)

so that

$$\frac{W_1}{W_2} = \frac{T \times M}{K} = \frac{92\,T}{4900} = \frac{T}{53}$$

If the weight of benzene (W_2) be 78, or 1 gram-molecule, then the weight of toluene (W_1) is $\frac{78 \times T}{53 \times 92} = 0.017\ T$ gram-molecules. But the solution in equilibrium with the solid benzene may be considered as a solution of benzene in toluene. Knowing its concentration, the vapor pressure of toluene from this solution can be calculated in terms of the vapor pressure of pure toluene at that temperature, by the modified equation of Raoult:

$$\frac{\Delta P}{P} = \frac{n_1}{N_1 + N_2}$$

Where N_1 = number of gram-molecules of benzene

N_2 = number of gram-molecules of toluene

$\frac{\Delta P}{P}$ = fractional lowering of toluene vapor pressure

$$\frac{\Delta P}{P} = \frac{1}{1 + 0.017\ T}$$

At 0° C., T = 5.5°

Therefore, $\frac{\Delta P}{P} = \frac{100}{109}$

Or, the vapor pressure of toluene from the solution is $\frac{9}{109}$ of the vapor pressure of pure toluene at that temperature (about 6 mm.) = 0.5 mm. This, then, represents the possible concentration of toluene vapor in equilibrium with solid benzene at 0° C.

In these calculations we have assumed that the simple law for the depression of the freezing point given above holds good over the range of temperatures considered. We intend to test this experimentally. If there are deviations they will probably tend to make the concentrations of toluene vapor

which can be in equilibrium with solid benzene greater than those calculated above. We also expected that the method for the estimation of benzene could be used in the presence of still larger quantities of toluene vapor on account of metastability of the benzene crystals, provided they were well frozen.

Similar reasoning will apply to a gas mixture containing benzene with xylene or other vapors.

In order to test these conclusions a series of experiments was carried out in the following way:

Air saturated with toluene vapor by bubbling it through toluene in a Geissler absorption tube was collected in a eudiometer. From this a measured quantity was drawn into the left flask of the differential pressure apparatus evacuated sufficiently to receive it. Determinations were also made with both toluene and xylene vapors present. In this case quantities of air separately saturated with the vapors were drawn into the eudiometer. These quantities were measured, so that the pressure of each vapor in the flask could be calculated for the temperature of the experiment.

The apparatus was then packed in snow, or snow and brine, which was kept well stirred, and the determination carried out in the usual way. Special care must be taken in breaking the bulbs of solid benzene in order not to fracture the bottoms of the flasks. The rod should be hit, not a hard blow, but a series of taps with a light object (we used the handle of a small screw driver). The bulb soon breaks and the solid benzene settles down in small pieces.

Expt. No.	Temperature of Bath	Calculated Pressures of Vapors in Flask Cm.	Pressure Developed Cm.
1	—4.4°	Toluene 0.078	—0.035
2	—8.0°	Toluene 0.122	—0.085
3	—8.3°	Toluene 0.155	—0.021
4	—6.6°	Toluene 0.167 Xylene 0.023	—0.055
5	—5.8°	Toluene 0.122 Xylene 0.034	—0.218
6	—5.0°	Toluene 0.237 Xylene 0.067	—0.011

In not a single case was the differential pressure developed towards the flask containing the vapors. This indicates that these vapors did not dissolve in the solid benzene. On the other hand, a small variable pressure was developed the other way. We are unable to say whether this was due to some source of experimental error in the particular apparatus used or whether it was actually caused by the presence of the toluene and xylene. We intend to investigate this phenomenon further.

Tests of this method for the estimation of the benzene and of the light oil content were carried out on a sample of illuminating gas collected in small gas holders.

The following results were obtained:

Expt. No.	Temperature	Difference in Pressure Developed Cm.
1	—17°	0.61
2	—18°	0.61
3	0°	0.58
4	0°	0.62
5	0°	0.60
6	4.5°	0.88
	6.5°	1.12
7	4.5°	0.91
	5.1°	0.98
	5.6°	1.12
8	22°	0.94
	20°	1.01

The following points are to be noted:

1—The pressure developed was practically constant from —17° to 0° C. This value (0.60 cm.) probably corresponds to the pressure of benzene vapor in the gas.

2—The first part of Expts. 6 and 7 was in each case carried out in a water bath at a temperature below the melting point of benzene. The result, 0.98 cm., obtained at 5.1°, when some solid benzene was present on both sides, probably represents the total pressure of the benzene and the light oils, for at a temperature so near the melting point of benzene the latter must have nearly all dissolved out.

3—The latter parts of Expts. 6 and 7 were done at a temperature slightly above the melting point of benzene and the difference in pressure read after all the solid benzene had disappeared. The high value 1.12 cm. obtained for the differential pressure is probably caused by solution in the liquid benzene of constituents from the gas other than the light oils.

4—The mean of the values obtained at room temperature (0.97 cm.), bulbs of moderate size being used, probably represents the total light oil content in the gas as has already been shown in this paper.

To sum up, determinations made at 0°, that is, in melting ice, gave the benzene content in the gas; and those done at ordinary temperatures with the proper proportions of liquid benzene gave the total light oil content.

Samples of illuminating gas, collected in small gas holders, were also analyzed by the method outlined above, at 23°, the following liquids being used in the bulbs:

1—Benzene only.

2—A solution of equal volumes of benzene and toluene.

3—A solution of equal volumes of benzene, toluene, and xylene.

The following results were obtained:

	Benzene Cm.	Benzene and Toluene Cm.	Benzene Toluene Xylene Cm.
Differential Pressure(1)	1.03	0.99	0.99
(2)	1.00	1.06	1.14
Mean.	1.02	1.03	1.06
Total Pressure Developed	9.0	5.0	4.0

In the first case, the toluene and xylene from the gas dissolve in the benzene. In the second case, the pressures of both the benzene and toluene from the solution in the bulbs are greater than their original pressures in the gas; they are estimated by the same principle. In the third case, all three vapors are estimated in this way. It is seen that the mean values of the results are about the same in every case, which confirms the conclusion given above, that when benzene is used in the bulbs at ordinary temperature, the differential pressure represents the total light oil pressure in the gas.

The advantage of using one of the solutions rather than pure benzene in the bulbs is seen in the figures representing the total pressures developed, for in these cases the pressures developed are much smaller, so that the danger of leakage is greatly decreased.

PRELIMINARY WORK ON THE VARIATION IN THE CONCENTRATION OF LIGHT OILS IN THE COAL GAS PRODUCED AT VARIOUS STAGES OF CARBONIZATION

We have shown above that the differential pressure method, bulbs of liquid benzene being used, gives an easy and fairly accurate method for the estimation of the light oil content of a gas mixture.

In order to obtain some idea of the change in the light oil content of coal gas as carbonization proceeds, we carried out the following experiments on one of the retorts of the Winnipeg Electric Railway Gas Plant: Through a hole drilled in the door of the retort, samples of gas were drawn off from time to time, washed with water, and the light oil content estimated. A 340 cc. estimation flask was filled by displacement of air with 2 to 3 liters of gas. This was not sufficient and the results are probably low, though they are comparable with each other, as the treatment was uniform throughout.

Time Min.	Light Oil Content of Gas Cm. Hg
0(*a*)	0.94
13	0.70
52	0.56
102	0.29
186	0.21
227	
240(*b*)	

(*a*) Retort charged with coal.
(*b*) Carbonization complete, retort emptied.

It will be seen that the gas which came over the first hour was rich in light oil; after that the content steadily declined.

COMMERCIAL POSSIBILITIES OF THE METHOD PARTICULARLY IN CONTROLLING THE PROCESS OF ABSORPTION OF LIGHT OILS AT RECOVERY PLANTS

Before the complete development of the apparatus and methods outlined above, we carried out, with considerable success, a series of tests on the absorption plant of the Toronto Chemical Co., at Sault Ste. Marie.

There seems to be no doubt that the methods of analysis outlined in this paper will be of great assistance in the control of the washing processes and in the development of more economical methods of light oil recovery. This will be taken up in more detail in a subsequent paper.

SUMMARY

I—The rate of development of the differential pressure in the new method for the estimation of vapors in gases has been investigated.

II—Theoretical considerations and experimental data are given concerning the estimation of one vapor in the presence of other vapors by the differential pressure method.

III—Theoretical considerations and experimental data are given concerning the variations in the differential pressures obtained according to the quantity of liquid used.

IV—A new method for the estimation of the benzene and of the total light oil content of gases has been developed.

V—A brief account is given of preliminary investigations, by this process, on the production of light oils during carbonization of coal. The utility of the methods developed in this paper for commercial processes is discussed.

We gratefully acknowledge the aid of the Honorary Advisory Council for Scientific and Industrial Research in Canada, which has made possible the assistance of Mr. MacGregor in this work.

Department of Chemistry, University of Manitoba
Winnipeg, Canada

STUDIES ON THE ABSORPTION OF LIGHT OILS FROM GASES

By Harold S. Davis and Mary Davidson Davis

Received March 27, 1918

INTRODUCTION

The physico-chemical aspects of the processes by which "light oils" are absorbed from gases are constantly receiving more attention by those concerned with their production at recovery plants. It is now recognized that the light oil vapors are not simply washed out of the gas mechanically, but are dissolved by the wash oil to form a true solution. At the same time, ideas as to what actually occurs in the process of absorption are not very definite. Two causes might be given for this:

1—The light oil mixture is considered to behave as a single compound, whereas the different chemical substances of which it is composed act independently of each other to a large extent, particularly as they are in the vapor state.

2—There is much confusion as to when an oil is to be considered saturated with respect to the light oils. This can be attributed partly to the reason given above and partly to a lack of clear understanding of the principles governing the dissolving of the vapors by the wash oil. Statements to the effect that the washing oil must exert a good solvent action on the light oils illustrate this lack of clearness.[1]

THEORY OF WASHING PROCESS FOR THE ABSORPTION OF BENZENE VAPOR

Consider a bubble of gas at a definite pressure and temperature, surrounded by the pure washing liquid. Suppose, further, that benzene is the only light oil vapor present in the gas, then benzene will dissolve in the oil until the vapor pressure of benzene from the surrounding oil is equal to that in the gas. It follows that the maximum content of benzene which can be absorbed by the oil from the gas is that which gives a vapor pressure of benzene from the solution equal to the vapor pressure of benzene in the gas.

Consider a scheme such as is given in Fig. I for washing the gas continuously with oil. The gas passing from A to B meets the oil travelling in the opposite direction. At B, fresh oil takes out the last traces of benzene from the gas, since such oil has no vapor pressure of benzene. The oil thereby acquires a vapor pressure of benzene proportional to its benzene content, and in passing from B to A it continuously

[1] This Journal, **10** (1918), 53. *Trans. Am. Inst. Chem. Eng.*, **9** (1916), 174.

meets gas with a higher vapor pressure of benzene, until at A it should leave with a vapor pressure of benzene equal to that in the gas entering at A. The benzene is separated by distillation from the oil at C and the debenzolized oil re-enters the absorption column at B.

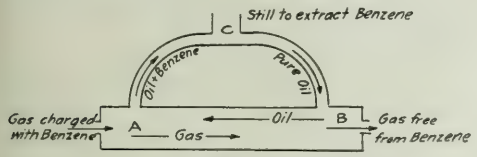


FIG. 1

To ensure complete removal of the benzene from the gas the following conditions are necessary:

(1) The contact between gas and oil in the space A to B must be sufficiently good to nearly maintain equilibrium at every point. The amount of oil which needs to be actually in contact with the gas at any time is determined by the rate at which the benzene vapor is absorbed into the oil, that is, by the efficiency of the washers.

(2) The rate of flow of the oil must be so regulated that the quantity of benzene, carried from the washers per second, shall be equal to the quantity brought in by the gas. It has been shown above that the washing oil can absorb only a definite proportion of benzene. If this proportion is known and the rate of passage through the washers, then the rate of flow of the oil necessary to completely remove the benzene from the gas can be readily calculated.

(3) The poor oil which enters the washers must be completely free from benzene *for no amount of washing will ever lower the vapor pressure in the poor gas below that from the poor oil with which it is finally washed.* The presence of benzene in the poor oil means that the steam distillation is inefficient and does not completely separate the benzene from the washing oil. Such inefficiency may cause a very serious loss to the plant, for the fraction of benzene lost will be the ratio of the vapor pressure of benzene from the poor oil to that in the rich gas.

In the previous paper, methods for measuring this ratio were described by means of which a check can be kept on the efficiency of the washing system and the still.

The following experimental work was undertaken to examine the conditions which determine the maximum benzene content which the oil can absorb from the gas.

THE DETERMINATION OF THE VAPOR PRESSURE OF BENZENE FROM ITS SOLUTION IN HIGH-BOILING AMERICAN PETROLEUM OIL

The benzene used in these experiments was obtained from a well-known firm. It was of high quality and when freshly distilled, the greater part boiled over at a temperature constant to much less than a tenth of a degree. It was then boiled in vacuum to expel dissolved air.

The oil used in these experiments had been refined from a mixture of American crude petroleums. It was obtained through the kindness of Mr. E. Bernard Smith, manager of the Dominion Tar and Chemical Company, who supplied the following details concerning its properties:

Distillation—First drop	278° C.
1 per cent	280° C.
87 per cent	360° C.
Specific Gravity—0.870 at 15.5° C.	

We found the sp. gr. to be 0.8677 at 23.1° C.

An approximate estimation of the vapor pressure of the oil at 100° C. was made by introducing it into a Torricelli vacuum. The result showed that the vapor pressure was small, certainly not more than 1 cm. at 100°, and therefore probably negligible at room temperature. The benzene and oil were miscible with each other in all proportions at ordinary temperatures. A 50 per cent solution deposited crystals of benzene at about —10° C.

The apparatus used was a simple form of the differential pressure apparatus described in the previous papers. However, only one of the flasks was provided with the special device by which a small sealed bulb of liquid could be broken inside it. The other flask, which was simply used to compensate for changes in temperature and atmospheric pressure contained only air.

By breaking a bulb of benzene in the first flask the saturation vapor pressure of benzene in air was measured. When the vapor pressure from a solution in the oil was desired, the bulb containing a known weight of benzene was broken in a known amount of oil in the bottom of the flask and a solution of the benzene was formed in the oil.

COLLECTED EXPERIMENTAL RESULTS

SOLUTION	Temperature	V. P. of Benzene Cm. Hg	Ratio V. P. Benzene / Per cent Solution
Pure benzene	23.2° C.	8.43	...
8.70 per cent benzene in oil	23.2° C.	1.99	0.229
4.74 per cent benzene in oil	23.2° C.	1.08	0.228
10.65 per cent benzene in oil	41.2° C.	5.20	0.488

DISCUSSION OF RESULTS

According to the experimental results, the vapor pressure of benzene at 23.2° C. from two solutions in oil, one of approximately double the concentration of the other, was directly proportional to the concentration; that is to say, the vapor pressure of benzene from a solution in oil and the concentration of benzene in the oil are related according to Henry's Law for the solubility of gases in liquids—a result of great theoretical and practical importance.

A further important principle can be deduced from the following table:

Temp.	V. P. of Benzene from a 1 per cent Solution in Oil Cm.	V. P. of Pure Benzene Cm.	Ratio V. P. of 1 per cent Solution / V. P. of Pure Benzene
23.2° C.	0.228	8.5	0.026
41.2° C.	0.488	19.2	0.025

That is to say, the ratio of the vapor pressure of benzene from a solution of definite concentration to the vapor pressure of the pure solvent is independent of the temperature (Von Babo's Law).

It is now possible to calculate the vapor pressure of benzene from a solution of any particular concentration at any temperature, since the vapor pressure of

pure benzene is known at that temperature, and also the ratio borne to it by the vapor pressure of benzene from a 1 per cent solution in oil.

The following table is calculated, on the assumption that the two laws given above hold over the ranges of conditions concerned, for a gas containing 1 mm. vapor pressure of benzene.

Temp	V. P. of Benzene Mm.	V. P. of Benzene from a 1 per cent Solution Mm.	Maximum Concentration Benzene Absorbable by Oil Per cent	Fresh Oil Grams Oil per cu. m. of Gas	Fresh Oil Required Gals. Oil (U. S. A.) per 1000 cu. ft. of Gas
−20° C.	5.8	0.15	6.6	70	0.53
−10° C.	12.9	0.33	3.0	150	1.15
0° C.	25.3	0.66	1.5	300	2.17
10° C.	45.3	1.18	0.85	540	3.74
20° C.	75.7	1.97	0.50	920	6.04
30° C.	120	3.12	0.32	1400	9.22
40° C.	183	4.76	0.21	2200	13.62

The amount of fresh washing oil required for any particular rate of flow of gas depends only on the temperature of washing. At first we thought that, if the benzene content of the rich gas varied, the rate of flow of oil necessary to completely absorb it from the gas must vary too. Consideration shows that this is not the case. Suppose the benzene content in the rich gas is doubled; then the maximum benzene content in the rich oil is also doubled; for, according to Henry's Law, the vapor pressure from the oil is proportional to the benzene content. Hence the same rate of flow of oil as before will suffice to remove all the benzene from the gas.

THE DETERMINATION OF THE AVERAGE MOLECULAR WEIGHT OF THE OIL WHEN DISSOLVED IN BENZENE BY THE METHOD OF THE LOWERING OF THE FREEZING POINT

It is evident from the experimental data given above that the efficiency of a medium for absorbing benzene from gases is determined by its power to lower the vapor pressure of benzene when dissolved in it. For dilute solutions in common solvents this power of lowering the vapor pressure is inversely proportional to the molecular weight of the dissolved substance. We suspected that this relation might hold for very concentrated solutions of washing oil in benzene.

The molecular weight of the oil when dissolved in benzene was determined in the ordinary way by Beckmann's method, using 19.88 g. benzene.

Weight of Oil Added	Lowering of Freezing Point Produced	Calculated Lowering of the Freezing Point per Gram of Oil
0.3813	0.450° C.	1.181° C.
0.4566	0.500° C.	1.095° C.
1.2617	1.180° C.	0.935° C.

It will be seen from the right-hand column that the proportional amounts of lowering caused by the weights of oil grew continually less. Extrapolation gives about 1.2° as the amount of lowering per gram of oil, when a small amount of oil was added. This corresponds to a value of 205 for the average molecular weight of the oil when dissolved in benzene.

The proportional lowering of the vapor pressure of benzene caused by the addition of 99 per cent of oil can now be calculated from the equation of Raoult:

$$\frac{\Delta P}{P} = \frac{n}{n + N}$$

Where ΔP = Lowering of the vapor pressure
P = Vapor pressure
n = Gram-molecules of dissolved substance
N = Gram-molecules of solvent

99 g. of oil = 0.48 gram-molecules of oil.
1 g. of benzene = 0.0128 gram-molecules of benzene
So that for a 99 per cent solution of oil in benzene
Fractional lowering of vapor pressure =

$$\frac{\Delta P}{P} = \frac{0.48}{0.48 + 0.0128} = 0.974$$

And the fraction of vapor pressure left is 0.026, in excellent agreement with the experimental result 0.026.

The determination of the molecular weight of an oil when dissolved in benzene seems therefore to afford a good method for testing the efficiency of the oil for absorbing benzene or other vapors from gases.

THEORY OF WASHING PROCESSES FOR THE ABSORPTION OF LIGHT OIL VAPORS

We shall base the following discussion of the process of absorption of light oils into washing oils on two premises, both of which are supported by the experimental data given later in this paper:

1—That each separate vapor contained in the gas dissolves in the washing oil, independently of the other vapors present, until equilibrium is reached between its vapor pressure in the gas and its vapor pressure from the oil solution.

2—That when washing of moderate efficiency is employed, equilibrium between the oil and each of the light oil vapors is reached much more quickly than has often been supposed.

Of course, each of the constituents of the gas, other than the light oils, also dissolves in the washing medium until corresponding equilibrium is reached, but as only a small amount of these substances need dissolve to secure equilibrium with the gas, their effect may be neglected.

Although it is necessary that the washing medium be able to dissolve the liquid light oils in fairly large quantities, it must not be supposed that the ability to dissolve these liquids is a measure of the efficiency of the oil as an absorbing medium. As a matter of fact, all the high boiling oils usually employed for scrubbing purposes are largely or completely miscible with the liquid light oils.

It has been pointed out above that the efficiency of an oil for absorption purposes depends on its power to lower the vapor pressures of the light oils when they are dissolved in it, and that this power depends on the average molecular weight. Other properties of the washing medium, such as viscosity, boiling point, tendency to froth, etc., may affect its usefulness as a washing medium, but they do not determine its ability to absorb the various vapors, if equilibrium is nearly reached at each stage of the washing. For, according to our first assumption, given above, each vapor can be absorbed into the washing medium until its vapor pressure from the solution is equal to its vapor pressure in the gas at that point.

In a washing process on the counter-current principle, the oil flowing in one direction meets the gas.

passing in the other direction. The oil constantly absorbs vapors from the gas, equilibrium between the vapor pressure of each substance in the gas and its vapor pressure from the oil being nearly maintained at every stage. But the oil does not become saturated with every vapor at the same stage of the washing, rather, the stage at which the oil becomes saturated with respect to any one vapor is determined by the saturation vapor pressure from the pure liquid of the same composition as the vapor in question.

Consider the absorption of benzene and toluene vapors from the gas into the oil. As long as the process of washing is so regulated that all these vapors are removed from the gas, then the number of gram-molecules of each of these substances in a definite quantity of rich oil is proportional to its original pressure in the rich gas. These dissolved quantities of the hydrocarbons, however, do not give vapor pressures from the solution proportional to their original vapor pressures in the rich gas.

For instance, the benzene content in the rich oil has reached its maximum when it gives a vapor pressure of benzene equal to that in the rich gas. Yet at this stage the dissolved toluene only gives a pressure from the oil equal to a fraction of the toluene pressure in the rich gas. This fraction is equal to the ratio of the saturation pressure of pure toluene to that of pure benzene, as may be proved from the following considerations:

Let X_b = original vapor pressure of benzene in the rich gas

X_t = original vapor pressure of toluene in the rich gas

N_1 = gram-molecules of benzene and N_2 gram-molecules of toluene contained in a definite quantity of rich gas

N = number of gram-molecules of washing oil necessary to completely remove all the benzene from the quantity of gas considered on a counter-current process

P_b = saturation pressure of pure benzene

P_t = saturation pressure of pure toluene

Y_b and Y_t = vapor pressure of benzene and of toluene, respectively, from the oil solution

Then $\frac{X_t}{X_b} = \frac{N_2}{N_1}$, and applying Raoult's equation,

$$Y_b = \frac{N_1}{N_1 + (N + N_2)} P_b,$$

$$Y_t = \frac{N_2}{N_2 + (N + N_1)} P_t$$

Or, $$\frac{Y_t}{Y_b} = \frac{N_2 P_t}{N_1 P_b}$$

Or, $$Y_t = \frac{Y_b X_t P_t}{X_b P_b}.$$

When the oil is saturated with benzene $X_b = Y_b$,

and $$Y_t = X_t \frac{P_t}{P_b}.$$

At 25° the vapor pressure of benzene is about 10 cm., of toluene about 3 cm., and of *m*-xylene about 0.9 cm., so that when the rich oil is saturated with benzene it is only $^3/_{10}$ saturated with toluene and $^9/_{100}$ saturated with xylene. Any attempt to obtain a higher percentage of toluene or xylene in the rich oil will result in loss of benzene, for some will now pass through without being absorbed.

It is evident that such terms as "saturation content of the oil" or "maximum enrichment of benzol," where benzol means light oils, have no concrete meaning.

If by the maximum enrichment of the washing oil is meant the maximum quantity of light oil which it can contain, without any light oil passing through the washing process unabsorbed, then it is reached when the vapor pressure from the washing medium of the lowest boiling compound in the light oil, in this case benzene, is equal to its pressure in the rich gas.

SATURATION OF THE RICH OIL

Confusion in regard to the principles outlined above is shown by a method in use for determining whether sufficient washing oil to remove all the light oil vapors is being brought in contact with the gas. In this method, fresh gas is passed through the rich oil; if the oil is found to take up additional quantities of hydrocarbons from the gas, as evidenced by an increase in weight, it is considered as having been unsaturated. To obtain the saturation content, gas is passed through the rich oil until it ceases to increase in weight, at which point it is considered saturated, all lower concentrations being considered unsaturated.

If the gas contained but one vapor, or several vapors dissolving as a single component, this conclusion would be correct. But in the case of a gas containing several vapors acting independently, as does the coal gas in question, the problem is very different.

Consider what happens when such a method is used on the coal gas of our experimental work, with an average benzene content of 6 mm. and an average toluene content of 1.5 mm.

Consider a typical absorbing oil (sp. gr. 0.87) with an average molecular weight of 205.

It has been shown above that the proportional lowering of the vapor pressure of benzene caused by the addition of 99 parts of oil is 0.9737, and the fraction of vapor pressure left is 0.0263. Similarly for toluene, it can be shown that the fraction of vapor pressure left is 0.0222.

The following table can then be calculated for any temperature, *e. g.*, 26° C.

Substance	Saturation Pressure Cm	V. P. 1 per cent Solution Cm.	Possible Concentration in Oil at 26° C. Per cent
Benzene.....	10	0.26	2.3
Toluene.....	3	0.066	2.3

As the amount of toluene in the rich gas is to the amount of benzene in the rich gas in the ratio $\frac{1.5}{78} : \frac{60}{92}$, it follows that when the oil has taken up 2.3 per cent of benzene, it will have taken up only 0.68 per cent of toluene, which is about $^5/_{17}$ of the possible amount. Or, toluene can still be taken up to the amount of 30 per cent of the total possible hydrocarbon content.

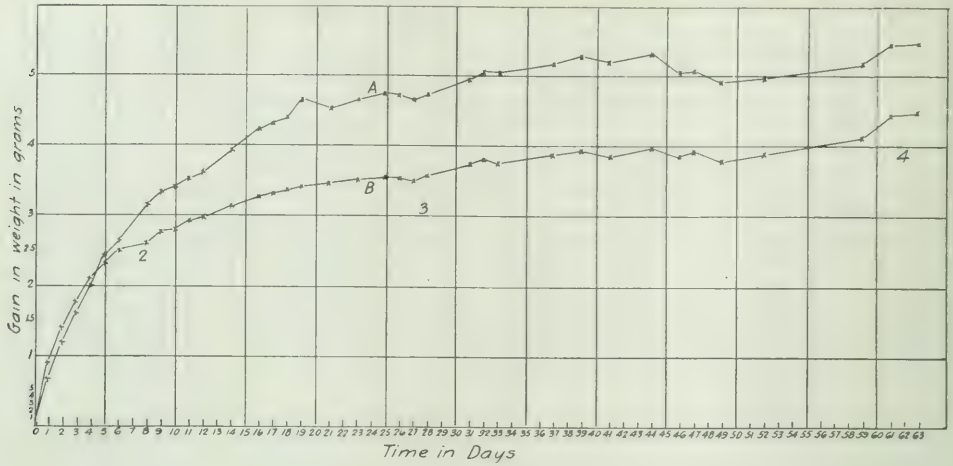


FIG. II

Similar considerations apply to the small quantities of high boiling compounds which exist in the gas and which are soluble in the oil. Each of these compounds will continue to be absorbed until the vapor pressure from the oil equals its vapor pressure in the gas. At the same time, the constitution of the oil solution will slowly change, and its absorbing power will be gradually modified. These factors would result in a steady, slow increase in the amount of the total hydrocarbons absorbed over a comparatively long period.

EXPERIMENTAL PART

EXPERIMENT I—In the first experiment, two conical flasks, A and B, of 125 cc. capacity, were used, containing, respectively, 103.8 g. and 101.8 g. of a typical straw oil (sp. gr. 0.87; average molecular weight, 205). Illuminating gas from a gas jet was bubbled through each, the pressure being regulated by stopcocks in the inlet tubes. At first the gas passed through at an average rate of 2 liters per hour, being somewhat faster in the case of B. Later, however, the gas was passing through A at a considerably faster rate than through B. This accounts for the curves of A and B crossing each other.

Both the ingoing and the outgoing gas passed through cotton wool, to prevent loss of weight from the oil passing over. The outgoing gas led to a Bunsen burner. In this and subsequent experiments the gas flasks were packed with wool in a copper container which was immersed in the water of a thermostat regulated at 26°.

The experiment ran from October 20 to December 26, the flasks being weighed every one or two days. There was trouble at the last, due to loss of weight by the passing over of the oil, particularly in B, so that the final results are somewhat low.

A few of the results are given below; they are shown completely in the curves plotted in Fig. II.

Time Days	Gain in Weight A Grams	Gain in Weight B Grams
1	0.675	0.917
8	3.192(a)	...
12	...	2.998(a)
19	4.687(b)	...
31	4.973	3.731
67	5.613	4.318

(a) At 2.98 per cent the oil should be nearly saturated with benzene (see above).

(b) At 4.6 per cent the oil should be nearly saturated with benzene and toluene if nothing else be present. As it is, the percentage will be somewhat higher.

EXPERIMENT II—A second series of determinations was carried out, this time using as absorbing flasks Bender and Holbein's potash bulbs, C and D, which contained 7.95 g. and 9.93 g. oil, respectively. Gas bubbled through C at the rate of one liter in 32 min., and through D at the rate of 1 liter in 17 min. The experiment was run from December 19 to 22, when it was found necessary to discontinue on account of the oil passing over.

Time Days	Gain in Weight C Gram	Gain in Weight D Gram	Gain in Weight C Per cent	Gain in Weight D Per cent
1	0.358	0.479	...	...
3	0.404	0.541	5.08	5.45

EXPERIMENT III—In the next experiment the bulbs C and D were connected in series, and gas from the mains bubbled through at the rate of 2 liters per hour, being washed first by D and then by C. It was found necessary to use an aspirator in order to obtain a flow of gas. C contained 10.6 g. and D, 10.4 g. oil. About 73 liters of gas passed through; the bulbs were weighed every hour. The experiment was run from January 1 to 18, at the end of which time D had gained 0.371 g. and C, 0.324 g. The complete results are plotted in Fig. III.

EXPERIMENT IV—In order to have a constant gas supply for this experiment, a 100 liter tank was filled with illuminating gas, by displacing water from it. It was so arranged that the pressure could be regulated as desired. The gas drawn from the tank was re-

placed by water, which was first saturated with illuminating gas.

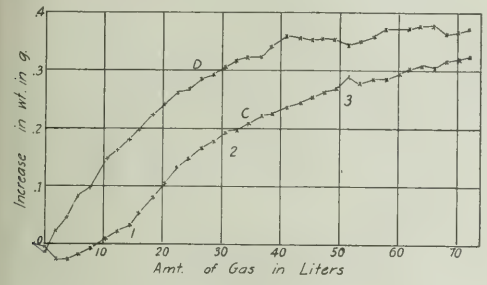


FIG. III

The expt. itself was substantially the same as Expt. III. The same bulbs were used, C containing 10.2 g. and D, 9.2 g. of oil; C was connected to the gas supply. The gas, as before, was drawn through by means of an aspirator at the rate of 2 liters per hour, 40 liters being drawn through altogether. The weights of the bulbs were taken every hour. The experiment was carried on from January 21 to January 25, when C had gained 0.293 g. and D, 0.215 g. The results are plotted in Fig. IV.

DISCUSSION OF EXPERIMENTAL RESULTS

The general form of the absorption curves in Fig. II is clear. There is first a fairly rapid, steady increase of weight (1 to 2), then a slower increase of weight (2 to 3), and finally a very slow increase (3 to 4) extending over a long period. We believe that the first rapid increase is due to the absorption of the benzene vapor from the gas, equilibrium being quickly attained. The next increase (2 to 3) is caused by the toluene and the xylenes, while the final slow increase (3 to 4) is caused by the absorption of the high boiling compounds existing in the gas in minute quantities.

If this explanation is correct, the following conclusion may be drawn:

When the oil has once become saturated with benzene and toluene, which form the greater part of the light oils absorbed from the gas, a lowering of the gas pressure will cause their concentrations in the oil to decrease, for some of the benzene and toluene will be lost. At the same time the other vapors will continue to be absorbed, but in such small quantities that the net result will be a loss of weight. The theory is pretty well substantiated by the curves of the first experiment, for after the point 2 has been reached, a great many fluctuations appear. Changes in atmospheric pressure which amounted to 25 mm. during the course of the experiment, variations in gas pressure, and possibly small changes in the concentration of light oil vapors in the gas, are undoubtedly responsible for these fluctuations.

In Fig. III, the curve, representing the gain in weight of the first bulb, is of the same form as the curves of Fig. II, and the same considerations apply to it. In regard to the curve representing the gain in weight of the second bulb, the following points should be noted:

At first there is a very slight increase in weight, then a rapid increase, so that the curve at 1 is convex towards the "x" axis. In the region of 2 the slope of the curve decreases, there being possibly a further decrease later on at 3.

If our explanation of the first curves is correct, and if equilibrium is really closely maintained at every stage, so that the gas coming into the second absorption bulb contains that amount of each vapor which is in equilibrium with its solution in the oil of the first bulb, the following argument holds:

Since it is the benzene pressure in the oil of the first bulb which grows most quickly, the toluene next, etc., one would expect the increase in weight of the second bulb to grow slowly at first, then rapidly until the oil approaches saturation with benzene, when it would fall off. As it approaches saturation with benzene and toluene, it should fall off still more. The absorption of the other substances from the gas would continue slowly, but a very long time would be necessary for the oil in the second bulb to become saturated with them, particularly with the high boiling compounds. Hence the percentage increase in weight of the second bulb would take a very long time to reach that of the first.

As shown in Fig. III, the curve was of the general form which we had anticipated.

Another factor tending to make the gain in weight of the second bulb always lower than that of the first was the necessity of using considerable aspiration in order to maintain a flow of gas, so that the pressure on the gas was always less in the second bulb than in the first.

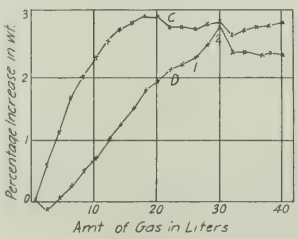


FIG. IV

At the point 1 in Fig. IV we put considerable pressure on the gas and regulated its outflow from the second bulb by a stopcock. The pressure on the gas in the second bulb being thus increased, there was a sudden gain in weight. When the pressure was decreased to its original value, the increase in weight dropped correspondingly, as indicated at the point 2 in the figure.

EXTRACTION OF TOLUENE FROM GASES

We have pointed out above that if the rate of flow of the wash oil is just sufficient to extract all the benzene from the gas, all the toluene is also extracted at the same time, but the oil never becomes saturated with respect to toluene. If the aim of the washing is to extract toluene only, a method of procedure much desired at the present time, then much less oil need be

used for washing. It has already been shown that only one-third as much oil is theoretically necessary to completely absorb all the toluene, as to completely absorb all the benzene.[1] It follows that if just this quantity of oil is used, about two-thirds of the benzene will pass through unabsorbed. Of course, in addition to the toluene, all the higher boiling compounds will be completely extracted from the gas.

In most commercial processes for the extraction of light oils, the gas is passed through several towers in series. Evidently the only advantage that several towers have over a single one is that they prolong the contact between gas and oil, so that equilibrium is more nearly reached at every stage. If this equilibrium is actually nearly maintained and if the rate of flow of oil is just sufficient to remove all the light oils from the gas, it follows that practically all the toluene will be absorbed in the first third of the tower system.

Confirmation of this tendency of the toluene to be absorbed in the first towers is obtained by a consideration of the relative proportions of benzene and toluene in the gas and in the tar formed at the same time. This tar may be considered as the first washing medium for light oils through which the gas has passed. The ratio of the toluene to the benzene in samples of English tar was 0.9 to 1.1; in samples of German tar, 0.4 to 0.6;[2] that is, the toluene content is about 70 to 80 per cent of the benzene content, whereas in coal gas the toluene content is only about 25 to 30 per cent of the benzene content.

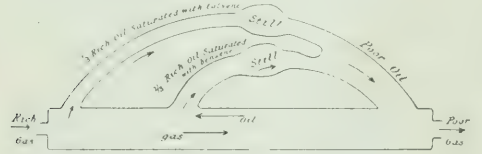


FIG. V

This tendency of the toluene to be absorbed into the first towers can, perhaps, be utilized in a system of washing such as that illustrated in Fig. V, so that all the toluene could be obtained in a relatively small amount of washing oil and benzene. The greater part of the expense and difficulty in a commercial plant comes, not in the washing of the gases, but in the separation of the light oils from the wash oil by steam distillation and in the fractionation of the light oils. The separation into the fractions is never complete, the large quantity of benzene always containing a small quantity of the more valuable toluene. It seems rational then to avoid as far as possible the mixing of the toluene with the benzene and to collect and distil the rich oil collected in the first part of the washing system separately from the rest of the oil.

ABSORBING MEDIA

We have already shown that, for the oil of our experiments, with an average molecular weight of 205, the maximum benzene content obtainable at 26° C. from a gas with a benzene content of 6 mm., is about 2.3 per cent, while the maximum light oil content is about 3 per cent. This result of course could be obtained only if there were perfect washing, *i. e.*, if equilibrium were exactly maintained at every point. In actual practice this maximum content would necessarily be somewhat lower.

These results agree with the statement of Sperr[1] that "in best practice, the amount of benzol absorbed (technically, the 'enrichment') is kept between 2 and 3 per cent of the absorbing oil."

Lunge,[2] however, states that one observer obtained an increase of weight in an oil of 20 per cent, and that another observer records an increase in weight of 10 per cent caused by the absorption of benzol. It is difficult to interpret these results without more specific data, as will be clear from the discussion of "saturation" given above. Still, unless these high results were due to the pressure on the gas being greater than atmospheric, they could be due only to the following causes:

1—High content of light oil in the gas.

2—An absorbing oil of low molecular weight.

If the results quoted above are correct they indicate great possibilities from the study of conditions necessary to produce the maximum content of light oil during carbonization. They also indicate that research may lead to the development of washing media with all the desired qualities of boiling point, fluidity, etc., having at the same time a comparatively low molecular weight. While to a certain extent the molecular weight of a compound determines its physical properties, such as the boiling point, still, exceptions to the general rule may be turned to good account in the development of new washing media.

Such media could absorb much larger quantities of the light oils than is possible for the washing oils at present employed.

SUMMARY

I—It has been shown, experimentally, that two important laws can be applied to the vapor pressure of benzene from its solution in oil: (1) Henry's Law for the solubility of gases in liquids; (2) Von Babo's Law for the constancy of the fractional lowering of the vapor pressure from a solution over variations of temperature.

II—These principles have been applied to calculate the flow of oil necessary to completely remove the benzene from a gas.

III—The molecular weight of a typical washing oil when dissolved in benzene has been found and a calculation made of the fractional lowering of the vapor pressure of benzene by the addition of 99 per cent oil. A method based on these results is suggested for standardizing oils in regard to their efficiency for absorbing vapors from gases.

IV—The theory of washing processes for the removal of a mixture of light oil vapors completely from a gas is discussed.

[1] The use of prebenzolized wash oil for the recovery of toluene from gases was advocated at a conference on coal supplies held at Manchester in 1915. THIS JOURNAL, **7** (1915), 438.

[2] Lunge, "Coal-Tar and Ammonia," 1916, **1**, 506, 509.

[1] *Met. and Chem. Engr.*, **16** (1917), 137.

[2] *Loc. cit.*, 67, 72.

V—The "saturation" of the rich oil is considered.

VI—Experimental data are given of the rates of gain in weight of absorbing vessels filled with wash oil when illuminating gas was passed through them.

VII—The extraction of toluene from gases is discussed and suggestion made for a more efficient scheme of washing in order to increase the yield of pure toluene.

VIII—The possibility of obtaining better washing media, through research, is suggested.

Department of Chemistry
University of Manitoba
Winnipeg, Canada

THE EFFECT OF FROST AND DECAY UPON THE STARCH IN POTATOES

By H. A. Edson

Received June 18, 1918

Severely chilled, frosted, and decayed potatoes are regarded by the trade, the grower, and the general public as worthless. On theoretical grounds, however, such material would seem to possess a potential value for starch production nearly or quite equal to that of sound stock. It is a matter of common knowledge among potato pathologists that the starch granules of frozen potatoes, and of most decayed stock as well, present a normal appearance under the microscope.

Decay in potatoes is initiated in most cases either by frost or by fungi, followed of course by bacteria, but often the bacteria play a relatively unimportant part in the process, except perhaps in the final stages. Southern bacterial rot, black-leg decay, and bacterial decay following flooding accompanied by high temperatures, constitute the most important exceptions to this general rule. The total amount of destruction from these three last-mentioned causes, however, is relatively small. In New York and New England, and in a few other regions, late blight decay is quite destructive certain seasons on stock from unsprayed or improperly sprayed fields. In these cases the destruction is accomplished largely through the action of so-called secondary organisms to which the *Phytophthora* gives entrance. Among these secondary invaders, *Fusaria* of various species are frequently encountered. Powdery dry rot, jelly-end rot, numerous types of dry rot as well as several soft or wet rots are caused by one or another species of *Fusaria*. Potato leak in California is caused by *Pythium*. Taking the country as a whole, parasitic *Fusaroa*, and frost in field, storage, or transit, combined with the parasitic and saprophytic *Fusaria* which usually follow frost, are responsible for the destruction of enormous amounts of potatoes. Shippers have expressed the opinion that frost is the most important single cause of loss encountered after the crop is harvested.

Since much of this injury seems more or less inevitable and is likely to continue, the question of possible salvage is worthy of consideration and one who is not primarily concerned with problems of potato utilization may be permitted to bring to the attention of those interested certain facts regarding this neglected source of starch supply with which he has become familiar during the prosecution of his duties as a potato pathologist. As already stated, the microscope indicates that the starch in frozen and in most decaying stock is normal. The action of frost and the results of invasion by organisms of decay appear to be exercised upon the lamellae of the walls and the protoplasmic contents of the cells rather than upon the starch. Such physiological studies as have been conducted upon the organisms under consideration indicate that most of them are either entirely incapable of cleaving starch or that their amylolytic power is weak. This is especially true of the filamentous fungi involved, but it also applies to many of the bacterial species associated in the decay of potatoes. This explains why the starch granules often remain free from corrosion even in cases of advanced decomposition.

With these facts in mind, preliminary trials were undertaken to further establish the action of decay-producing organisms upon potato starch, and the possibility of its recovery from frozen and from decayed material. The first tests were conducted upon frosted and decayed potatoes obtained during routine examination in connection with the service of the Bureau of Markets for inspection at destinations. Four types of material were included:

1—Frozen potatoes which had not been allowed to thaw.

2—Frozen potatoes subsequently thawed and softened, but not materially decayed.

3—Fusarium decayed stock in which the indications were that slight field frost undetected at the shipping point probably predisposed the material to decay.

4—Decayed portions only of the material described in 3.

The potatoes were pulped by grinding in a small hand corn mill and the starch recovered by repeated, successive shakings with 10 or 15 volumes of water, sedimenting the pulp, and decanting the supernatant liquid. For the final purification only 1 or 2 volumes of water were used.

Since the original weight of the samples before injury could be determined only for 1, the percentage yields could not be calculated, but they appeared to be normal in amount and they were certainly of good quality and free from odors. That from 4 (decayed portions only), while a good white starch, was not so clear as that from the other three classes of material. This was due in part to the fact that the sample was not washed before pulping and particles of earth sedimented with the starch. The microscope revealed also a considerable number of free, unbroken cells with their starch content intact embedded in the pure material. The brownish cellulose walls of these cells doubtless contributed to the discoloration.

In another series of experiments Green Mountain potatoes from the same sack were employed. Eleven samples of equal weight were washed and treated as indicated below:

1—Normal; extracted at once for a control.

2—Frozen solidly; thawed and extracted after an interval of one day.

3—Frozen solidly; thawed, heavily inoculated with a mixed spore suspension of potato-destroying *Fusaria*, held in the laboratory 4 days at about 70° F., and extracted.

4—Same treatment as 3, but held for 16 days.

5—Same treatment as 3, but held for 20 days.

6—Normal; extracted at close of experiment as control.

7—Inoculated with *Fusarium oxysporum* and held in a moist incubator at 25° C. until completely decayed.

8—Inoculated with *Fusarium radiciola* and held in a moist incubator at 30° C. until the greater portion of each of the tubers decayed. The rot obtained was in some cases dry, in others wet.

9—Inoculated with *Fusarium radiciola* and held in a moist incubator at 30° C. with abundant aeration until completely decayed. The rot obtained was altogether very wet and soft.

10—Inoculated with *Rhizopus* and held in a moist chamber in the laboratory until most of the tissue was involved in decay. The rot was dry and apparently due in part to *Rhizopus* and in part to other fungi and bacteria present.

11—Inoculated with *Pythium debarayanum* and held at room temperature, approximately 70° F., until decay resulted.

The results are briefly presented in tabular form below:

TABLE I—YIELDS OF STARCH FROM DECAYED POTATOES

No.	Treatment	Yield Per cent	Grade
1	Control	10.29	1
2	Frozen, held 1 day	10.30	2
3	Frozen, inoculated, held 4 days	9.93	2
4	Frozen, inoculated, held 16 days	9.53	1
5	Frozen, inoculated, held 20 days	6.83	4
6	Control	12.13	1
7	Decayed by *F. oxysporum*	11.43	3
8	Decayed by *F. radiciola*	9.19	3
9	Decayed by *F. radiciola*	12.88	1
10	Decayed by *Rhizopus*	6.04	3
11	Decayed by *Pythium debarayanum*	5.76	2

Microscopic examination of the starch from these samples revealed no indications of injury to the grains from any of the treatments employed except in the case of *Pythium*, which exerted a solvent action on the granules. Macroscopically all were of good quality. The washed samples were free from the odor of decay. According to color they could be separated into four grades as indicated in the table but the difference in clarity between Grade 1, the lightest, and Grade 4, the darkest, was by no means striking. Under the microscope it could be determined that the degree of variation from pure white was proportional to the quantity of free, unbroken, starch-laden cells in the sample. This in turn seemed to depend upon the type and degree of decay. The low yields from Sample 11 appear to be due in part to the solvent action of the organism on the starch, but the outcome in the case of Samples 5 and 10 was not the result of starch destruction during decay but of excessive loss during recovery. At least the examinations made of the discarded pulp and the recovered starch point to that conclusion. The mechanical condition of the pulp obtained on grinding the samples varied materially according to the type of decomposition. In some, the middle lamellae of the cells were quite completely dissolved, leaving the cellulose lamellae intact and the cells detached. Many such free starch-bearing cells were not ruptured during the process of pulping and more or less difficulty was experienced in separating them from the free starch. As already indicated they discolored the samples more or less when they were retained; and as they were filled with starch, the yield was lowered when they were washed away. The difficulty of complete separation was considerably increased in Samples 5 and 10 where practically all the tissue was involved in a dry rot. The pulp contained many free cells and many small aggregates of cells surrounded by a mat of radiating mycelial strands by which they became entangled in sedimentation.

The highest yield was obtained from Sample 9 which underwent very complete wet decay involving the cellulose lamellae of the walls as well as the middle lamella. The semifluid obtained on breaking the skins of the potatoes of this lot consisted of free starch grains floating in a matrix of residual material. Much of the tissue was sufficiently disintegrated to pass readily through cheesecloth without pressure or the use of additional water. Two-thirds of the entire yield secured came from washing this portion without grinding and the balance from the remainder after it was pulped. The behavior of this sample suggests the possibility of employing *Fusarium radiciola* for the destruction of the pulp in the preparation of special potato starch for use in biological work where a high degree of purity is essential. Before a practical method of this sort could be established it would of course be necessary to standardize the procedure so as to secure the condition of temperature, humidity, and aeration affording a maximum cellulose destruction.

Frosted and decayed potatoes have been found in these trials to be entirely capable of producing acceptable and frequently normal yields of clean, white starch of good quality. Much of this material appears to possess a potential value for the production of sizing starch approximating that of the stock at present used for this purpose. The mechanical difficulties in recovery from decayed pulp are sometimes greater and sometimes less than from normal. Modified procedure better adapted to these abnormal pulps could doubtless be devised, but there seems to be no reason why the present methods might not be applied profitably in the meantime in the production of sizing starch in factories at the large shipping centers installed to utilize the great quantities of frozen and decayed potatoes arriving during the fall and winter. This would turn to profitable account large supplies at present without value, but which are a serious burden of expense, since to their cost of production must be added transportation and dumping charges.

BUREAU OF PLANT INDUSTRY
U. S DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE RETICULATION OF GELATINE

By S. E. Sheppard and F. A. Elliott

Received July 23, 1918

The reticulation of the surface of negatives is often a source of trouble to photographic workers. This trouble is most likely to occur in hot weather and is generally produced after fixation, either during or just subsequent to washing. The wet gelatine layer becomes more or less finely wrinkled or corrugated, the network of puckers forming a pattern, generally extending over the whole of the negative, but sometimes only over part of it.

As will be seen from the illustrations (Figs. I, II, III) the "grain" of the network may vary considerably from very coarse dimensions down to very fine and even microscopic dimensions. This reticulation persists with only slight modification after drying. At the same time, as will be seen from the figures, if it occurs on a developed plate, the silver deposit undergoes a redistribution along with the reticulation of the gelatine, accumulating in the raised portions and diminishing or vanishing in the valleys or troughs between.

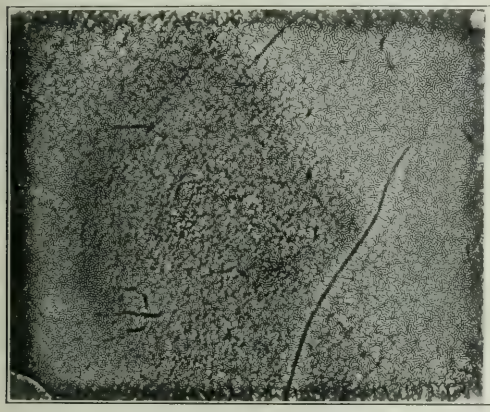


Fig. I

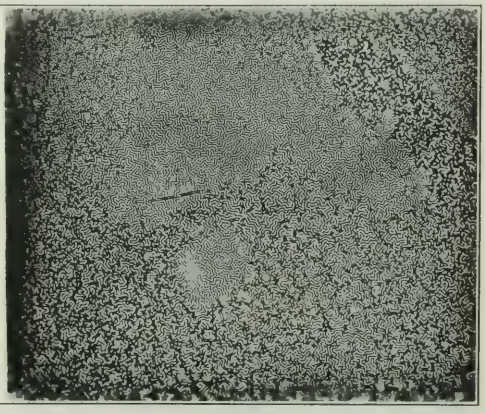


Fig. II

This reticulation has been utilized in some photomechanical processes; thus it is by the reticulation of gelatine that the "grain" of a collotype is produced. It has been employed in the production of irregularly grained "half tone" screens, in which the reticulation pattern takes the place of the cross line rulings of the regular screens.

An understanding of the conditions affecting and determining reticulation will not only be of practical use but will tend to throw light upon the physicochemical nature of gelatine, and perhaps help toward the scientific specification of gelatines for photographic use.

SWELLING OF GELATINE IN WATER AND ITS SHRINKAGE ON DRYING

The immediate cause and mechanism of reticulation will be best understood if we first consider a few facts on the normal swelling and shrinkage of photographic gelatine film which takes place in this treatment and use.

There are two aspects to this: in one we have only to consider change of mass or bulk; in the other, change of shape. As to the first, any piece of gelatine placed in water within a temperature range of roughly 0° to 20° C. swells, at first rapidly, then more slowly, and finally reaches a limit. Fig. IV shows the curve of this swelling plotted against the time.

The limit attained not only depends upon the temperature, but also upon the character of the gelatine, and, to a very marked extent, upon the presence of foreign substances, especially electrolytes, in the water. Acid and alkali in particular have a very great influence upon the swelling, as will be seen from the curve (Fig. V), which shows results actually obtained with a sample of gelatine.

In this curve the ordinates give the amount of water absorbed by 1 g. air-dry gelatine on final swelling (about 48 hrs.) while the abscissae give concentrations of acid and alkali in normality. As is evident, the swelling or absorption of water is extremely sensitive to both acid and alkali or, in terms of the ionic theory, to hydrogen and hydroxyl ions. In fact, the actual sensibility is of the same order as that of the dyes used as analytical indicators. The minimum ab-

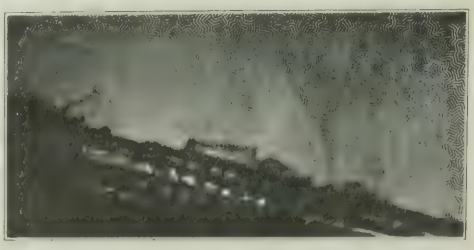


Fig. III

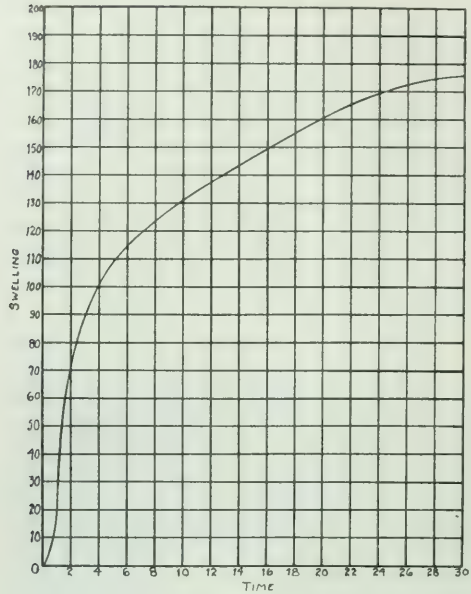


FIG. IV

sorption probably lies in reality at a point represented by the dissociation of pure water, according to the equilibrium,

$$H^+ + OH^- \rightleftarrows H_2O,$$

but this is masked usually by residual acidity or alkalinity of the gelatine. The precise determination of this point for a given gelatine will probably prove of some importance in the specification of photographic gelatines. It is of great interest since in passing from an alkaline to an acid state the swelling goes through a very pronounced minimum.

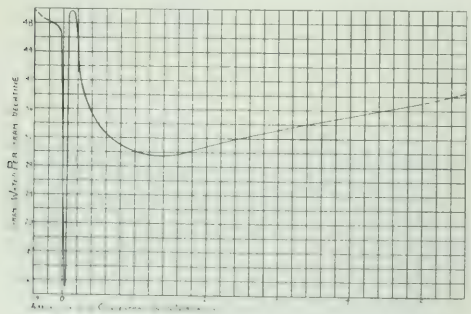


FIG. V

The influence of neutral salts in solution upon swelling is too complex to be discussed fully. It will be sufficient to note that some, such as iodides, act in the direction of increasing the swelling (hydration); others, as sulfates, in the direction of diminishing it. So long as only salts of the alkali metals and ammonia are considered, it is the acid part or anion which is of chief importance, and these salts have been arranged in a series, indicating their effect upon swelling. The effect of a given salt depends much upon its concentration and above all on the acidity or alkalinity of the solution.

Now, turning to the influence of shape upon swelling (and conversely) we find that a dominant factor here is that of the condition in which the gelatine first swelled or was cast and dried. Gelatine, in the abstract, as a homogeneous material alike in all directions, should, theoretically, tend to swell or shrink uniformly without change of shape, only altering its mass or bulk. If gelatine could be dried very slowly so that the loss of moisture proceeded at the same rate in all parts of the mass then it would shrink without change of shape, but such a condition cannot be realized in practice and gelatine dries more rapidly on the surface than in the interior, thus producing stresses and distortion. In the case particularly important to us, the gelatine is coated on glass or film support and firmly attached to it, so that one side is eliminated as regards drying, etc. The gelatine cannot spread off the plate, so that its swelling and shrinkage are limited to one direction, *viz.*, that perpendicular to the plane of the support (Fig. VI). This state of affairs is determined in advance by the first drying down of the jelly (or emulsion) on the support; it is not peculiar to the photographic film, since ordinary sheet or leaf gelatine which had been dried on nets shows the same tendency to have its principal expansion perpendicular to the face of the sheet.

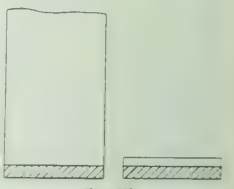


FIG. VI

PRODUCTION OF RETICULATION

A gelatine film, under normal conditions, can be repeatedly swollen and dried without losing its capacity to swell and shrink normally to the plate. It is evident that a certain strain must be imposed upon the gelatine in drying, which is removed by swelling. If we consider an ideal unit cube of the swelling gelatine, supposed free from all constraint, it would tend to expand uniformly in all directions. This ideal uniform expansion corresponds to a uniform swelling pressure, *i. e.*, a pressure the same in all directions. We can consider this resolved into forces perpendicular to the surface, and forces parallel to the surface. Actually, the gelatine layer in sheets or on plates does not swell uniformly. The forces parallel to the surfaces which would, of course, tend to remove the film from the glass or support, must be compensated. This compensation is in a measure external or initially external, being due to the adhesion of the gelatine to a rigid support, but it is chiefly internal, arising from a uniform strain or tension impressed by the mode of drying.

Now suppose the gelatine layer be subjected to

drastic internal action, excessive swelling and excessive dehydration, either successively, or, in a measure, simultaneously, then gelatine jelly will be strained beyond its elastic limit, showing either a total or a partial reaction.

Total reaction would imply the detachment of the layer from its support, a result which is seen in frilling and floating off, as a result of excessive lateral expansion.

If, however, the adhesion to the support is maintained, but the newly disengaged tangential or lateral forces are not entirely compensated, then the strain distribution in the gelatine layer ceases to be uniform and we get a local puckering or folding, similar in character to that produced in the earth's surface by tangential forces acting on restricted areas of semi-liquid igneous rocks.

Thus the immediate mechanism of reticulation is the production of restricted tangential dilation, which is partially arrested.

This, however, leaves unsettled the inner physical chemistry of the process, that is, the origin of an excess swelling pressure (the super-pressure) and of a partial or localized arrest of this. This can be discussed best in dealing with specific cases of the production of reticulation.

EXPERIMENTAL PRODUCTION OF RETICULATION

A typical case, which has the advantage of following ordinary photographic procedure, is as follows: A Seed 23 plate is "flashed," developed in a standard pyrosoda developer for 4 min. at 80° F., then rinsed, and fixed in a standard hypo-bisulfite fixing bath at 80° F. Reticulation was then found to depend upon the temperature of the wash water as follows:

Temperature	Reticulation
70° F.	None
80° F.	None
90° F.	Faint
100° F.	Strong

Instead of water, stronger and more definite results were obtained by an after-treatment with the following solution:

50 cc. 95 per cent Ethyl Alcohol
40 cc. 5 per cent Formaldehyde
110 cc. Water

In this case the following factors may have played a part:

1—Prehardened gelatine in the emulsion.

2—Tanning agents produced in development.

3—Excess swelling pressure in hot developer, etc., and particularly in washing.

That reticulation can be produced by the combined action of both a swelling or softening agent and a hardening or anti-swelling agent to restrain this is shown by the production of reticulation by the following combination:

No.	Hardening Agent	Softening Agent
1	Tannic Acid	Acetic Acid
2	Quinone	Acetic Acid
3	Chromic Acid	Hot Water
4	Mercuric Iodide	Potassium Iodide

All of these combinations produce reticulation, but 1 and 2 have only a theoretical interest, as they are difficult to control. The other two pairs are more susceptible of control, although it must be emphasized that in any case the balance between hardening and softening agents must be delicately adjusted, and that the measure of control is limited. Further, the occurrence or production of reticulation is in a very large degree dependent upon the nature of the gelatine. The so-called "hard" gelatines tend readily to reticulation, while the "soft" ones only give transient signs of it.

An experiment on this point gave the following results:

Gelatine	Coating Per cent	Reticulation in Potassium Mercuric Iodide
A-Hard	8	Strong, permanent
B-Hard	8	Strong
C-Soft	8	Very faint, transient
D-Soft	8	Very faint, transient
E-Soft	8	Very faint, transient

The following results were obtained with combinations of softening and hardening agents 3 and 4.

CHROMIC ACID AND HOT WATER—Chromic acid is, of course, a well-known hardening agent for biological tissues. Working with 8 per cent hard gelatine, machine-coated on glass, a 10 per cent solution of chromic acid at 20° to 22° C., followed by washing with water at 56° C., was found to afford the best conditions.



FIG. VII

POTASSIUM MERCURIC IODIDE—The solution of mercuric iodide in potassium iodide known as Brücke's reagent was found to be a convenient strength for use. According to the formula for this, 120 g. of mercuric iodide are to be dissolved in a solution of 50 g. potassium iodide in 500 cc. water, and the whole diluted to 1000 cc. We found, however, that under these circumstances only about 72.6 g. of mercuric iodide could be dissolved at room temperature; nor was this result much affected by heating to 50° C. It should be noticed that these quantities are near to those necessary for the double salt, $2KIHgI_2$ or K_2HgI_4. In this combination, the softening agent is the iodide, or more specifically the iodion, I^-, while the hardening

or coagulating agent is the mercuric salt, or, again, the mercuric ion Hg^{++}. Attempts made to increase the proportion of mercury were without success. A saturated solution of potassium iodide at 18° to 20° C. was made, containing 128 g. potassium iodide to 100 cc. of water, or 56.2 g. in 100 g. solution, which agrees fairly with the value 59 per cent at 20° C. given as the solubility in Landolt - Börnstein. This solution was saturated at 20° C. with mercuric iodide, taking up 64 g. In this the ratio of 2KI to HgI_2 is 0.69, whereas the actual double salt would call for 0.73. This solution was used as a saturated stock solution and Brücke's reagent is equivalent to 10 parts stock saturated plus 90 parts water.

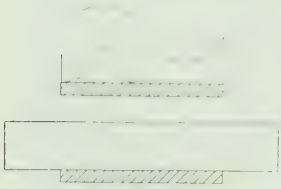


FIG. VIII

Working with the 10 per cent saturated (Brücke's reagent) and hard gelatine, 8 per cent machine-coated, the following results were obtained:

Duration of Treatment Min.	Effect
2¾	Small pock marks about 1 mm. apart produced in 40 sec. followed by reticulation which was much lessened in drying
3½	As before, but reticulation somewhat more persistent on drying
5	As before, but with continued treatment reticulation became fainter and vanished on drying
10	As before, but the whole surface finally softened and could not be dried, softening and running
10	After treatment, this was chilled 15 min. on ice, then immersed for 2 min. in 3 per cent formaldehyde. This conserved the reticulation

The formaldehyde after-treatment seems generally necessary with this agent to "fix" the reticulation. Using soft gelatine, 6 per cent solution machine-coated, and a wide range of concentration of the potassium mercuric iodide solutions, only slight and transitory reticulations were observed in the higher concentrations, giving way, however, to a general softening and liquefaction. Attempts to overcome this by preliminary hardening with formaldehyde were not successful. Prehardening with chrome alum showed better results. In the case of the mercury-potassium iodide combination, while it is not possible to increase the mercuric iodide ratio above a certain limit, other permanent or temporary hardeners may be added. In particular it was found that Brücke's reagent with the addition of 6 per cent of saturated Na_2SO_4 solution gave very fine, uniform reticulation.

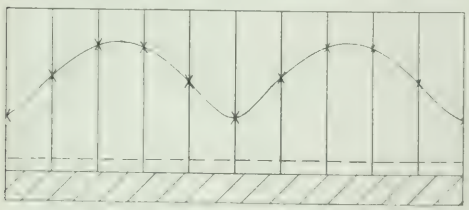


FIG. IX

Sodium sulfate used in the reticulation process makes the "grain" finer, while after-treatment with formaldehyde increases or conserves the depth of the wrinkles.

An important conclusion from these experiments is that apparently reticulation may start in more than one way. Thus with the Brücke reagent, and with chromic acid followed by hot water, reticulation proper was generally preceded by the appearance of small pock-like markings of about 0.2 to 0.3 mm. diameter. These would sometimes align themselves in "streaks," and in any case seemed the foci of the subsequent reticulation. These markings are shown in Fig. VII. On the other hand, in the reticulation produced by the use of hot water after development and fixation, these initial markings did not appear.

EFFECT ON THE SILVER IMAGE

It is noteworthy that when the reticulating film contains developed silver particles—as in negatives after fixation—there is an apparent migration of the silver particles, the ridges being denser, the valleys much less dense or even quite clear.



FIG. X

The question arises, whether reticulation is simply a puckering of a sheet grown larger by lateral dilation, larger than the support boundaries, but retained on this by local adhesion, particularly at the edges, as is indicated in Fig. VIII, or is a mosaic-like alteration of hardening and softening effects, the ridges being more swollen, the valleys more tanned, as suggested by Fig. IX.

It is evident that in the first case the excess in the ridges is simply due to the total thinning (by the lateral dilation) plus local thickening due to folding of the increasing sheet. In the other case, the greater density in the ridges would be due to an actual migration of silver due to tension, similar to that occurring on the drying of moisture spots, when the tension in drying softens the gelatine and forces the particles into the periphery of the spot. This effect is shown in Fig. X, a drawing made by Mr. M. B. Hodgson

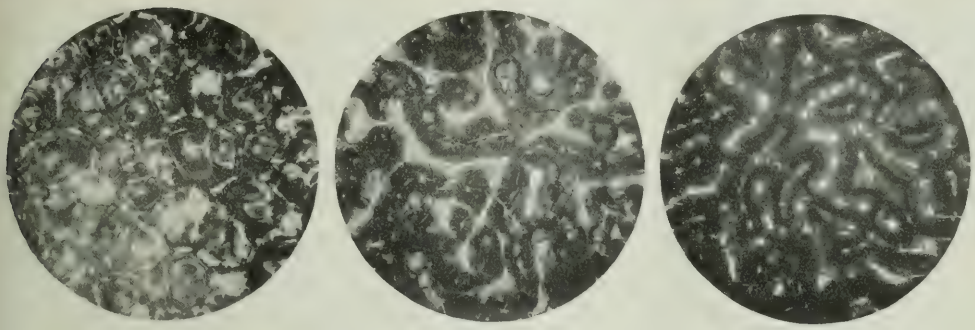


FIG. XI

from microscopical observations. In the latter case we should have in reticulation a great and increasing number of microscopic replicas of such "moisture spots," tending to run into each other and form one system, like cracks in a drying mass.

The theory of alternate softening and hardening, or of differential swelling, couples up readily with the fact already noticed that in many cases reticulation starts from a number of isolated points. When softening and tanning agents are present together in a gelatine gel, a certain amount of selective adsorption and differential diffusion will occur. A molecule or ion having a tanning action will tend to be adsorbed or fixed *in situ*, and its own specific diffusion will be hindered. Molecules or ions having a softening action may modify the action on tanning agents, but their own diffusion will be facilitated by their hydrating and softening action on the gelatine.

It is easy to see that we should have then a condition of rhythmic coagulation of the gelatine very similar to that shown in the well-known Liesegang rings. In this latter case, when two salts which react to form a precipitate are allowed to diffuse together through a gelatine gel, the precipitate, such as silver chromate or silver halide, is not deposited uniformly, but rhythmically, in alternate rings or layers.

Actually it is observed that reticulation generally starts in one or more regions and fills up by the spread of these; in some cases from isolated foci. It seems then that reticulation in its earliest stage involves something like the nucleation of a crystallizing solution. In such a solution, crystallization may start either at nuclei already present in the solution or by the formation of new ones, but in the latter case there is required a higher degree of supersaturation for crystallization to start. At what points in such solution or melt the first nuclei appear is a matter of pure chance and it is apparently much the same with the start of reticulation.

THE CONNECTION BETWEEN RETICULATION AND THE "GRAININESS" OF NEGATIVES

In one important case where it is very probable that incipient reticulation is at work, foreign nuclei are available. This is in the case of the ordinary development of a photographic emulsion.

It is known that, apart from differences in emulsion, different developing agents and treatments affect the "graininess" of the developed image. By this is not to be understood the elementary plate grain, but such clumping in second order aggregates as is liable to be objectionable in projection. This granulation depends upon development, and in the same way, resolving power depends upon development and the developer.[1] It is hardly to be doubted that

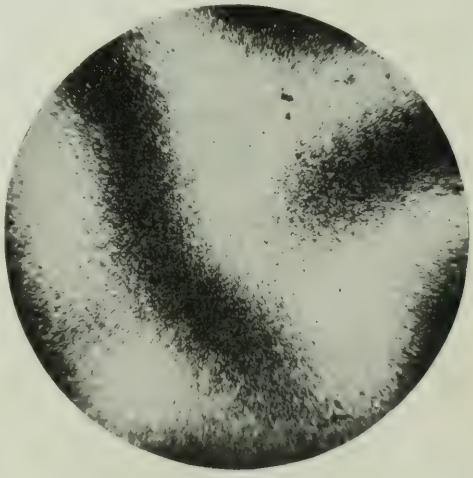


FIG. XII

we have in this case a selective adsorption and differential diffusion of developers, producing what amounts to incipient reticulation, nuclei being formed by the developed silver particles, with their tendency to adsorb the colloidal reaction products of development, which have tanning or coagulating properties. Consideration of the great change in the swelling equilibrium shown on passing from an alkaline to an acid condition (Fig. V) shows also that the opera-

[1] K. Huse, "Photographic Resolving Power," *J. Am. Optical Soc.*, 1 (1918), 119.

tions subsequent to development are very liable to develop still further any sub-microscopic reticulation, and again to coarsen the "grain" of the image. It is hoped to follow this up experimentally when time permits, instruments having been devised for measuring both granularity and minute swellings.

In Fig. XI are given photomicrographs of some of the reticulated preparations described, taken with vertical illumination at 100 diameters.

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
ROCHESTER, N. Y.

LABORATORY AND PLANT

METHODS OF ANALYSIS USED IN THE COAL-TAR INDUSTRY. I—CRUDE TARS

By J. M. WEISS
Received July 20, 1918

INTRODUCTION

In April 1911, S. R. Church[1] published a paper which described in some detail the analytical methods as used by The Barrett Company at that time. This was supplemented by a later paper in 1913,[2] giving certain revisions and additions which had been made up to that time. These methods, with others, have been in use in the laboratories of The Barrett Company and many other companies for an extended period and have been given the test of continued use. Some of the methods have been the subject of exhaustive investigations to determine the variants which limit the accuracy of the tests. For instance, J. M. Weiss presented a paper[3] dealing with the "free carbon" tests on tars and pitches and the factors influencing the results, together with some theoretical consideration of the material known as "free carbon." There have also been numerous publications on the testing of tar products, emanating from various sources, such as the Office of Public Roads, the U. S. Department of Agriculture, the American Society for Testing Materials, the American Gas Institute, etc., and also from many individuals, but we do not intend to present here a bibliography of the literature on coal-tar product methods of analysis, but merely to indicate under a few of the tests published the main sources from which we have drawn.

About a year and a half ago, we realized that the directions of our testing methods were more or less incomplete in detail and that in many cases important points were left unemphasized. Accordingly, a chemists' committee was formed, consisting of S. R. Church, F. J. Gerty, J. B. Hill, K. B. Howell, H. E. Lloyd, J. G. Miller, M. R. Walczak, and the writer, whose purpose it was to revise and standardize the existing tests. A description of each test was prepared by one or another of the committee and sent for comment to each member of the committee, a majority of whom were actual laboratory workers of long experience. The comments were compiled and, where necessary, experimental work was instituted to settle points which were in dispute. The methods were not put into final form until the committee was substantially unanimous regarding all the details of the methods.

We are presenting in this paper a selected list of methods which we believe are of very general interest to all engaged in the manufacture or use of coal-tar products. This paper will be followed by three others, one dealing with the methods of test for refined tars and pitches, another with methods of test for creosote oils and carbolic oils, and the last, benzols and light oils.

Many of the tests are widely used throughout the country and have been adopted by a majority of the producers and consumers of tar products. A number of these tests are the standard methods of such associations as the American Railway Engineering Association, American Society for Testing Materials, etc. We are presenting them in the belief that it will be helpful to those engaged in the testing of tar products to have these standard methods collected together in compact form convenient for reference. The illustrations are mainly assembly drawings, but the special apparatus can now be obtained through almost any apparatus house. We have furnished detailed plans and specifications of all our special laboratory apparatus to every chemical glassware manufacturer and laboratory supply house of whom we were cognizant.

For each test on which we have carried out sufficient exhaustive research, to enable us to do so, we have made a statement as to its accuracy.

SAMPLING

Before considering the tests in detail a few words on sampling would not be out of place.

The sole practical purpose of laboratory testing or analysis is to obtain information as to the composition, quality, and properties of a given material. Usually, this material is in large bulk. To make the desired test on the entire bulk of material would obviously be impracticable as well as necessitating frequently the destruction of the material. It therefore becomes necessary to select from the bulk of a material, a portion or sample of same, which shall be representative of the entire bulk and which can be tested and its properties determined. Obviously, the interest and commercial values attach to the properties and qualities of the bulk of material and only to the properties and qualities of the sample as far as the sample is representative of the bulk. It is therefore necessary to take every possible precaution to see that the sample is *in every case representative*. The laboratory methods, apparatus, and technique may be perfect and the results recorded may be accurate as to the quality of the sample tested. If, however, that sample is not representative of the bulk, the value of the test is commercially nil. The entire theory of sampling is therefore based on the principle

[1] THIS JOURNAL, **3** (1911), 227.
[2] *Ibid.*, **5** (1913), 195.
[3] *Ibid.*, **6** (1914), 279.

of obtaining a sample which *shall be and remain representative.*

Materials may be grouped as homogeneous and heterogeneous. A homogeneous material is a material which is uniform in quality and composition throughout. A heterogeneous material is one which varies in quality or composition throughout. There is, of course, no such thing as a perfectly homogeneous material, except in the cases of pure chemical compounds, true solutions, and mixtures of perfect gases. Obviously, a sample taken from any part of a homogeneous material will be representative of the entire bulk. Sampling of homogeneous materials therefore becomes a relatively simple matter.

LIQUIDS—The sampling of liquids presents a somewhat more difficult problem. Where the liquid is thin, non-viscous, and does not contain immiscible constituents, a homogeneous condition usually exists, and a sample from any part of the bulk is usually representative of the whole. Where, however, viscous or immiscible materials are present, the constitution is usually heterogeneous.

Most of the liquids handled by the coal-tar chemist fall into this latter class. In such cases, great care must be taken to obtain thoroughly representative samples. While it is impossible to set absolute standards as to the methods of sampling these materials, the following mehods represent good practice.

METHOD I—A $1/2$ in. sampling pipe shall be inserted in the line through which the oil is being pumped, on the discharge side of the pump, preferably in a rising section of the pipe line. This sampling pipe shall extend half way to the center of the main pipe and with the inner open end of the sampling pipe turned at an angle of 90° and facing the flow of the liquid. This pipe shall be provided with a plug cock and shall discharge into a receiver of 50 to 100 gal. capacity. The plug cock shall be so adjusted that, with a steady continuous flow of the oil, the receiver shall be filled in the time required to pump the entire shipment. The receiver shall be provided with a steam coil sufficient to keep the contents at a temperature not exceeding 120° F. Immediately upon completion of the pumping, the contents of the receiver shall be very thoroughly agitated and a duplicate 1 qt. sample taken immediately for the test. The amount of the drip sample collected shall be not less than 1 gal. for each 1000 gal. of oil handled, except in the case of large boat shipments, where a maximum of 100 gal. is sufficient. Care must be taken that the bleed cock does not shut off partially or entirely during the pumping. It is necessary to insure a *uniform flow* of material throughout.

METHOD II—Where the material to be sampled is handled by gravity flow, Method I can frequently be employed by inserting a drip sampler into the end of the discharge nipple. Where this is for any reason impracticable, an alternate method, II, consists in taking dipperful samples at *frequent* and *regular* intervals, from the open stream. These dipperful samples should be combined in a covered receiver. The combined gross sample should be not less than 0.1 per cent of the whole material of which the sample is representative. The combined gross sample should be placed in a receiver, in which the material can be kept fluid, and stirred thoroughly to homogeneous consistency. Small samples may then be taken for analysis.

While it is preferable to take a sample of material during passage through a pipe or in gravity flow, it is also necessary to take samples of materials while at rest, as in storage tanks, mixing tanks, etc. In such cases, Method III or IV shall be employed.

METHOD III—Small bottles weighted with metal should be fitted with tight stoppers to which strings are attached. The bottle shall be lowered to a fixed depth into the liquid, whereupon the cork shall be pulled from the bottle by the string and the bottle allowed to fill with material. After sufficient time for the filling of the bottle, it is pulled up. A cut of a suitable arrangement in use at several of our plants is shown in Fig. I.

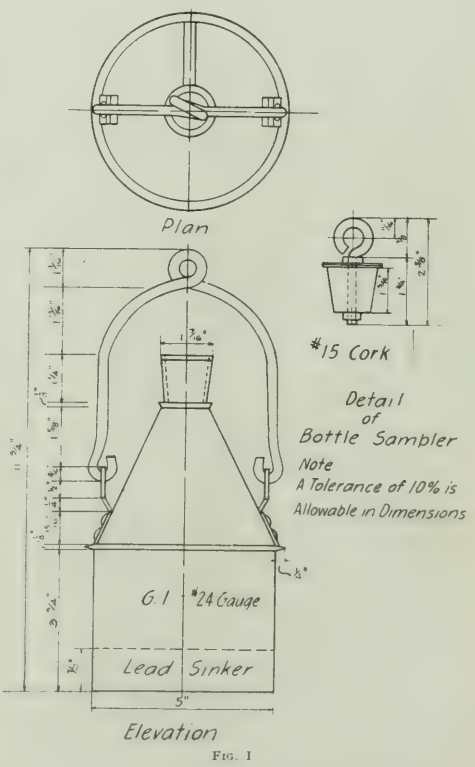


FIG. I

Bottled samples should be taken from a sufficient number of different depths in the liquid to insure obtaining a combined sample which is representative of the whole. The combined sample should then be agitated and a similar sample taken from it for analysis. In case the cross-sectional area of the container

varies throughout the vertical depth of the liquid, a number of samples should be taken at different levels, the number at each level being proportional to the cross-sectional areas at such levels.

In tank cars for all ordinary cases we recommend that samples be taken from three zones, *viz.*, the top foot section of the car, the middle foot section, and the bottom foot section. These should be combined in various proportions depending on the diameter of the car. We recommend that composite samples be made up as shown in the following table:

Diam. of car Feet	Zone	Proportionate weight to be given sample
6	Top	11
	Middle	25
	Bottom	11
7	Middle	1
	Bottom	2
	Bottom	1
8	Top	1
	Middle	3
	Bottom	1

Of course, if free water is present in large amount, this should be noted separately and care be taken not to include it in the samples taken.

METHOD IV—Many storage tanks, particularly large ones, are equipped with sample cocks along the side of the tank and arranged at one-foot intervals. After taking samples by this method an equal amount is drawn from each cock and the samples thoroughly mixed before the final laboratory sample is taken. (This, of course, assumes that the tank is one of uniform cross section.) In taking a sample by this means, the nipple from each cock shall extend at least 6 in. inside from the shell of the tank and the operator shall allow sufficient material to flow through the cock to clear the line before taking his final sample. We would caution the operator, however, that samples from the side of the tank should not be taken too close to the bottom of the tank. This will avoid inclusion of the sediment normally present in the bottom of the tank.

SOLIDS—Solids are almost always heterogeneous in constitution. It is impossible to advise definite and arbitrary methods for obtaining samples. Each case must be worked out for itself, bearing in mind the particular conditions in the case. It is usually preferable to take samples during the unloading of cars or the transit of the material in conveyors. In such cases, a number of small samples should be taken at *frequent* and *regular* intervals from the material in transit and these samples combined to form a representative combined sample.

Occasionally, solids are tested as received, in bags or barrels. In such cases, it is desirable to take a small sample from every *n*th bag or barrel combining same to obtain the representative combined sample.

Generally, samples taken from the bulk, in piles or cars, are unreliable and not representative. Where it is necessary to take such samples before the unloading of the car, small samples should preferably be taken from at least twelve spots throughout the bulk and these small samples collected to form the representative combined sample.

In taking such small samples, it is desirable to take 8 samples from the corners of the car, 4 near the bottom, and 4 near the top of the material. To these should be added 4 samples from the center of the car, 2 from the top, and 2 from the bottom of the material.

The combined representative sample taken by any of the above methods should be in amount at least 0.1 per cent of the total bulk of material sampled. These combined samples should be carefully mixed and reduced in size to a convenient laboratory sample, by the standard method of quartering. In carrying out this quartering, a hard clean surface should be selected, free from cracks and protected from rain, snow, wind, and beating sun. Do not let cinders, sand, chips from floor, or any other material get into the sample. Protect the sample from loss or gain in moisture. The combined sample should be carefully mixed, spread out on this surface into a circular layer and divided into four equal quadrants. Two opposite quadrants should be combined to form the representative reduced sample. If this sample is still too large for laboratory purposes, the quartering operation shall be repeated. In this manner, the sample shall finally be reduced to a size suitable of handling by the laboratory.

GENERAL PRECAUTIONS—Scarcely second in importance to the necessity of obtaining a representative sample, is the necessity of preventing the composition or property of the sample from changing during handling or storage prior to laboratory analysis. Some materials are very hygroscopic and must be kept in tightly stoppered bottles to prevent absorption of moisture. This is particularly true of dry felt, lime, and finely divided mineral materials. Other materials are volatile and must be kept in tightly closed cans or bottles to prevent loss of their lighter constituents.

A great many samples are taken of hot materials in process of distillation where the high temperature has produced a high vapor pressure which will cause considerable loss of the more volatile constituents when exposed to the atmosphere. Usually in the case of these materials, the volatilization of oil is apparent by the vapor rising from the liquid and becoming condensed in the cold atmosphere to a cloud. In the case of some of the lower-boiling materials, however, a high vapor pressure is produced at moderately low temperatures and a volatilization of the sample is continually going on, although this may not be so apparent by reason of the fact that the vapors from this material are not readily condensed in the atmosphere.

It is, therefore, particularly desirable to watch the sampling of such materials carefully and make sure that the sample is kept in a tightly covered container until it has cooled to a point where it exhibits an inappreciable vapor pressure.

CRUDE TAR TESTS

TEST B2—WATER

APPARATUS—Copper still, 6 in. by $3^1/_2$ in. Ring burner to fit still. Connecting tube. Condenser

trough. Condenser tube. Separatory funnel. Thermometer, 0°–250° C. See Fig. II.

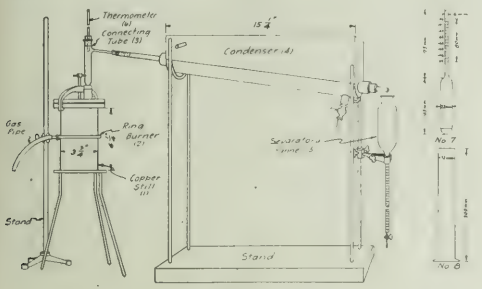


FIG. II

METHOD—Fifty cc. of coal-tar naphtha or light oil shall be measured in a 250 cc. graduated cylinder. 200 cc. of the tar to be tested shall be added. The contents shall be transferred to the copper still, the cylinder shall be washed with 100–150 cc. more of naphtha, and the washings added to the contents of the still. The lid and clamp shall be attached, using a paper gasket, and the apparatus set up as shown in Fig. II. The condenser trough shall be filled with water. Heat shall be applied by means of the ring burner, and distillation continued until the vapor temperature has reached 205° C. (401° F.). The distillate shall be collected in the separatory funnel, in which 15 to 20 cc. of benzol have been previously placed. This effects a clean separation of the water and oil. The reading shall be made after twirling the funnel and allowing to settle for a few minutes. The percentage shall be figured by volume.

PRECAUTIONS—When fresh supplies of naphtha or light oil are obtained, they shall be tested to determine freedom from water.

ACCURACY—One-tenth of 1 per cent.

NOTE—For works-control an iron still of the same size and shape as the copper still specified above may be used. Some laboratories omit the use of the thermometer and judge when the water is off by the appearance of the distillate. These variations must never be applied where check test is required or in case of dispute.

TEST B3—DEHYDRATION (PREPARATION OF DRY TAR)

APPARATUS—Same as Test B2.

METHOD—About 300 to 400 cc. of tar shall be placed in the copper still without the addition of naphtha. The apparatus shall be set up as in Fig. II, except that an ungraduated separatory funnel may replace the special graduated one. The distillation shall be carried on cautiously at first to prevent foaming and continued until the vapor temperature reaches 170° C. (338° F.). Any oil which has distilled over shall be separated from the water (warming sufficiently, if crystals are present, to insure their solution). This separated oil shall be thoroughly mixed back into the residual tar in the still, after the latter has cooled to a moderate temperature. The dehydrated tar shall be then transferred to a suitable container.

NOTE—A temperature of 170° is used because this is sufficiently high to expel all water from the still. In Test B2 a higher temperature is used to insure flushing out the condenser tube.

TEST B4—SPECIFIC GRAVITY (SPINDLE)

APPARATUS—Hydrometer: special, calibrated against water at 15.5° C. (60° F.), of suitable scale range.

Cylinder: see Fig. II.

METHOD—It is not usually possible to make the test by this method at 15.5° C. (60° F.) as ordinary tars are not sufficiently liquid at this temperature. The cylinder shall be filled with the dry tar (see B3), the latter thoroughly stirred, and the temperature noted. The hydrometer shall be inserted and the reading taken. Care shall be taken that the hydrometer does not touch the sides or bottom of the cylinder and that the surfaces of the tar are free from froth and air bubbles. For every degree centigrade above 15.5° C., at which the test is made, add 0.000685 to the observed reading. (This is equivalent to 0.00038 for every degree Fahrenheit above 60° F.) Unless instructed to the contrary, report results at 15.5° C. (60° F.).

ACCURACY—This method is not recommended as an accurate method. If accuracy is desired, use Test B5 or B6. It is sufficiently accurate for ordinary testing of incoming tar shipments.

NOTE—The hydrometer used, when first obtained, should be standardized.

TEST B5—SPECIFIC GRAVITY (PYCNOMETER)

APPARATUS—Modified Hubbard Bottle (Fig. III).

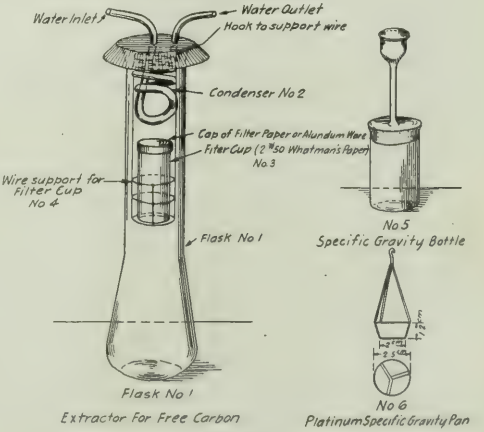


FIG. III

STANDARDIZATION OF BOTTLE—The bottle shall be weighed empty, filled with water, and held in a bath at 15.5° C. (60° F.) until the volume becomes constant. The water shall then be adjusted to the mark, the bottle dried superficially, and weighed. Each bottle used in the laboratory should be numbered and a

record kept of its weights—empty, and filled to the mark with water at 15.5° C. (60° F.).

METHOD—Tar, dehydrated as under B3, shall be used. Introduce 10 g. of dry tar into the bottle at 40° to 50° C.; allow to cool and weigh. *Freshly boiled* distilled water shall then be added and the bottle kept in a bath at 15.5° C. (60° F.) until no further volume change takes place. (This usually takes about 30 min.) The water shall then be adjusted to the mark, the bottle dried superficially, and weighed.

Let A = weight of bottle
B = weight of bottle + water at 15.5° C.
C = weight of bottle + tar
D = weight of bottle + tar + water at 15.5° C.

$$\text{Then: Sp. gr. at 15.5° C.} = \frac{C - A}{(B - A) - (D - C)}$$

PRECAUTIONS—The use of freshly boiled distilled water is essential to accurate results.

ACCURACY—Within 0.003.

NOTE—In exceptional cases tar is very liquid, and, upon the addition of water, partially floats through the water, giving an oily film on the surface. In such cases, do not add water, but fill the bottle with tar, hold at 15.5° C. (60° F.) until the volume becomes constant, adjust to the mark and weigh. The weight of the tar divided by the weight of water necessary to fill the bottle to the mark at 15.5° C. (60° F.) gives the specific gravity.

TEST B6—SPECIFIC GRAVITY (PLATINUM PAN)

APPARATUS—Special platinum pan (Fig. III).

STANDARDIZATION OF PAN—The clean pan shall be ignited, cooled, and suspended by a waxed thread on the left-hand arm of an accurate chemical balance. Its weight in air and its weight in freshly boiled, distilled water at 15.5° C. shall then be noted in the usual way.

METHOD—The clean pan shall be filled with tar and suspended from the balance by the same thread as was used in the standardization. The weight of the pan plus tar should be noted, first in air and second in freshly boiled, distilled water at 15.5° C.

Let A = weight of pan in air
B = weight of pan in water at 15.5° C.
C = weight of pan and tar in air
D = weight of pan and tar in water at 15.5° C.

$$\text{Then: Sp. gr. at 15.5° C.} = \frac{C - A}{(C - A) - (D - B)}$$

PRECAUTION—Allow the pan and tar to remain in water at 15.5° C. for 10 min. before taking the water reading.

ACCURACY—Within 0.003.

TEST B7—INSOLUBLE IN BENZOL (FREE CARBON)

APPARATUS—Extraction flask. Condenser and cover, wire support. See Fig. III. Extraction thimble (prepared by operator[1]). Cap of filter paper or alundum. The latter are 30 mm. inside diameter by 14 mm. high. Balance: an ordinary analytical balance accurate to 0.0005 g. Steam bath, water bath, or electric hot plate. Beakers, 100 cc. Carbon filter tubes, 37 mm. size. Weighing bottle, 32 mm. by 70 mm. Camel's hair brush, 14 mm.

METHOD—Tar dried as under B3 shall be used. After drying, it shall be passed hot through a 30-mesh sieve to remove foreign substances. The amount of tar to be taken for test depends on the content of insoluble material and shall be:

Less than 5 per cent, 10 g.
5 per cent to 20 per cent, 5 g.
Above 20 per cent, 3 g.

If the content of insoluble material cannot be approximated, the larger amount shall be taken. The amount shall be weighed into a 100 cc. beaker and digested with pure toluol at 90° to 100° C. for a period of *not over thirty minutes*. The solution shall be stirred to insure complete digestion. A filter cup prepared as described shall be weighed in a weighing bottle and placed in a filter tube supported over a beaker or flask. The thimble shall be wet with toluol and the toluol-tar mixture decanted through the filter. The beaker shall be washed with toluol until clean, using the camel's hair brush as a policeman to detach solid particles adhering to the beaker. All washings shall be passed through the filter cup. The filter cup shall then be given a washing with pure benzol and allowed to drain. The cap shall then be placed on the cup and the whole placed in the extraction apparatus and extracted with pure benzol until the descending benzol is completely colorless. The cup shall then be removed, the cap taken off, and the cup dried at 97° to 100° C. After drying, it shall be allowed to cool in a desiccator and weighed in the weighing bottle. The increase in weight represents matter insoluble in benzol.

PRECAUTIONS—If the first filtrate shows evidence of insoluble matter, it should be refiltered. The 30-min. period allowed for digestion must not be exceeded.

ACCURACY—5 per cent of insoluble matter present. In other words, with 20 per cent of "free carbon" present, a 1 per cent accuracy may be expected.

NOTE—Where *only approximate* results are desired, tars containing not over 5 per cent of water may be tested without dehydration and the results calculated back to a dry tar basis.

TEST B8—FIXED CARBON[1]

APPARATUS—Platinum, Rhotanium, or Palau crucible, 20 cc., standard shape, provided with a tightly fitting cover.

METHOD—Dry tar (see B3) shall be used. One gram of tar shall be placed in the crucible, the cover applied, and the crucible placed on a platinum, nichrome, or fireclay triangle over a Bunsen burner, with the bottom of the crucible 6 to 8 cm. from the top of the burner. The burner flame shall be regulated to a height of 20 cm. when burning free. The tar

[1] These shall be made of Whatman No. 50 filter paper. To make a cup, two 15 cm. circles shall be taken and one cut down to a diameter of 14 cm. A round stick about 1 in. in diameter shall be used as a form. The stick shall be placed in the center of the circles of filter paper, the smaller inside, and the papers folded symmetrically around the stick to form a cup about 2½ in. long. A little practice enables the operator to make these evenly and quickly. After being made they shall be soaked in benzol to remove grease due to handling, drained, dried in a steam oven at 97° to 100° C., cooled in a desiccator and kept there until used.

[1] Based on report of Committee on Coal Analysis, *J. Am. Chem. Soc.*, **21** (1899), 1116, *et seq.*

shall be heated gently until the tendency to foam has passed and shall then be exposed to the 20 cm. flame of the burner for 7 min. At the end of this period the flame shall be removed, the crucible transferred to a desiccator, and allowed to cool. The residue in the crucible, less ash, is "fixed carbon."

PRECAUTIONS—The test shall be carried out in a part of the laboratory free from draughts. The upper surface of the crucible cover should be free from carbon at the end of the ignition period.

ACCURACY—1 per cent.

NOTE—The loss on ignition in the above test is called "volatile combustible matter" and may be reported if desired.

TEST B9—ASH

APPARATUS—Open platinum, porcelain, or silica crucible.

METHOD—Tar dried as under B3 shall be used. Weigh 10 g. of tar into the crucible and incinerate to constant weight. The residue in the crucible is ash.

PRECAUTION—The heating shall be conducted so as to avoid foaming at the start or carrying away of ash during the ignition. It should be carried out in a part of the laboratory away from currents of air.

TEST B10—VISCOSITY (ENGLER)

APPARATUS—Engler viscosimeter: A. H. T. 41352; E. & A. 4790, or improved model A. H. T. 41360; E. & A. 4792. The latter type differs from the former in that the inner container is totally immersed in the outer bath and the top of the inner container is double-walled. The outer bath is also larger and provided with a stirrer. It is easier to maintain a uniform temperature with the latter instrument, but with careful temperature regulation identical results are obtained with both instruments. Sugar flasks, 100 cc. Stop-watch.

METHOD—Tar dried as under B3 shall be used. Before use it shall be screened through a 20-mesh wire gauze to remove extraneous matter. The tar shall be heated on a steam bath to approximately the correct temperature before introduction into the viscosimeter. The outer bath shall be kept at a temperature of from 1° to 3° C. above the inner temperature desired. The tar shall be filled in up to the top of the fixed points in the viscosimeter. (This requires approximately 250 cc. of tar.) The tar shall be kept at the proper temperature for 3 min., the plug released, and the time of flow (in seconds) of 100 cc. noted.

PRECAUTIONS—In allowing the material to run from the viscosimeter, it is better to let it impinge on one side of the measuring flask, as this avoids the formation of bubbles and consequent obscurity of the reading. After each test the aperture should be examined to make sure that it is free from obstruction.

The aperture should be cleaned with a soft piece of tissue paper and not with rough twine or any other material which may scratch or damage the aperture.

Up to 80° C., water may be used as the bath in the outside jacket; above this, it is better to use a heavy lubricating oil.

NOTES—The temperature differential to be maintained between the inner and outer baths varies with the temperature of test and the room temperature. The temperature of the inner bath usually drops after the material has flowed out to a point sufficient to uncover the thermometer bulb (more particularly with the old type of Engler viscosimeter), but if the outer bath remains constant, this apparent drop does not affect the results.

Some specifications require the use of 200 cc. In this case use 200 cc. sugar flasks and note the time of flow of 200 cc., otherwise the procedure is the same.

Specific viscosity is sometimes required. This is a ratio and is obtained by dividing the time of flow of the material by the time of flow of an equal volume of water at the same temperature. Unless otherwise stated, the volumes compared should be 200 cc.

TEST B11—SULFUR

APPARATUS—Crucible 50 cc. platinum, nickel, or silica. Usual inorganic, gravimetric, analytical apparatus.

METHOD—One gram of material shall be weighed into the crucible and 1.5 g. of Eschka mixture added. (Eschka mixture consists of 2 parts of pure magnesium oxide and 1 part of pure anhydrous sodium carbonate. The mixture should be light and fluffy.) The tar and Eschka mixture shall be intimately mixed and the crucible placed over a very low Bunsen flame. The crucible shall be set in a round hole in a 6 in. sq. asbestos board so that the flame impinges only on the bottom of the crucible and the products of combustion from the burner are deflected from the open top of the crucible.

The heating of the crucible shall be conducted very slowly until no more fumes are given off. This requires 5 to 6 hrs. The heat shall then be gradually increased and the mixture stirred with a platinum rod or wire until all the carbon particles are burnt off and the mass is white. At the close of the ignition the bottom only of the crucible shall not be more than at a dull red heat. The white residue shall be washed into a beaker with 200 cc. of water, 20 cc. of pure bromine water added, boiled for 5 min., and filtered. The precipitate on the filter shall be washed with boiling water until the filtrate gives no test for bromides with nitric acid, and silver nitrate solution. The filtrate and washings shall be combined, acidified with 5 cc. of pure concentrated hydrochloric acid, and the excess of bromine removed by boiling. 10 cc. of 10 per cent pure barium chloride solution shall then be added drop by drop to the boiling solution and the precipitated barium sulfate allowed to collect and agglomerate by standing in a warm place over night. The barium sulfate shall be filtered out in a Gooch crucible, using suction, washed with hot water until free of chlorides (test with nitric acid and silver nitrate), ignited, cooled in a desiccator, and weighed. From the weight of barium sulfate, deduct the weight obtained in a blank test (see Notes below) and multiply by 0.13734 to obtain the weight of sulfur.

NOTES—A blank test shall be made heating the same length of time under the same conditions as in the regular determination, and using the same amount of all reagents in each step of the test.

The asbestos mat on the Gooch crucible used in filtering the barium sulfate should be prepared as follows:

Finely cut Tremolite (Italian) asbestos is shaken up with water and an asbestos mat deposited under suction on the Gooch. The mat is washed with dilute acid, dilute alkali, and distilled water, and the crucible ignited. The washing and ignition are repeated to constant weight. A Gooch prepared in this way is quick and accurate, quick because of speed of washing and the fact that there is no paper to burn off, and accurate because there is no chance of reduction of barium sulfate by the carbon of filter paper.

THE BARRETT COMPANY
17 BATTERY PLACE, NEW YORK CITY

SYNTHETIC PHENOL[1]

By ALBERT G. PETERKIN, JR.

Received July 20, 1918

It is difficult to estimate the quantity of any of the products from coal tar which is available, because, on the one hand, the production of tar is changing from day to day, due to the continued increase in the number of coke ovens, and on the other hand, its consumption for fuel purposes is affected by greater or less difficulty in obtaining supplies of coal. It is safe to say, however, that it would not be practical or even possible to-day to make more than five to six million pounds of phenol per year available from this source.

The United States used before the war some 5,000,000 lbs. of phenol per year, the consumption being divided among pharmaceuticals, resins of the Bakelite type, dyestuff intermediates, and the explosive, picric acid. At the beginning of the war, the demand immediately increased, due to the increased manufacture of picric acid. The French Government, particularly, became a large customer of manufacturing concerns in this country, both for phenol and picric acid. The production at the time just before the entrance of this country into the war had jumped to something like 72,000,000 lbs. of phenol per year.

It is likely that 1919 will see a very great increase in the production of phenol in this country. Coal tar as a direct source of phenol is therefore a negligible factor in view of the present demand.

Whatever the merits of picric acid as an explosive, a real objection to its manufacture in such times as these lies in the relatively enormous amount of raw materials involved, and the necessity for the correspondingly great consumption of our valuable transportation facilities. For example, to make 100,000,000 lbs. of synthetic phenol requires in round numbers:

	Pounds
Benzol	115,000,000
Fuming sulfuric acid (9½ per cent)	280,000,000
Caustic soda	180,000,000
Lime	42,000,000
Limestone	190,000,000
Coke	38,000,000
Niter cake	42,000,000
TOTAL	884,000,000

[1] Read before the American Institute of Chemical Engineers, at Berlin, N. H., June 21, 1918.

or nearly nine times that of the finished product, using the generally adopted process and working with fair economy. To say that it is an extravagant process is to put it mildly, but it has maintained itself with considerable obstinacy in the face of many attempts to improve and shorten it.

Fig. I shows the old process diagrammatically. It

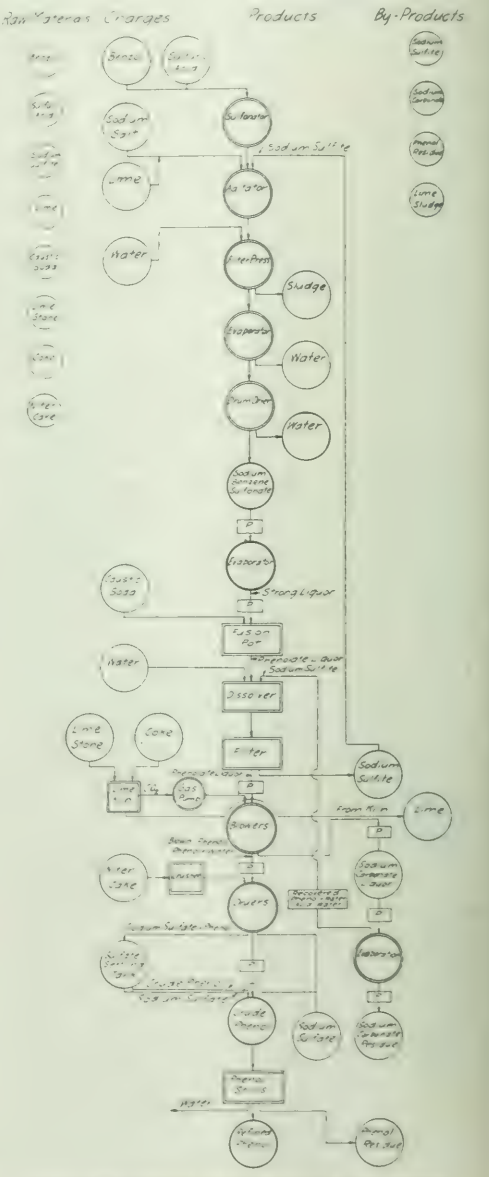


FIG. I—CHART SHOWING THE OLD SYNTHETIC PHENOL PROCESS

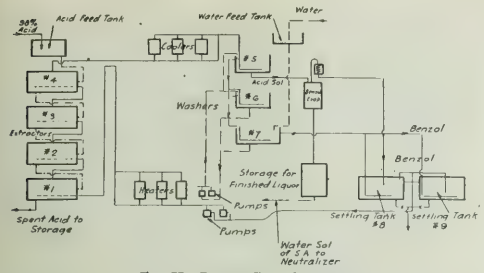


Fig. II—Dennis-Bull Process

has been described many times and a bare outline will suffice now. Benzol is sulfonated at temperatures varying from 50° to 70°. The strongest acid that may be used with economical results, in the writer's opinion, is fuming sulfuric acid containing $9^1/_2$ per cent of free SO_3; the limitation being enforced by the necessity of avoiding the formation of diphenylsulfone. Since the composition of the spent acid from the sulfonation is a constant, the amount of sulfonic acid necessary for the completion of the reaction is increased very largely as the concentration of the initial acid is decreased. It has not been considered economical, therefore, to use acid weaker than one containing 98 per cent H_2SO_4. The figures given above are for the higher concentration. The result of the sulfonation is a solution of sulfonic acid, sulfuric acid, and water. The sulfuric acid and water together make a spent acid of approximately 80 per cent H_2SO_4 and 20 per cent H_2O. The solution then contains, in round numbers, 60 per cent sulfonic acid and 40 per cent spent sulfuric acid. The sulfonic acid is required in the form of sodium salt. The procedure in all plants is essentially the same, although many minor variations have been adopted. Slaked lime is placed in the agitators and the mixture of sulfonic and sulfuric acid slowly added during agitation. The sodium salt may be formed by addition of sodium sulfite obtained from the fusions later in the process. When this procedure is adopted, the mixture in the agitators consists of a water solution of sodium benzosulfonate and a mixture of solid calcium sulfite and calcium sulfate. The whole is heated to 115° in order to obtain the sulfate in proper crystalline form for filtering, and is passed through the filter presses. The resulting solution of sodium benzene sulfonate contains approximately 12 per cent of the salt and small quantities of calcium sulfate, due to the slight solubility of this material. It is important to remove all calcium salts, both for the sake of the tubes in the evaporators and because of the havoc they cause in the fusion operation. This is accomplished by the addition of the necessary small

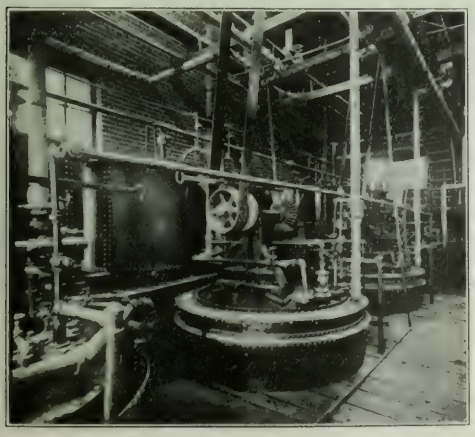


Fig. III—Sulfonators. Top View

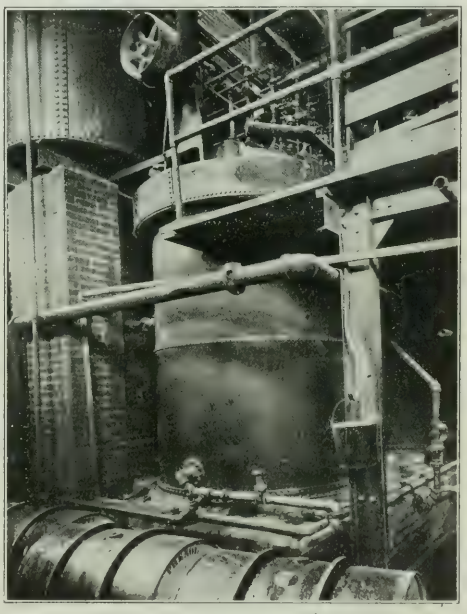


Fig. IV—Sulfonators. Side View

amount of sodium carbonate and refiltration. Some factories make the soda salt in two steps, adding sodium carbonate to the filtered solution of calcium benzosulfonate; others add only the amount of lime necessary to react with the sulfuric acid, in making the soda salt in one step, which makes the use of the by-product sulfite difficult, due to the liberation of SO_2. The 10 per cent solution is evaporated down to the saturation point, and the salt obtained from the syrup by means of drum dryers. The salt, preferably retaining about 10 per cent of water, is fed into melted caustic soda in the fusion kettles, there being about one mole of soda in excess. The temperature during the fusion is maintained between 320° and 350°, the salt being fed in slowly during the operation.

320° C. appears to be the critical temperature of the reaction. As the result of the fusion, a light brown



FIG. V—AGITATORS

liquid mass with the appearance of melted chocolate is obtained, which is poured hot into such an amount of water as will dissolve the phenolate and leave the sodium sulfite in solid form. This is done in vessels marked "dissolvers," which are provided with stirrers. Only about 10 per cent of the sulfite formed remains in the solution and this amount can undoubtedly be decreased. The phenolate liquor is filtered from the sulfite on open sand filters. The sulfite is agitated with water, separated by means of filter presses, washed free of phenol, and marketed as an impure sodium sulfite. A typical analysis of this material is:

	Per cent
Moisture	24.20
Na_2SO_4	7.12
Na_2SO_3	62.30
Insol. in hot H_2O	0.46
C_6H_5ONa	0.60

The wash water is used in the dissolvers so that its sulfite is deposited again on the filter beds.

The phenolate liquor is carefully diluted to a gravity corresponding to a phenol content of about 16 per cent. This diluted solution is placed in a series of tanks. Thirty per cent carbon dioxide gas generated from a mixture of coke and limestone is passed through it. These so-called "blowers" are arranged so that the gas may pass from one to another in any direction desired. The strong gas goes first through the almost neutralized phenolate and leaves from a strongly alkaline solution, thus avoiding any possibility of loss due to the vapor pressure of phenol at the temperature of the spent gases involved, which is about 50° C. It is not possible to entirely neutralize the phenolate solution by means of carbon dioxide in one operation unless such a large excess of CO_2 is introduced as to transform all the carbonate to bicarbonate, which is undesirable. When the passage of the gas is discontinued, the phenol layer contains in solution about 10 per cent phenol as sodium phenolate, while the carbonate layer is free from phenolate but contains approximately 2 per cent of phenol. The carbonate is completely freed from phenol by means of a steam distillation; a 4 per cent solution of phenol is obtained in this way. The crude phenol, containing 10 per cent of phenolate, may be completely acidified with CO_2, by replacing the carbonate solution with water. Niter cake, however, used as an acidifying agent, has the advantage of simultaneously removing a large percentage of the water present. The dehydration reduces the water content of the crude phenol from 30 per cent to less than 14 per cent, and relieves the refining stills of a great burden. The crude acid is placed in a simple still from which is obtained a first fraction of water and phenol, a middle fraction of pure phenol, and a residue of the more complex phenolic bodies formed in the fusion. The synthetic phenol produced is exceedingly pure; it is comparatively easy to obtain material melting at 40°. Redistillation gives a product melting at 40.6° C. The true melting point of pure phenol is in our opinion 40.8° C.

The great economies possible in the process are obviously to be made in the cutting down of the 100 per cent excess of sulfuric acid, the reclaiming of the caustic soda, and the marketing of the sodium sulfite in a useful and valuable form. The maximum yield



FIG. VI—EVAPORATORS—DISSOLVERS



FIG. VII—RECORDING GAUGE, AUTOMATIC TEMPERATURE CONTROL

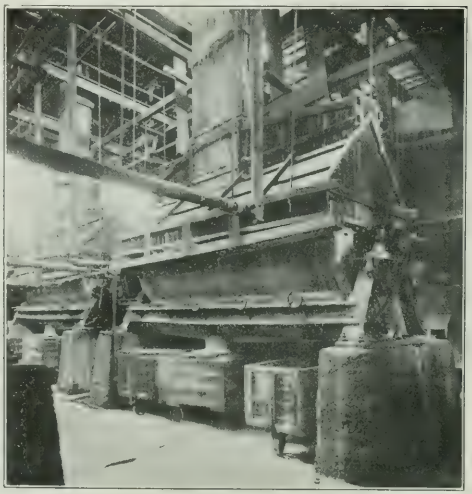


FIG. VIII—DRUM DRYERS

which has been claimed for the process is about 80 per cent. Our work has shown that the fusion operation alone will not yield more than 90 to 92 per cent of the theoretical, and in practice it is difficult to maintain this high standard. Under present conditions, the average American practice probably results in a total over-all yield of between 60 per cent and 75 per cent. As chemical processes go, the process requires an inordinate amount of labor and the repeated handling of the material gives ample opportunity for mechanical losses, particularly in view of the restlessness of workmen under present conditions.

Two methods have been suggested to reduce or conserve the excess of sulfuric acid used. Daniel Tyrer of England (U. S. Patent No. 1,210,725) passes benzol vapor through sulfuric acid of as low concentration as 90 per cent H_2SO_4, at temperatures varying between 100° and 185° C. That part of the benzol vapor not reacted upon carries with it to a condenser the water of reaction, and so gives a constant concentration to the sulfuric acid, keeping it active. Tyrer claims in this way to get about 80 per cent of the amount of sulfonic acid theoretically obtainable from the sulfuric acid used. This method has not yet been tried on a large scale in this country.

The second method is that of Dennis and Bull. Some two years ago, Professor L. M. Dennis,[1] of Cornell University, discovered that although the solubility of pure sulfonic acid in benzol was negligible, benzol would take up from the mixture of sulfuric and sulfonic acids between 2 and 3 per cent of its own volume of the sulfonic acid. In working out this idea, it occurred to Mr. Hans Bull,[2] of The Barrett Company,

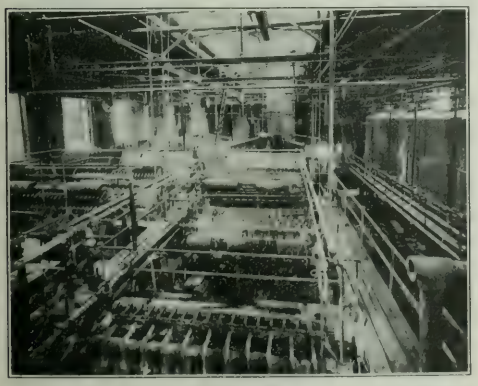


FIG. IX—FILTER PRESSES

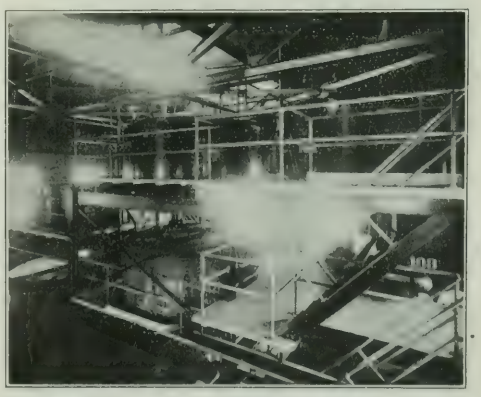


FIG. X—GENERAL ARRANGEMENT DENNIS-BULL PROCESS

[1] U. S. Patents 1,212,612, 1,211,923, 1,227,894, 1,228,414, 1,229,593.
[2] U. S. Patents 1,247,499, 1,260,852, 208,632.



FIG. XI—WASHERS

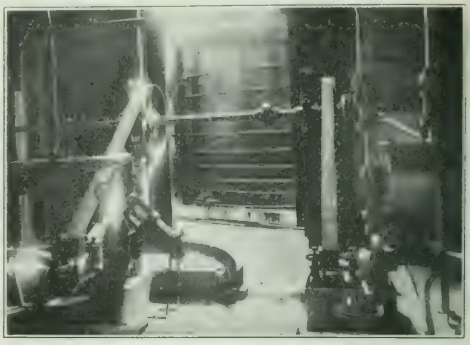


FIG. XII—PUMPS AND ONLY WORKING PARTS

that the sulfonation could be made simultaneously with the extraction. These ideas have been utilized in the evolution of an extremely simple process which not only saves 90 per cent of the excess sulfuric acid as a spent acid containing 70 to 77 per cent H_2SO_4, but eliminates a good percentage of labor, all the lime, and substantially reduces the deplorable cost of repairs, due to the many moving parts of the old installation.

The process will be easily understood from Fig. II. The vessels 1, 2, 3 and 4, so-called "extractors," each contain at rest a layer of a solution of sulfonic and sulfuric acids of varying proportions. The benzol passes continually upward through this series of extractors, the vessels being under a pressure equivalent to the head of benzol. The distribution of the liquid in fine bubbles is effected by means of perforated branch pipes. After the passage of the benzol for a certain length of time, the solution in No. 1 is free from sulfonic acid and consists of 77 per cent H_2SO_4. When this has been accomplished the so-called "spent acid" is withdrawn. The solution in No. 2, which probably contains 10 per cent of sulfonic acid, is dropped into No. 1. The solution in No. 3, which contains probably 25 per cent sulfonic acid, is dropped into No. 2, and the solution in No. 4, which contains probably 40 per cent sulfonic acid, is dropped into No. 3. Into No. 4 is then slowly introduced a charge of 98 per cent sulfuric acid. The flow of benzol is not interrupted at any time. Sulfonation takes place almost immediately and the volume of the benzol flowing through, approximately 200 gal. per min., is so great as to effect almost instantaneous removal of the heat of reaction. The benzol is maintained throughout at a temperature of 60° C. This is accomplished by heaters at the bottom of the system and coolers at the top. After passing through the coolers, the benzol, which will contain approximately 2 per cent sulfonic acid, passes successively through the washers 5, 6, and 7, containing water.



FIG. XIII—EXTRACTOR

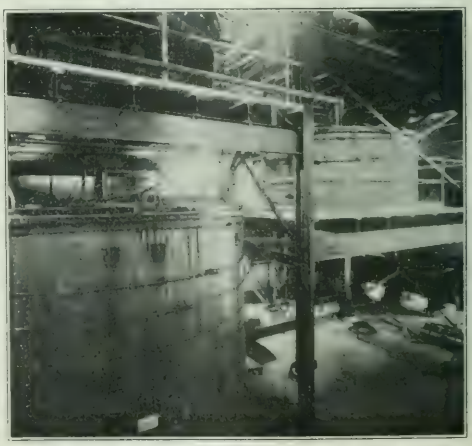


FIG. XIV—FINAL WASH TANK AND RECEIVER FOR WATER SOLUTION OF BENZENE SULFONIC ACID

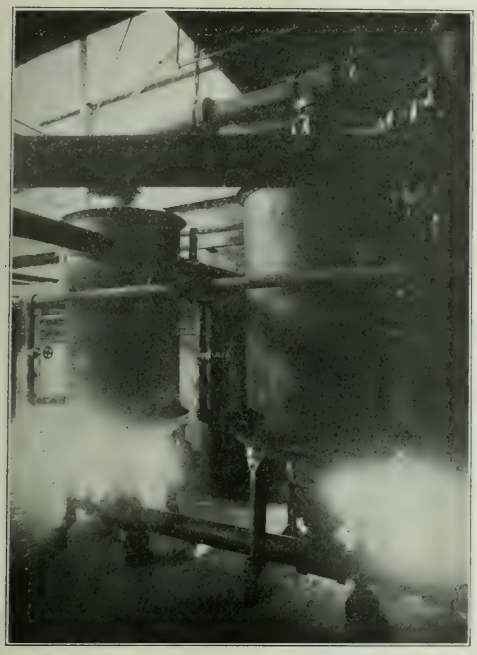


FIG. XV—COOLERS

The benzol falls from one vessel to another by gravity, there being no pressure on this part of the system. The sulfonic acid remains in the water and the benzol leaves the last washer entirely relieved of its burden. It is passed to large settling tanks where the rate of flow is slowed down to such an extent as to allow the sulfonic acid solution, carried in suspension, to settle, and from these tanks flows to the pump and is forced through the heaters to the extracting system once more. When such an amount of sulfonic acid has been deposited in washer 5 as to bring it to the strength desired, it is removed to an evaporator and the solution from washer 6 pumped to No. 5, and that from No. 7 to No. 6. Fresh water is put into No. 7. A water solution of sulfonic acid can be obtained containing 60 per cent or even more sulfonic acid and contains also about 2 per cent by volume of benzol in solution. The benzol is removed by evaporating a small percentage of the water. The solution of sulfonic acid is then neutralized, either by the carbonate solution from the phenol blowers or with the solid sulfite of soda. The sodium benzosulfonate obtained contains some 5 or 6 per cent of sodium sulfate, due to the solubility of sulfuric acid in the benzol solution of sulfonic acid (one part sulfuric to twenty parts sulfonic). The advantages of the process are obvious. The initial cost of the plant is about 50 per cent of the old style plant, which it displaces, it runs practically without attention, and requires from one-third to one-fourth the number of laborers. Taking for granted complete extraction of the sulfonic acid, which proves quite possible, and a removal of the benzol from the water solution of sulfonic acid, the losses possible are confined to mechanical causes, that is, either leaks or evaporation. The yield under the old process, from benzol to sodium benzosulfonate, is about 90 per cent. The new process makes easily possible a yield of 98 per cent, leaving the mechanical losses out of consideration. The formation of disulfonic acid and of sulfone is negligible. The spent acid is concentrated to 93 per cent and used repeatedly. The operations (1) discontinuous sulfonation, (2) liming, (3) filtering, and (4) evaporating, involving complex machinery and many moving parts, have all been displaced with the one simple and continuous operation, extraction and sulfonation going on simultaneously, the only moving parts being two small pumps. The enormous simplification of the process achieved will be made more evident by photographs than by any description.

Another improvement in the process, very generally adopted, has been the so-called "liquid fusion," by means of which the drum dryer, with its dust and spatter, has been eliminated. "Liquid fusion" consists in the introduction of a saturated solution of sodium benzosulfonate directly into liquid caustic soda at a point above the reaction temperature. The reaction, when the temperature is properly controlled, goes even more smoothly than with the solid, since there is no tendency to dust and float, and the rapid evolution of the steam gives better agitation. The fusion is a great source of loss in yield. Well-conducted fusions, where the temperature has been kept down and which for that reason show no evidence of oxidation, give between 86 and 90 per cent yield. Our experience shows that using the liquid fusion method a high yield is more easily obtained than with the dry salt.

So much for innovation. Another important economy to be achieved in this process, and one even



FIG. XVI—SETTLING TANKS

more important than that of sulfuric acid, is that of caustic soda. Neutralizing the phenolate with sulfuric acid, as is often done, is a gross and inexcusable waste. Providing that the lime can be utilized, the difference in cost between the neutralization with CO_2, as generated from limestone and with sulfuric acid, is immeasurably in favor of the former and the operation is exceedingly simple, once the necessity for clear solutions is understood and the fact of the solubility of phenolate in phenol. If any salts are precipitated by the carbonation of the phenolate, an emulsion is obtained from which the phenol will settle only with great difficulty. The avoidance of this emulsifying is merely a question of dilution, however, and no real obstacle is involved. The soda, not only of the phenolate, but the excess soda, is obtained in the form of a weak solution of sodium carbonate, which can be readily causticized and made available at the plant for the fusion operation.

The fusion reaction is:

$$C_6H_5SO_3Na + 2NaOH = C_6H_5ONa + Na_2SO_3 + H_2O$$

If half of the sulfite is used for the formation of the soda salt, only one molecule of soda is consumed and this goes out of the plant in the form of sodium sulfite, a useful and marketable product. Since in the Dennis-Bull process, SO_2 is evolved from the neutralization of the sulfonic acid when sulfite is used, it is possible also to produce bisulfite of soda.

The large amount of limestone needed is not a relatively important objection from the point of view of cost, but it presents a transportation problem of considerable magnitude. The disposition of the calcium carbonate sludge from the causticization may involve considerable expense. From the transportation point of view alone, the calcination of the carbonate sludges, in rotary kilns, as a source of CO_2 and of lime, is justified. This has been successfully tried in connection with other operations and has been found economical in districts somewhat remote from the limestone fields.

Were the various economies indicated taken advantage of there would result a startling decrease of raw materials

	Decrease Per cent
Sulfuric Acid	40
Caustic Soda	60
Lime	90
Limestone	100

and a corresponding decrease of tonnage to be transported from a total of 884,000,000 to 397,214,400 per million pounds of phenol, or about 50 per cent.

The Barrett Company
17 Battery Place, New York City

CURRENT INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

FAN DYNAMOMETER BRAKE

In the fan dynamometer of W. G. Walker and Co., Emeryhill St., London, intended for measuring the brake horsepower of aero and other engines, the power is absorbed by revolving the instrument in air. The device consists of a pair of jaws or arms, made of well-seasoned ash, adapted to grip at their central part or propeller hub. The blades, of aluminum or steel, can be moved radially to any suitable position. Given the revolutions of the engine, the horse-power can be immediately read off from the curves supplied with the instruments. A correction is given for variation in atmospheric conditions. The instruments are made in four sizes, covering between them a range from 300 to 500 h. p.

SOAP AND GLYCERIN MANUFACTURE IN INDIA

It is understood that the Madras government contemplates shortly opening a soap factory at Hyderabad and that a recent visit of the Director of Industries and Commerce of Hyderabad to Malabar was for the purpose of collecting information and copying the government soapery in Malabar as regards plant, etc. It is believed that the Bombay government will soon establish a soapery and indeed it is evident that the several provinces are inquiring into the possibilities of the soap business which Sir F. A. Nicholson has so successfully established and proved to be a sound commercial proposition. More than all this, it is quite probable that the Munitions Board before very long will be running large factories at various centers in India for the manufacture of glycerin. A glycerin industry is well calculated to bring in its wake factories for the manufacture of soaps and candles and altogether the outlook for the oil trade is certainly promising. The west coast, it may be mentioned, is eminently suited for the manufacture of glycerin, since oils of all descriptions are very largely available.

NEW VOLTAIC CELL

La Nature for April 6, 1918, describes a new form of voltaic cell, with electrodes of zinc and carbon in a solution of sal-ammoniac, which is due to Mr. Féry, and has been in use for some time on the French railways. The negative electrode is a plate of zinc which rests on the bottom of the glass containing jar, the copper wire connected to it being insulated up to a point well above the level of the solution in the jar. The positive electrode is a carbon tube of diameter about half that of the jar, pierced with holes, which rests on the zinc plate, being insulated from it by an ebonite cross. The evaporation of the sal-ammoniac solution is prevented by the wooden cover. During the action of the cell, the lower part of the solution becomes acid, owing to the descent of the dense zinc chloride, while the upper part becomes alkaline, owing to the ammonia produced. The depolarization of the cell is effected by the air alone. The electromotive force of the cell is 1.18 volts, and a cell giving 90 amp. hrs. weighs only 2.1 kg.

OILSEED INDUSTRY OF RHODESIA

In view of the fact that even before the war it was becoming difficult to cope with the world's demand for oils and fats for the manufacture of margarine and that this difficulty has been increased during the war, it is interesting to note that the cultivation of oilseeds promises to become an important industry in Rhodesia. At present, ground nuts and sunflower seeds are the only oilseeds produced commercially, but experiments conducted with other oilseeds show that these may be successfully grown. Castor seed, sunflower seed, sesame seed, and linseed grown in Rhodesia have been tested at the Imperial Institute, London, and have given entirely satisfactory results. Before the war sesame seed was chiefly crushed on the continent but this is now being done in the United Kingdom.

CANE BY-PRODUCTS IN NATAL

A comparatively new South African enterprise is represented in the manufacture of rectified alcohol, methylated spirit ether, and cane-wax by a cane by-products company at Merebank in Natal. The original venture was the extraction of wax from the refuse of the sugar mills. This product is termed mila and in appearance is like rubble. Mila is dried on the sugar estates and then sent to Merebank where it is put in an extractor which is constructed in two sections, the upper part of which has a false perforated bottom. At the top is a condenser and a benzene tank combined, and, after being subjected to a certain process, the wax and benzene pass through a side-glass into the bottom chamber. Here the benzene is driven from the wax and the latter put into moulds. The company lately, according to the *Board of Trade Journal*, has undertaken to manufacture "natalite" (or motor spirit) which it is claimed will in time displace petrol for driving machinery and particularly motors. The source of natalite is molasses from the sugar estates, which is brought to Merebank and drained into 250,000 gal. tanks. The molasses is then run into large vats and fermented. Next it is pumped up into a receiver and the wash run into a still. The spirit is separated by a heater from the wash which is used for fertilizing purposes. The vapor of the spirit passes through two columns and a still in which the good spirit is separated from the best of 70 overproof. The best is used for the preparation of natalite, the weaker for making methylated spirit.

THE SYNTHETIC MARKET

Owing to the continued scarcity of cloves and clove oil, says the *Oil and Color Trade Journal*, **53** (1918), 1483, the price of eugenol has risen still further, and vanillin is a very firm market at $17 to $17.50 with an upward tendency. There has been no further advance in artificial rose products, and phenylethyl alcohol is still obtainable at $31.25 to $35, according to quality, but phenylethyl aldehyde is dearer and up to $45 has been paid for small quantities. Coumarin is scarce at $43.75, and heliotropine is in fair demand at about $8.75. All kinds of synthetic musk are scarce and the cheapest, pure, is xylene musk at $20.75. Cheaper varieties, diluted usually with acetanilide which was, of course, the diluent used in original musk-Baur, are offered at about $7.50 to $8. Safrol is dearer at $1.25 and bromostysol can only be obtained in small quantities at $24 to $24.50 per lb. Terpineol is worth nearly, if not quite, $1.80 per lb., for best qualities free from water.

SULFATE OF AMMONIA

Recently published statistics show that the production of 700,000 tons of sulfate of ammonia was expected in Germany for 1917, while, according to recent available data, the quantity for 1915 was 549,000 tons. For 1917, the American production is estimated at 400,000 tons and the capacity for production for 1918 may reach 500,000 tons. The Japanese output is continually increasing. In 1914, it scarcely exceeded 16,000 tons, in 1915 the figure had risen to 31,824 tons, while in 1916 the total became 38,203 tons. For 1917 the estimated output was 50,800 tons.

EXPLOSIVE CHEMICALS

M. Stettbacker discussed this question before the Swiss Chemical Society recently. Nitroglycerin develops 1,580 calories; oxylignite (explosive with liquid-air base), 2,200 calories; ethylene ozonide and benzene triozonide give similar figures but are more disruptive. More powerful explosives are conceivable; trichlorate of glycerin can develop 3,600 calories and, if a mixture of liquid hydrogen and liquid ozone were feasible, the calorific value would be 4,500.

DETERMINATION OF OXYGEN IN IRON

The method for the quantitative determination of oxygen in iron was proposed by Ledebur in 1882. He heated the iron in a current of hydrogen and absorbed the water formed by the combination of part of the hydrogen with the oxygen in the iron by the aid of phosphorus pentoxide. This and similar methods have found little application, however, because the analysis takes too long a time, 4 to 5 hours, and Ledebur was doubtful as to its reliability. The oxygen may be present in the iron as such or it may be combined with the iron and with various other elements in the iron and these compounds are not reducible with the same ease. It is assumed that manganous oxide and silicates, likely to be present as slag enclosures, are not reduced by hydrogen at temperatures of 900° or 1,000° C. which are generally the prescribed limits of such analyses, when ferrous iron is reduced. At the same time, says *Engineering*, it would be highly desirable to follow the advancing deoxidation of metallurgical processes by analytical means and to have some method of determining the occluded oxygen in iron to which some metallurgists attribute considerable importance. It is interesting to note that P. Oberhoffer, of Breslau, claims to have simplified the Lederbur method so that a complete analysis can be made within an hour and that metallurgical processes can be followed. The apparatus (*Stahl und Eisen*, Feb. 7, 1918) consists of a hydrogen generator apparatus for purifying that gas, a mercury air pump of the Bentell type, a combustion tube of silica-glass, and a tubular electric furnace. The iron specimen, turnings as a rule, is heated in a tube by means of burners to facilitate the complete evacuation of the tube, the hydrogen is then admitted and the furnace slipped over the tube which is raised to a temperature of 950° C.

ITALIAN DYE AND CHEMICAL INDUSTRY

An Italian contemporary, says the *Chemical Trade Journal*, 62 (1918), 398, commenting on the status of the aniline dye industry in Italy, states that the necessities of the war have obliged producers of coal gas in that country to make benzol and toluol for the manufacture of explosives but that, after the war, these products will serve for the manufacture of aniline dyes. It is calculated that the plants now in Italy can already supply the following quantities of materials annually: pure benzol, 12,000 tons; toluol, 2000 tons; naphthalene, 3000 tons; phenol, 500 tons; and anthracene, 560 tons. These quantities, it is said, are more than sufficient to meet any demands from future aniline factories in Italy. As regards chemicals, it is said that large quantities of such chemicals as sulfuric acid, oleum, nitric acid, ammonia, chlorine, soda, etc., are being manufactured in Italy and that that country will in future not be so dependent upon foreign sources of supply as she has been in the past.

SKODA WORKS PEACE PREPARATIONS

Die Zeit quotes from an article in the *Pravo Lidu* on the measures taken in the Skoda Works in preparation for peace. A special department of engineers and commercial directors has been formed to work out a detailed plan for converting the works from an undertaking for the production of war material into one for the manufacture of peace products. A great department is being set up for the manufacture of machinery, especially agricultural machinery for export trade, with the object of securing the Balkan market in the first place. The Skoda factories have large stocks of machines which will be thrown on the Rumanian market. It is expected that a great impetus to shipping will be witnessed in the Dardanelles and part of the works will be devoted to the manufacture of motor boats for export to Turkey and Bulgaria. Ships (for Adriatic ports), motors, and flying machines are also to be built.

MACHINERY IN SOUTH AMERICA

Imports of machinery to South America must always be of paramount importance since none of the states are at present self-supporting in this direction. How considerable is the demand may be judged from the fact that just before war broke out there were in active operation in the Argentine no fewer than 29,690 industrial establishments showing an increase of 65 per cent since 1904. The capital invested in these establishments represented a sum of $330,000,000, the percentage of native-owned factories being 14.67. Over 118,000 emp loyees are constantly at work producing goods—all more or less in competition with foreign importation—worth $982,000,000. Naturally, the greater number of these factories are to be found in the cities—Buenos Aires, Rosario, Santa Fé, Mendoza, etc., where there are plants and equipment equal to any in Europe, if foundries and machine shops are excepted. Other markets for engineering ware, such goods as iron and steel plates and sheets, tubes, pipes, iron and steel fittings, electrical appliances and apparatus are available. The German concern which supplied Buenos Aires with electric light and made all its purchases direct from Berlin has offered to hand over everything to the Buenos Aires municipality. Fully one-half of the total imports into Argentina of electrical appliances formerly came through this company. Now this source is cut off and the sale of small motors, insulators, cables, dynamos and accessories might be greatly augmented by having agents for these goods in the port towns.

CEMENT MORTARS AND MAGNESIUM CHLORIDE

Some experiments, according to *Engineering*, 105 (1918), 636, on the influence of magnesium chloride on cements to be used in frosty weather, were made last winter, by the Verein Deutsche Portland Zement Fabrikanten. Pure specimens were mixed with standard sand in the proportion 1 : 3 and with ordinary water or with an aqueous solution of magnesium chloride. The specimens were exposed to a temperature of —7° C. (20° F.), and the ordinary specimens took three days to set sufficiently for removing the mould casing, while the specimen made with the magnesium chloride set within one day. On the other hand the strength tests performed after one week and four weeks were in favor of the cement made with water only; the values were 185 kg., 205 kg., 295 kg., and 344 kg. per sq. cm., respectively. Thus, the addition of magnesium chloride lowers the strength of the cement somewhat, not sufficiently, however, to exclude the use of the reagent when cement has to be laid down in cold weather.

BLAST FURNACE PRACTICE

Several communications made at the annual meeting of the Iron and Steel Institute related to practice with blast furnaces. The report of the committeé on this subject summarizes the replies to a series of inquiries addressed to all owners of blast furnaces in this country. Mr. T. C. Hutchinson describes some modifications in practice and design that led to considerable fuel economies, in one case a reduction of coke consumption by 2 cwt. per ton, and increased the output of iron by 33.7 per cent. The saving of fuel was attributed entirely to the better distribution in the furnace by the increased size of the bell and the life of the furnace lining was also considerably improved. A paper by Dr. J. E. Stead on "Blast Furnace Bears," makes interesting reading. "Bears," it should be explained, are the masses of metal which are found below the hearth level of a blast furnace after the furnace has been blown out. A number of bears were analyzed with somewhat curious results. Quite a variety of compounds and crystalline formations were found to occur. Among the substances noted were nitrocyanide of titanium, large idiomorphic crystals of double carbide of manganese and iron, and carbonless iron masses rich in phosphorus.

CHROME TANNING

At a recent lecture before the Royal Society of Arts, London, on "Recent Developments of Leather Chemistry," Dr. H. R. Procter suggested an alternative method of chrome tanning which would overcome the difficulties arising out of the shortage of glucose and sugar. He did not claim the method to be the result of some great discovery but thought that it might be of value to the trade. The process depends on the use of sodium dichromate, which is preferable to the potassium salt besides being more soluble in water. Four pounds of sodium dichromate can be dissolved in a gallon of water without giving a thick solution. Into this is passed a current of liquid sulfur dioxide or the fumes from sulfur burning in a furnace are passed through the solution, this latter method being both cheap and effective. In this way is obtained a chrome extract containing 18½ per cent of chrome oxide to the gallon, richer than any on the market and requiring only dilution with water. Professor Procter admitted that he had not experimented long with this solution, but in the experiments which he had carried out he found that in 24 hrs. the skins were apparently thoroughly tanned and rather thicker than when they went into the solution. As a sole leather tannage, he considered this solution to be very promising.

ELECTRICAL MACHINERY

A pamphlet issued by Messrs. Vickers, Glasgow, contains about 60 excellent reproductions of photographs illustrating the electrical machinery made by the firm. Some views of the shops in which the machines are manufactured are followed by a section dealing with generating plant of all kinds for both direct and alternating current. Another section is devoted to rotary converters and motor generators and a third to both direct and alternating current motors of numerous types and sizes. The last section illustrates the application of electric motors to the driving of machinery, such as lathes, small rolls, winches, mine hoists and particularly planers fitted with the firm's patent automatic reversing drive. The brief descriptions under each photograph are printed in English, Spanish, Fr ench, and Italian

ELECTROLYTIC PROCESS

By a new electrolytic process, aluminum can be coated with nickel, silver, copper, or other metal. The process can be applied to sheets, rods, wire, tubing, etc., and to aluminum alloys in castings or worked products. With nickel plating a hard, beautiful finish, taking a fine non-tarnishing polish, is given while the aluminum is much strengthened with no great addition to its weight.

RECOVERY OF TIN

Chemical Trade Journal quoting from a contemporary gives a review of the methods which have been proposed for the recovery of tin from waste tinplate. One depends on the use of acids to dissolve the tin from the steel but here there is the difficulty in preventing the steel from being dissolved at the same time. Another in which caustic alkali is the solvent employed has been used to dissolve the tin and obtain clean steel. In a third the scrap tin is treated with dry chlorine gas, the product being stannic chloride. According to a process suggested by Bergser, an aqueous solution of tin tetrachloride is used as a solvent. The product obtained is stannous chloride which can be electrolyzed into tin and chlorine. The latter can in turn be used for making tin tetrachloride from stannous chloride. By electrolysis also the metal can be recovered from the solution formed with the aid of acids or alkalies. Solder can be extracted in a desoldering furnace provided with a means for obtaining a neutral atmosphere to prevent excessive oxidation and when a clean steel is obtained, hydraulic or mechanical presses are used for pressing it into blocks weighing about 1 cwt.

ANALYSIS OF ALUMINUM ALLOYS

Rapid methods of analysis of aluminum alloys, says *Engineering*, 105 (1918), 587, are now in demand. Messrs. B. Collitt and W. Regan in a recent paper express their agreement with the recommendations previously made by Mr. J. H. Stansbie, *viz.*, (1) to open out the alloys with a solution of caustic soda, (2) that in this way practically all the zinc and aluminum would be in the filtrate, while copper, iron, nickel or magnesium and all the manganese (except a trace) would remain on the filter, (3) that a small amount of aluminum would also remain on the filter so that the iron could not be precipitated by ammonium. They distinguish for analytical purposes alloys containing 10 per cent and 20 per cent of zinc, up to 5 per cent of copper, and small amounts of one or more other metals (Fe, Ni, Mn, Mg); alloys with up to 5 per cent copper and amounts up to 2.5 per cent of other metals including zinc; lead and tin were absent in the alloys they had dealt with. They did not make use of gravimetric (density determination), magnetic, and electrolytic methods (though the latter would be convenient for zinc). Manganese they estimate volumetrically with the aid of stannous chloride; silica was always tested for but a convenient method for determining aluminum does not exist as yet.

CATALYST FROM METALLIC SALTS

According to a new German patent, the mass obtained by precipitating the metallic salts on an inorganic carrier is dried and mixed with the material to be treated, or is triturated with an inert solvent and is then treated to expel the water and volatile acid of the salt which would otherwise act adversely on the reduction process. If the catalyzer is intended for reducing fats and oils, Kieselguhr, asbestos, etc., are saturated with nickel acetate, the dried mass being ground extremely fine with a little oil and then heated to 150° or 200° C. in a closed apparatus filled with stirrers and connected to a vacuum pipe. When the water and volatile acid have been drawn off, the catalyst is rendered more active by a current of hydrogen. The product is claimed to be stable and to stand carriage.

NEW MINING EXPLOSIVE

The *Board of Trade Journal* says that a new explosive is now being used in South African mines and is resulting in a great saving of nitroglycerin. The shortage of the latter owing to its use for ammunition was, indeed, leading to difficulties in the industry. Hitherto, the standard explosive used has been gelignite, which contains 57 per cent of glycerin. It is now almost replaced by sengite, which is a gun-cotton explosive specially prepared and put into cartridges for the mines. The ingredients of sengite are more readily obtainable than nitroglycerin and they are added to gun-cotton. Sengite is not altogether a new explosive, but it is new to mining practice.

NEW SOURCES OF OIL SUPPLY IN GERMANY

The straits to which Germany has been reduced by the cutting off of oil supplies from outside has led to some remarkable discoveries or at least communications of discoveries. Prof. R. France, of Munich, claims to have discovered a new source of oil in certain cryptogrammic plants growing in Bavaria to which he has given the name "Esaphone." He calculates that by adding thereto certain other parasitic plants growing in Germany some 1,200,000 kilos of oil of excellent quality can be obtained per annum. As it does not congeal except at about 40° below zero, he suggests that it would be highly useful for aeroplanes and the engines of vessels going to arctic regions. Prof. France also states that by collecting the drops of resin which collect in spring upon felled pine and fir trees about 60 liters of oil could be secured from every cord of wood.

ULTRA-FILTER

In many analyses, especially in acid determination by the inversion of sugar, rapid filtration of turbid liquids is necessary. Such liquids are apt to pass turbid through ordinary filter paper. In the *Chemiker Zeitung*, Dr. Wolfgang Ostwald describes how an ultra-filter may be made from an ordinary filter with the aid of some 4 per cent collodion solution. The filter is placed in a funnel and wetted with water so as to lie well against the glass; the collodion is then poured into the filter; as the collodion is insoluble in water, it turns into an emulsion which soaks into the paper. The collodion solution is filtered and the paper allowed to dry. After 5 min. the process is repeated. The filter is now stiff; it is taken out of the funnel, placed in distilled water to coagulate the collodion, and is afterwards ready for use. As a rule, only the small filter cone which is fitted into the lower part of the funnel need be treated in this way.

LUBRICATING MATERIAL

Owing to the scarcity of grease in Germany, engineers in that country are paying much attention to other forms of lubricating material. *Der Papier Fabrikant* says that from 40 to 60 per cent of tallow mixed with mineral oil is effective and economical and that high grade graphite may be substituted for the tallow. Artificial graphite is manufactured in Germany, both by intensive chemical treatment and by subjecting carbonaceous material to the heat of an electric arc in a space from which air has been excluded.

INDIAN RESIN

The Indian Munitions Board Handbook, recently issued, states that the Indian pure resin industry has made rapid strides within recent years and shows promise for the future. At present, resin tapping is carried out only in the United Provinces and the Punjab and is confined to one species of pine, namely, the *chir* of the Himalayas, which covers some 1,500 sq. mi. in the Government forests and another 1,800 sq. mi. in the native states. Even if it is assumed that only a portion of the total area will lend itself to remunerative tapping, an extension of operations is possible on a larger scale in the case of this pine alone, while it is possible that systematic tapping on an appreciable scale may be introduced later in the case of the blue pine of the Himalayas and the pines of Assam and Burma. Tapping and distillation are in the hands of the Forest Department which, at present, manages two distilleries, one at Bhowali, in the United Provinces, and the other at Jallo, in the Punjab. Statistics still show that there is room for a large expansion in the Indian output for the supply of India's requirements alone, apart from stimulating trade with China, Java and other foreign countries. At present, the Indian resin industry is in the position of having to retard or accelerate its expansion with reference to the speed with which the remaining Indian markets can be secured and foreign markets developed.

BRITISH BOARD OF TRADE

During the month of June inquiries have been made by firms at home and abroad regarding sources of supply of the following articles. Firms able to supply information regarding these things are requested to communicate with the Board of Trade, 73 Basinghall St., London, E. C.:

Acetylene gas burners
Agate in the rough for mortars and pestles, 4 in. to 5 in. in diameter
Bootlace tags
Earrings, cheap
Machinery for Making:
Roofing papers
Buffalo hide pickers (as used in looms)
Serrated edge on grass hooks
Spouts of galvanized iron for use in tapping rubber trees
Straw tubes, for iced drinks, etc.
Tenter hooks, tinned
Wood travelling trunks, cheap, covered in leather, cloth or canvas

SCIENTIFIC SOCIETIES

CLEVELAND MEETING, AMERICAN CHEMICAL SOCIETY

The 56th General Meeting of the American Chemical Society will be held at the Hotel Statler, Euclid Avenue and East 12th Street, Cleveland, Ohio, September 10 to 13, 1918.

Registration and all meetings, except as specially announced, will be held at the Hotel. Registration will begin at 3 P.M., September 9. Information regarding other hotels may be obtained from the chairman of the committee on hotels.

CHAIRMEN OF LOCAL COMMITTEES

Executive: A. W. Smith, Case School of Applied Science, Cleveland, Ohio. Hippolyte Gruener, Adelbert College, Cleveland, Ohio.

Finance: W. A. Harshaw, 720 Electric Bldg., Cleveland, Ohio.

Entertainment: Hippolyte Gruener, Adelbert College, Cleveland, Ohio.

Hotels: H. H. Gronemeyer, 1887 East 93d St., Cleveland, Ohio.

Entertainment of Ladies: Miss Josephine Grasselli.

GENERAL PROGRAM

MONDAY, SEPTEMBER 9

Afternoon: Council Meeting. University Club
Evening: Dinner to the Council at University Club (tendered by the Cleveland Section).

TUESDAY, SEPTEMBER 10

Morning: General Addresses.
Address. Assistant Secretary of War, Benedict Crowell
"The American Chemists' Place in Warfare" Charles L. Parsons
"The Work of the Chemical Section of the War Industries Board" Charles H. MacDowell
"War Disturbances and Peace Readjustments" Grinnell Jones.
"The Place of the University in Chemical War Work." Edward W. Washburn
"The Work of the Government Research." Lieut. Col. Wilder D. Bancroft.
Afternoon: General Symposium on the "Chemistry of Dyestuffs."
Evening: Banquet and Smoker at Hotel Statler.

WEDNESDAY, SEPTEMBER 11

Morning: Divisional Meetings, Hotel Statler.
Afternoon: Excursions [see THIS JOURNAL, **10** (1918), 653].
Evening: President's Address: "A Retrospect and an Application."

THURSDAY, SEPTEMBER 12

Morning: Divisional Meetings.
Afternoon: Divisional Meetings. Outing to one of the country clubs, followed by reception at Cleveland Museum of Art.

DIVISIONAL PROGRAMS

The usual meetings, including the annual election of officers, will be held by all the Divisions, and by the Rubber Chemistry Section, with the following special program:

THE DIVISION OF BIOLOGICAL CHEMISTRY is planning a symposium on plant chemistry.

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS, besides continuing the symposium on the chemistry of dyestuffs, is planning a symposium on potash and a continuation of the very successful symposium on metallurgical subjects started at the Boston meeting.

PAPERS FOR THE MEETING

THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS have voted that the titles of all papers should be sent to the Secretary of the Division, which title should be accompanied by an abstract; that any title sent without an abstract shall not be printed in the program, and that the time limit for the presentation shall be 5 minutes, unless special arrangements are made with the Secretary of the Division.

By vote of the Council no papers may be presented at the meeting, titles for which are not printed on the final program.

"By Title" should be placed on the announcement of any paper where the author is to be absent, so that members may understand in advance that the paper will not be read.

ADDRESSES OF DIVISIONAL SECRETARIES

Agricultural and Food Chemistry: Fred. F. Flanders, 88 Corey Road, Brookline, Mass.
Biological Chemistry: I. K. Phelps, Bureau of Chemistry, Washington, D. C.
Fertilizer Chemistry: F. B. Carpenter, Virginia-Carolina Chemical Co., Richmond, Va.
Industrial Chemists and Chemical Engineers: S. H. Salisbury, Jr., Northampton, Pa.
Organic Chemistry: H. L. Fisher, Columbia University, New York City.
Pharmaceutical Chemistry: George D. Beal, Chemistry Building, University of Illinois, Urbana, Ill.
Physical and Inorganic Chemistry: W. E. Henderson, Ohio State University, Columbus, Ohio.
Water, Sewage and Sanitation: W. W. Skinner, Bureau of Chemistry, Washington, D. C.
Rubber Section: J. B. Tuttle, Firestone Tire & Rubber Co., Akron, Ohio.

ABSTRACTS OF PAPERS

In order that the meeting may receive due and correct notice in the public press, every member presenting a paper is requested to send an abstract to Dr. Chas. H. Herty, 35 East 41st St., New York City, Acting Chairman of the Society's Publicity Committee. The amount of publicity given to the meeting and to the individual papers will entirely depend upon the degree to which members coöperate in observing this request. A copy of the abstract should be retained by the member and handed to the secretary of the special division before which the paper is to be presented in Cleveland. Short abstracts will be printed in *Science*.

FINAL PROGRAM

The final program will be sent to all members signifying their intention of attending the meeting, to the secretaries of sections, to the Council, and to all members making special request therefor to the Secretary's office.

THE CHEMICAL SOCIETIES IN NEW YORK CITY

1918-1919 SEASON—RUMFORD HALL, THE CHEMISTS' CLUB

October 11—American Chemical Society.
October 25—Society of Chemical Industry.
November 8—American Chemical Society.
November 22—Society of Chemical Industry.
December 6—American Chemical Society. *Joint Meeting* with Society of Chemical Industry and American Electrochemical Society.
January 17—Society of Chemical Industry. *Perkin Medal Award.*
February 7—American Electrochemical Society. *Joint Meeting* with Society of Chemical Industry and American Chemical Society.
March 7—American Chemical Society. *Nichols Medal Award.*
March 21—Society of Chemical Industry.
April 11—Society of Chemical Industry. *Joint Meeting* with American Chemical Society and Society of Chemical Industry.
May 9—American Chemical Society.
May 23—Society of Chemical Industry.
June 6—American Chemical Society.

CALENDAR OF MEETINGS

American Institute of Mining Engineers—Annual Meeting, Denver, Colorado, September 2 to 7, 1918.

American Chemical Society—Fifty-sixth (Annual) Meeting, Cleveland, Ohio, September 10 to 13, 1918.

National Exposition of Chemical Industry (Fourth)—Grand Central Palace, New York City, September 23 to 28, 1918.

American Electrochemical Society—Autumn Meeting, Princeton, N. J., September 30 to October 2, 1918.

FOURTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES, GRAND CENTRAL PALACE, NEW YORK, WEEK OF SEPTEMBER 23 TO 28, 1918

PROGRAM OF ADDRESSES AND MOTION PICTURES

MONDAY, SEPTEMBER 23

Evening: OPENING ADDRESSES:
Dr. C. H. Herty, Chairman Exposition Advisory Committee.
Dr. Wm H. Nichols, President American Chemical Society.
Mr. F. J. Tone, President American Electrochemical Society.
Dr. G. W. Thompson, President American Institute of Chemical Engineers.

TUESDAY, SEPTEMBER 24

Afternoon: SYMPOSIUM ON ACIDS AND CHEMICAL ENGINEERING:
A. Hough, "Chemical Engineering in Explosives; T. N. T., T. N. A., Picric Acid, Nitrobenzol."
E. J. Pranke, "Development of Nitric Acid Manufacture."
Evening: MOTION PICTURES.

WEDNESDAY, SEPTEMBER 25

Afternoon: SYMPOSIUM ON POTASH:
C. A. Higgins, "Recovery of Potash from Kelp."
Linn Bradley, "Recovery of Potash from Iron Blast Furnaces and Cement Kilns."
John W. Hornsey, "Potash from Desert Lakes and Alunite."
H. W. Morse, "Potash from Searles Lake."
Evening: MOTION PICTURES:
Alkali Industries:
1. Electrical Precipitation of Potash from Cement Dust.[1] (Research Corporation.)
2. Colloid Chemistry.

THURSDAY, SEPTEMBER 26

Afternoon: SYMPOSIUM ON CERAMICS—Meeting of the American Ceramics Society:
L. E. Barringer, "Manufacture of Electrical Porcelain." (Illustrated.)
A. V. Bleininger, "Recent Development in the Ceramic Industries."
H. Ries, "American Clays."
F. A. Whitaker, "Manufacture of Stoneware." (Illustrated.)
J. B. Shaw, "Fuel Conservation."
S. C. Linberger, "Carborundum Refractories."
Evening: MOTION PICTURES:
Glass Making[1] (Corning Glass Works).
The Making of Cut Glass[2] (Ford).
Manufacture of Electrical Porcelain[1] (General Electric Company).
The Making of Pottery[1] (Ford).

[1] 1 reel. [2] 2 reels.

FRIDAY, SEPTEMBER 27

Afternoon: SYMPOSIUM ON METAL INDUSTRIES:
Leonard Waldo, "Development of Magnesium Industry."
Alcan Hirsch, "Ferrocerium Pyrophoric Alloys."
Theodore Swann, "Ferromanganese."
Joseph W. Richards, "Ferro-Alloys of Silicon, Tungsten, Uranium, Vanadium, Molybdenum and Titanium."
Evening: MOTION PICTURES.

SATURDAY, SEPTEMBER 28

Afternoon: SYMPOSIUM ON INDUSTRIAL ORGANIC CHEMISTRY:
S. P. Sadtler, "Industrial Organic Chemistry and Its Progress."
C. A. Higgins, "Kelp as a Source of Organic Solvents."
G. H. Tomlinson, "Wood Waste as a Source of Ethyl Alcohol."
Evening: MOTION PICTURES.

Among other films that will be shown each evening of the week are the following:

OIL INDUSTRIES

The Spirit of the Flowers—Essential Perfume Oils.
The Story of a Cake of Soap.
Light from the Rocks—Natural Gas.
Lake Asphalt Industry (Barber Asphalt Paving Co.).
Asphalt Roofing Industry (Barber Asphalt Paving Co.).
Asphalt Colloids (Barber Asphalt Paving Co.).

WATER POWER; ITS DEVELOPMENT AND USE

Niagara Falls.
Power Transmission.
Power of Wealth—Hydraulic Development.
Canadian Shawinigan Falls Power Development and Its Surrounding Chemical Industries[3] (Shawinigan Water & Power Co.).
Fixation of Atmospheric Nitrogen at Niagara Falls and Feeding the Soil with It[2] (American Cyanamid Co.).

CARELESSNESS; THE DESTRUCTION OF LIFE, WEALTH AND RESOURCES

Careless America (Firestone—Universal).
The Crime of Carelessness.
The Workman's Lesson.
Vaccines for Prevention of Disease.
Keep your Business Going[2] (General Fire Extinguisher Co.).

MISCELLANEOUS CHEMICAL INDUSTRIES

Manufacture of Zinc Oxide (New Jersey Zinc Co.).
Manufacture of Genuine Wrought Iron Pipe[3] (A. M. Byers Co.).
From Log to Lumber[4] (Southern Pine Association).
Moving a Forest to France[4] (Southern Pine Association).
The Wonderland of the Appalachians[3] (Clinchfield Railway).
The Operation of a By-Product Coke Plant[2] (H. Koppers Co.).

[3] 3 reels. [4] 4 reels.

LIST OF EXHIBITORS AT THE FOURTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES

COMPLETE AS FURNISHED BY THE MANAGERS OF THE EXPOSITION ON AUGUST 14, 1918

Abbé Engineering Company
Abbé, Paul O.
Ainsworth & Sons, Wm.
Air Reduction Company
Alberene Stone Company
American Aniline Products Company, Inc.
American Blaugas Corporation
American Ceramic Society
American Chemical Manufacturing Company
American Chemical Society
American Cyanamid Company
American Dyestuff Reporter
American Electrochemical Society
American Institute of Chemical Engineers
American Kron Scale Company
American La France Fire Engine Company, Inc.
American Leadburning Company
American Metal Company, Ltd.
American Meter Company
American Pipe Bending Machinery Company
American Scientific Instrument Company
American Steel Package Company
American Transformer Company
American Water Softener Company
Anaconda Copper Mining Company
Angel, H. Reeve & Company, Inc.
Aniline Dyes & Chemicals Company
Anti-Hydro Waterproofing Company
Apex Chemical Company
Arnold, Hoffman & Company, Inc.
Arkell Safety Bag Company

Bachmeier & Company
Baker, J. T., Chemical Company
Baltimore Cooperage Company
Barber Asphalt Paving Company
Bario Metal Corporation
Barrett Company
Bary de, Albert, Jr.
Bausch & Lomb Optical Company
Bayonne Casting Company
Beach-Russ Company
Becker, Christian, Inc.
Beckley Perforating Company
Bethlehem Foundry & Machine Company
Bound Brook Chemical Company
Boyer Oil Company, Inc.
Boyer Oil Manufacturing Company
Bristol Company, The
Brown Instrument Company
Buffalo Foundry & Machine Company
Butterworth-Judson Corporation
Byers, A. M., Company

Calco Chemical Company
Campbell, John, & Company
Canada Carbide Company
Canadian Chemical Journal
Canadian Electro Products Company
Canadian Electrode Company
Carborundum Company
Carrier Engineering Corporation
Celite Products Company
Celluloid Zapon Company
Central Dyestuff & Color Company
Central Scientific Company
Ceylon Company, The
Chemical Catalog Company, Inc.
Chemical Color & Oil Daily
Chemical Company of America
Chemical Construction Company
Chemical Engineer, The
Chemical & Metallurgical Engineering
Chemical Pump & Valve Company
Chemical Warfare Service
Chile Copper Company
Chile Exploration Company
Chromos Chemical Company, Inc.
Clinchfield Products Corporation
Color Trade Journal
Consolidated Color & Chemical Company
Consumers Dyewood Products Company
Contact Process Company
Corning Glass Works
Crandall, Pettee Company
Crane Company
Crane Packing Company
Crescent Color & Chemical Company
Crescent Ink & Color Company

Day, J. H., Company
De Laval Separator Company
Denver Fire Clay Company
Department of Agriculture—Bureau of Chemistry
Detroit Range Boiler Company
Devine, J. P., Company
Diamond State Fibre Company
Dorr Company, The
Dow Chemical Company
Drackett, P. W., & Sons
Du Pont Chemical Works
Du Pont, E. I., de Nemours & Company—Wilmington
Du Pont, E. I., de Nemours & Company—Arlington Works
Du Pont Fabrikoid Company
Duriron Castings Company
Dye Products & Chemical Company

Edison International Corporation
Electro Bleaching Gas Company
Electrolytic Engineering Corporation
Electrolytic Zinc Company
Electron Chemical Company
Elmore, G. H.
Elyria Enameled Products Company
Empire Chemical Company
Empire Laboratory Supply Company
Everlasting Valve Company

Fleisher, W. L., & Company, Inc.
Foote Mineral Company
Foxboro Company, Inc., The
Fuller Lehigh Company

Garrigues, Chas. F., Company
General Bakelite Company
General Bauxite Corporation
General Ceramics Company
General Chemical Company
General Electric Company
General Filtration Company
General Fire Extinguisher Company
Georgia Chamber of Commerce
Georgia Mineral Products Company
Georgia Potash & Chemical Company
Glens Falls Machine Works
Gordon Engineering Company
Greiner, Emil, Company
Groch Centrifugal Flotation Company
Guernsey Earthenware Company

Hanovia Chemical & Manufacturing Company
Hardinge Conical Mill Company
Harrison Works
Hauser-Stander Tank Company
Haynes Stellite Company
Hayward, S. F., Company
Heald, John H., Company, Inc.
Hemingway, Frank, Inc.

Hepworth S. S. Company
Hellenic Chemical & Color Company
Hercules Engineering Company
Hercules Powder Company—Chemical Sales Department
Herold China & Pottery Company
Hodges Water Still Company, Inc.
Holly Pneumatic Systems
Hood, B. Mifflin, Brick Company
Hooker Electrochemical Company
Hoskins Manufacturing Company
Huff Electrostatic Separator Company
Hunter Dry Kiln Company
Huyck, F. C., & Sons

Imperial Color Works
Imperial Dyewood Company, Inc.
Independent Chemical Company
Industrial Filtration Corporation
Innis, Speiden & Company
Irving National Bank
Isco Bantz Company
Isco Chemical Company

Jacques Wolf & Company
Janney, Steinmetz & Company
Jewell Polar Company
Journal of Industrial & Engineering Chemistry

Kalbfleisch Corporation
Kalbperry Corporation
Kewaunee Manufacturing Company
Keystone Minerals Company
King Chemical Company
Klipstein, A., & Company
Knight, Maurice A.
Knoxville Board of Commerce
Koppers, H., Company

Leeds & Northrup Company
Life Savings Devices Company
Little, Arthur D., Inc.
Lummus, Walter E., Company, The
Lungwitz, Emil
Luzerne Rubber Company

Macbeth-Evans Glass Company
Machinery Utilities Company
Manufacturers Record
Marden, Orth & Hastings Company, Inc.
Mathieson Alkali Works, Inc.—Niagara Branch
Mathieson Alkali Works, Inc.
Maynard, T. Poole, Ph.D.
Maywald, Frederick, F. C. S.
Meek Oven Manufacturing Company
Mendleson Corporation
Merck & Company
Metals Disintegrating Company, Inc.
Metz, H. A.
Mine & Smelter Supply Company
Miner-Edgar Company
Monarch Manufacturing Works, Inc.
Monongahela Valley Traction Company
Mott, J. L., Iron Works
Moulton Engineering Corporation
Multi Metal Separating Screen Company

Nash Engineering Company
Nassau Valve & Pump Corporation
National Aniline & Chemical Company
National Color & Chemical Company
National Glue & Gelatine Company
National Gum & Mica Company
New Jersey Zinc Company
Newport Chemical Works, Inc.
New York Commercial
New York Revolving Portable Elevator Company
Niagara Alkali Company
Niagara Electro Chemical Company
Nichols Copper Company
Nitrogen Products Company
Norton Company

Obex Company
Oil, Paint & Drug Reporter
Oliver Continuous Filter Company
Ontario Bureau of Mines
Organic Salt & Acid Company

Page Steel & Wire Company
Palo Company
Parks, G. M., Company
Peerless Color Company
Penn. Salt Manufacturing Company
Pfaudler Company
Philadelphia Quartz Company
Philadelphia Textile Machinery Company
Pneumercator Company, Inc.
Powdered Coal Engineering & Equipment Company
Pratt Engineering & Machinery Company
Precision Instrument Company
Precision Thermometer & Instrument Company
Process Engineers, Ltd.
Product Sales Company
Provost Engineering Company

Quigley Furnace Specialties Company

Raritan Copper Works
Raymond Bros. Impact Pulverizer Company
Rector Chemical Company
Republic Chemical Company
Research Corporation
Roessler & Hasslacher Chemical Company
Rolling Chemical Company
Rossendale-Reddaway Belting & Hose Company
Ruggles-Coles Engineering Company
R. U. V. Company, Inc., The

Schaeffer & Budenberg Manufacturing Company
Schaum & Uhlinger, Inc.
Schutte & Koerting Company
Schwartz Sectional System
Scientific Equipment Company
Scott, Ernest, & Company
Semet-Solvay Company
Seydel Manufacturing Company
Sharples Specialty Company
Shawinigan Electro Metal Company
Shawinigan Water & Power Company
Shriver, T., & Company
Sidio Company of America, Inc.
Simmons, John, Company
Solvay Process Company
Southern Pine Association
Southern Ball Clay Company
Sowers Manufacturing Company
Sparks, John C.
Stamford Extract Manufacturing Company
Standard Extract Company
Stevens-Aylsworth Company
Stauffer Chemical Company
Stein, Hall & Company
Sterling Color Company
Stokes, F. J., Machine Company
Stresen-Reuter & Hancock Company
Stuart & Peterson Company
Sturtevant Mill Company
Swen-on Evaporator Company

Tagliabue, C. J., Manufacturing Company
Takamine Laboratory, Inc.
Tank Equipment Company
Taylor Instrument Companies
Textile Colorist
Textileather Company
Textile World Journal
Thermal Syndicate, Ltd.
Thermo Electric Instrument Company
Thwing Instrument Company
Tolhurst Machine Works
Trades Reporting Bureau, Inc.

Uehling Instrument Company
Union Dye & Chemical Corporation
United Filters Corporation
United Lead Company
U. S. Cast Iron Pipe & Foundry Company
U. S. Industrial Alcohol Company
U. S. Industrial Chemical Company
Universal Oil Company
Valley Iron Works
Van Dyk & Company
Van Emden, H., & Company

Wallace & Tiernan Company, Inc.
Warner Chemical Company, Inc.
Warner Klipstein Chemical Company
Werner & Pfleiderer Company
Westinghouse Electric & Manufacturing Company
Whitall Tatum Company
Williamsburg Chemical Company

Zapon Leather Cloth Company
Zaremba Company
Zavon, Inc.

AMERICAN ELECTROCHEMICAL SOCIETY FALL MEETING AT PRINCETON

The August bulletin of the Society contained the following notice:

The officials of Princeton, and our local members, headed by Professor Northrup, have given us a most cordial invitation and we are assured of a warm welcome. There are fine physical and chemical laboratories to be seen, and fine fellows to get better acquainted with, and a real, rich scientific program. The date is September 30 to October 2, 1918, immediately following the Chemical Exposition in New York. Programs will go out with the September bulletin. If you have never visited Princeton, now is your best chance; if you have, you do not have to be urged to go again.

AMERICAN ELECTROCHEMICAL SOCIETY

The American Electrochemical Society has passed the following resolutions concerning alien enemy members:

WHEREAS, A communication has been submitted to the Board of Directors bearing the signature of sixteen members, in accordance with Paragraph 5, Article III of the Constitution, requesting "that all members of the Society who are subjects of Germany or Austria be dismissed, on the ground that they are opposed to the United States of America in its war for the preservation of civilization, and are consequently enemies of the majority of the members of our Society," therefore be it

Resolved, That it is the sense of this Board that all members of the Society who are enemy aliens and who are in sympathy with the enemies of the United States of America in the present war should be dismissed from membership on the grounds above set forth, and

Resolved, That the Secretary be instructed to send a copy of this Resolution to all such members requesting that they either appear in person at the meeting of the Board of Directors to be held at the Niagara Club, Niagara Falls, N. Y., Saturday, August 24, 1918, at 11.00 A.M., or file answer by letter stating whether or not they support the aims and ideals of the United States of America in the present conflict.

GENERAL SYMPOSIUM ON THE CHEMISTRY OF DYESTUFFS

At the Cleveland Meeting of the AMERICAN CHEMICAL SOCIETY there will be held in connection with the Division of Industrial Chemists and Chemical Engineers a symposium on the chemistry of dyestuffs, in all its phases, including the use, application, and manufacture. This symposium will be held on Tuesday, September 10, at 2 P.M., and will be continued to Wednesday morning.

Successful establishment of a complete dyestuff industry in America together with its continuous development is so fundamentally related to the chemistry of the subject that all interested in this industry must try to develop to the fullest possible extent every phase of the chemistry of dyestuffs.

The plan is that out of this symposium will grow regular sectional meetings on dyestuffs and we bespeak the coöperation of everyone interested in dyestuffs.

While every chemist in this industry has been busy with development and problems occasioned by the abnormal conditions of the war, yet we feel sure that now is the time to start laying emphasis on the *chemistry of dyestuffs*, the *very backbone of the industry*. We ask all interested to coöperate by attending this symposium.

THE CALCO CHEMICAL COMPANY
BOUND BROOK, N. J.

R. NORRIS SHREVE

NOTES AND CORRESPONDENCE

ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS

The Second Annual General Meeting of the Association was held at the Chemical Society's Rooms, Burlington House, Piccadilly, London, on Thursday, July 11, 1918, for the purpose of appointing scrutineers to examine the ballot papers, for the reception and adoption of the report and accounts, the election of auditors, and the reception of the report of the scrutineers. Dr. Charles Carpenter, D.Sc., M.I.C.E., occupied the chair.

After the notice convening the meeting had been read by the Secretary, Captain G. Mount, D.S.O., and the scrutineers to examine the ballot papers had been appointed, the Chairman moved the adoption of the report of the Council of the Association.

Dr. Carpenter in the course of his speech said that the Association had made satisfactory progress and that one indication of that progress was the increase in membership and the corresponding increase in capital.

During the year the Association suffered loss in the death of Mr. R. D. Pullar, who had been a loyal and conscientious member of the Council, and of Mr. Thomas Tyrer, well known in the chemical trade for many years.

In dealing with the item in the report referring to the Directory, the Chairman said that it was now well in hand, the bulk of it being in the printers' hands. A good part of the work of translation had been done, that which was not complete being the translation of the Russian and Japanese sections. This portion had been delayed by reason of the great demand for translators of these languages. The Directory will be printed in English, French, Italian, Spanish, Portugese, Russian, and Japanese, and will thus provide for a very comprehensive circulation throughout the markets of the world of information relating to British manufacture in connection with chemical products.

In the paragraph dealing with foreign trade there was described a very useful system which has been put into operation for placing at the disposal of members of the Association information available at the Department of Overseas Trade and the Foreign Office. Some fifty members had taken advantage of this machinery and expressed appreciation of it.

In the matter of reconstruction, it was reported, the Council had done very useful work. The Chairman outlined what had been done from the setting up of the Committee appointed by Dr. Addison to advise as to the procedure which should be adopted for dealing with the chemical trade down to the present negotiations with reference to the establishment of joint industrial councils. He thought the Meeting would agree with him that in dealing with the question of industrial alcohol the Association had also been very helpful. When it was remembered how long it had taken to educate the Government on the technical questions connected with the use of alcohol in chemical manufacture, he felt that a great advance had been made in the acceptance of the recommendations of the Alcohol Committee of the Association. In this connection he thought they owed something to the foundation laid by their late lamented friend, Mr. Thomas Tyrer.

The Information and Statistical Bureau has been established with the view of avoiding overlapping and waste of time and energy in research and manufacture. The scheme for the formation of the Bureau has met with a large amount of approval and has given proof that the Council is at any rate making an endeavor to do something substantial in dealing with what is one of the difficult problems facing chemical industry at the present time.

The Council has supported the efforts of the Chemical Society in establishing a comprehensive library of chemical technology. The desire is not only to extend the library, but to extend the hours during which the library is available, and in financially supporting this scheme the Association is contributing to the future welfare of chemical work in the country.

With regard to the difficult problem of the dye industry the speaker thought that the course followed in 1915 in developing the explosive manufactures of the country, *viz.*, to use all and everybody, great and small, in order to get all working in the direction of making up the terrible shortage, was the right one, and the concentration of the work in the hands of only a few firms, as appears to be the present policy in dealing with the dye situation, would not produce such a measure of national success as if all the resources of the country were utilized.

In conclusion, the Chairman referred to the appointment of Mr. W. J. U. Woolcock as General Manager of the Association, and to that of Captain G. Mount as Secretary. The appointment of suitable persons for these positions had been no easy matter, but he could assure the Meeting that in these two officials they had two men admirably suited in every way to carry out the particular duties required of them.

The motion for the adoption of the report was seconded by the Vice Chairman, Mr. R. G. Perry, and after discussion was carried unanimously.

Messrs. Feasey and Company were elected auditors for the ensuing year, and after the scrutineers had reported the result of the ballot the Chairman announced the constitution of the new Council and group committees and moved a vote of thanks to the Chemical Society for the use of their rooms. This was seconded by the Rt. Hon. J. W. Wilson, M.P., and carried enthusiastically.

The Vice Chairman, in moving a vote of thanks to Dr. Carpenter, stated that for two years Dr. Carpenter had been the mainstay of the Association. He had done more work than anybody else in connection with its formation and he had done the lion's share of it since. The vote of thanks was seconded by Mr. Roscoe Brunner, who remarked that it might quite rightly and justly be stated that Dr. Carpenter had led the Council in all its work. The vote of thanks having been most heartily accorded, and Dr. Carpenter having replied, the proceedings then terminated.

THE SULFURIC ACID INDUSTRY[1]

By C. J. Goodwin

The report recently published by the Departmental Committee on Sulfuric Acid and Fertilizer Trades is already bearing fruit in steps taken to form a National Association of Sulfuric Acid Makers, and it is to be hoped that the other recommendations made by the Committee will also lead to a more complete examination of manufacturing details. War conditions did much to arouse inefficient manufacturers from their former lethargy, and led to the gradual introduction of more efficient plant and methods by means of individual trial and error, but the Committee's conclusion that in the majority of cases scientific cost-keeping is usually conspicuous by its absence, is well founded. The strict control of output and prices, and especially profits, has since caused a partial return to this lethargic attitude, but the probability that only the more efficient works will be permitted to survive on account of reduced post-war requirements should now result in well-directed ef-

[1] Reprinted from the *Chemical Trade Journal and Chemical Engineer*, April 20, 1918.

forts in regard to scientific management and the elimination of waste.

While the Committee recommend that the information regarding cost-keeping, etc., collected at Government establishments, should be placed at the disposal of private manufacturers *after* the war, it would seem a more obvious and satisfactory course to do so now in order that manufacturers may put their houses in order forthwith. This also applies to the cost data upon which the Committee base their conclusions in regard to the relative advantages of the available systems for the manufacture of different strengths and grades of acid. By thus fostering not only scientific cost-keeping and management, but also the spirit of competition, the process of ultimately eliminating inefficient works will be facilitated, as the necessary data will be available over a sufficient period of time.

It is clear that pre-war data of manufacturing costs are no longer applicable, and, indeed, very little has been published in this country regarding them since Guttman's paper.[1] The position is further complicated, not only by the arguments adduced by the Committee, but by many other considerations. Among these may be mentioned: (1) That it is now possible to install and operate contact plant either without the payment of royalties or, at any rate, with reduced royalties; (2) the present and future increased freight charges and other dues on imported pyrites and sulfur; (3) the crude sulfur position; and (4) the cost and de-arsenication of acid from the lead-chamber process. Taking these in order, the conclusion of the Committee that the Grillo process, or a modified form of the Grillo process, is the most likely competitor of the chamber or tower systems will find general acceptance. In comparing the value of Grillo acid with chamber acid, allowance must be made for the fact that it is free from arsenic, iron, and other impurities.

The Committee also make no mention of the possibilities of a "mixed" system of contact and chamber plant such as has been introduced in America. As regards pyrites and crude and recovered sulfur, the cost of these will be interdependent, and the post-war situation will naturally depend largely on available tonnage, freight rates, the attitude of the sulfur-producing countries and companies, and the position of the metal market. The dominating factor will be the cost per unit of available sulfur after making allowance for residual ore values, arsenic content, and extra cost of additional fuel for ores of low sulfur content, and as crude sulfur only requires about one-half as much tonnage as pyrites, and a still smaller proportion as compared with zinc or the like concentrates, the question of freight rates, available tonnage, etc., will be important factors, and give rise to continual controversy. At present, mainly owing to difficulties in importation, sulfur is increasingly displacing pyrites in America and elsewhere, and as a result great improvements have been effected in the design of rotary and other types of sulfur burners. Apart from the prime cost per unit of available sulfur, such plant leads to more intensive working as a richer gas results. Economies also result in labor and running expenses, and in the cost of purifying plant for the burner gases. When all these factors have been taken into account, it is not improbable that the use of crude and recovered sulfur will be introduced in this country to a greater extent than at present, especially if freight rates remain high.

As regards de-arsenication, it seems desirable to place comparative costs also at the disposal of manufacturers, both as regards plant in which the arsenic is removed prior to entering the Glover tower by methods similar to those obtaining in contact processes, and also those in which weak acid is treated by sulfuretted hydrogen and the like prior to concentration or sale. Naturally, the whole output of a given works does not, as a rule, require de-arsenication, and in cases where the output is intended solely for superphosphate and certain other processes, de-arsenication is unnecessary. For such plants it is unlikely that the chamber or tower processes will be superseded, and the aim of the largest works will be to cater for all branches of the trade, and to install and operate the various types of sulfuric acid plant in such proportions that the output of each grade of acid can be regulated to correspond with current sales.

If the National Association of Sulfuric Acid Makers is to justify its title, the component parts of that body will, it is hoped, sink all trade differences and jealousies, and pool information, trade, and results in the fullest sense of the word. In addition, a Central Information or Intelligence Department, combined with a properly conducted Industrial Experiment Station attached to one of the larger and more efficient works should be organized and supported by all the individual members of the Association, who would draw upon it, not only for cost and experimental data, but for all information regarding the future development of the industry. Such a Central Intelligence Department would, without interfering with individual enterprise, try out and report on improved plant an processes; it should be a self-supporting institution earning dividends by results, but would require a guaranteed minimum income in the first instance.

These notes are not intended as a detailed criticism of the Committee's Report, but are written to stimulate investigation, discussion, and correspondence, through the medium of this JOURNAL and otherwise. Much could be written regarding manufacturing methods, details of plant, and new processes, but this would be outside the scope of the present article. Among such topics may be mentioned the pre-drying of air supply to burners, etc.;[1] the cost of storage of acid for contact and tower systems; the relative advantages of the different kinds of filling material for towers; pyrites and fuel storage; drying and conveying plant; concentration plants; with special reference to packed concentration towers; electrical fume and dust precipitation; burners for spent oxide and low-grade ores;[2] use of ammonia and Ostwald process instead of nitrate of soda; leadless Glover and Gay-Lussac towers, in acid-proof masonry; and, last, but not least, the scientific control of the chamber process. The latter point was not dealt with by the Committee, and the proposals of investigators like Fairlie[3] merit further attention. It is to be hoped that the authorities will give further material and individual support to these problems.

[1] *J. Soc. Chem. Ind.*, **22** (1903), 1331.

[1] British Patent No. 16,981, 1915.
[2] *Ibid.*, No. 108,986, August, 1917.
[3] *Trans. Am. Inst. Chem. Eng.*, p. 319, *et seq.*

CHEMISTRY FOR THE PUBLIC

Editor of the Journal of Industrial and Engineering Chemistry:

I have arranged with a local paper to contribute a weekly article on various phases of industrial chemistry in relation to the war. I have undertaken this because I am anxious to do what I can in this community to advertise chemistry and give the layman a more intelligent conception of what industrial chemistry is. The paper, which is the largest in the district has taken very kindly to the idea and has given me a column on the editorial page.

I would be glad to have any suggestions for material which the Publicity Committee might be able to give, and your permission to make occasional use of ideas or phrases from your editorials.

I believe that if someone could be found in each community who is willing to do something of this kind, a great deal of good could be accomplished.

TERRE HAUTE, IND. RAYMOND D. COOKE
July 8, 1918

CIVIL SERVICE RULES WAIVED FOR WAR GAS INVESTIGATORS

EXECUTIVE ORDER

The Secretary of War is hereby authorized to employ, without reference to the requirements of the civil service act, such persons in the Research Division, Chemical Warfare Service, at the American University, as may be needed in conducting certain investigations and construction work relating to gases and chemicals used in war, it being understood that all possible use will be made of the registers of eligibles of the Civil Service Commission. This authority shall continue only during the present war.

The Commission concurs with the War Department in recommending this order because of the urgent and highly confidential character of the work involved and the fact that it must be organized and prosecuted with the greatest dispatch and be safeguarded most effectively.

THE WHITE HOUSE
July 19, 1918

WOODROW WILSON

RESEARCH FELLOWSHIP STATE COLLEGE OF WASHINGTON

The Department of Chemistry of the State College of Washington, Pullman, Washington, announces the establishment of a fellowship, to be devoted to research on the extension of the chemical uses of magnesite, paying $600 a year. Applications are invited from young men having the Bachelor's degree in chemistry from a college giving a four-year course. The appointee will give twelve hours a week to instructional work in elementary chemistry, the remainder of his time being given to research and study in advanced courses leading to the M.S. degree. Interested parties should send photograph with their application, together with letters of recommendation and statement of special qualifications.

CHEMICAL ENGINEERING IN OUR UNIVERSITIES

Editor of the Journal of Industrial and Engineering Chemistry:

In the list of institutions given on p. 645 of the August number of the JOURNAL, I notice that we are reported as possessing no course in Chemical Engineering. I cannot understand how the writer of the paper arrived at such a notion.

As a matter of fact we had one of the first complete courses given although we do not claim to have really started before 1912. You may be very sure that we have a course now and have had one since that date, a comprehensive and difficult course.

By this mail I am sending you our latest catalog on page 94 of which you will find the course in Chemical Engineering set forth and I beg of you to note that there is no camouflage in it nor any so-called paper courses.

We are situated near "large manufacturing enterprises involving chemical control and chemical processes." Our students are not given "an opportunity" to visit such plants but are *compelled* to do so, and are conditioned if they fail to make a proper report.

DEPARTMENT OF CHEMISTRY
RENSSELAER POLYTECHNIC INSTITUTE
TROY, N. Y., August 13, 1918

W. P. MASON

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

Two pieces of legislation which are of direct importance to chemical industries are on the point of taking final form at this writing. They are the Revenue Bill and the War Minerals Bill.

Regardless of the levies on war profits and excess profits, which may be contained in the bill which the Committee on Ways and Means will report to the House, it is practically certain that the legislation will go on the statute books with an 80 per cent, or greater, tax on war profits and with nothing more than the perfecting of the existing graduating tax on excess profits. The Senate does not hold the present Committee on Ways and Means in high esteem in regard to its ability to draft revenue legislation. Extensive changes are certain to be made in the Upper House. The temper of the House of Representatives apparently is unusually critical of the work being done by the Ways and Means Committee. The bill is certain to receive a very general overhauling in the House itself. It is very certain, however, that the bill will be out of the hands of Congress prior to the launching of the fourth Liberty Loan campaign on September 28. The Ways and Means Committee expresses its opinion in the platinum controversy by applying the luxury tax of 10 per cent on platinum jewelry and by singling platinum jewelry out for an additional tax of 10 per cent.

The War Minerals Bill, which is of vital interest, not only to the mining and metallurgical industries, but to all users of mineral materials, which heretofore have been largely imported, is in process of being rewritten by the Senate Committee. The bill which will be introduced is likely to be a compromise between proposed measures submitted by Senator Henderson, of the War Industries Board, and the Interior Department. From information reaching Washington, it would seem that the chemical industries are well divided as to whether control of these minerals is necessary or whether the placing of broad powers in the hands of a government agency would not produce more harm than good.

An insistent demand for a bonus on gold production is coming from the West. Economists in the government service are giving the matter studious attention. They apparently are not convinced that a bonus will do more than double the yardstick The matter has come prominently to the attention of the Committees on Mines and Mining of the Senate and of the House. Attention by Congress to the problems involved is assured. Those best informed are of the opinion that no more can be done than to remove the petty annoyances that are hampering gold mining. They take little stock in the various proposals whereby the industry would be cleared of its difficulties by a single radical step. That encouraging things are being done already is shown by the action of the Priorities Board in announcing that it will give preferential treatment to tools, machinery, and equipment, and will use its influence in securing ample fuel and labor supplies and the maximum of transportation service. Decided aid also was given the gold mining industry by the stabilization of the price of silver, which now is enjoying what is tantamount to a fixed price in excess of $1.00 an ounce.

More should be done to utilize potash-bearing materials, in the opinion of one of the best known authorities on this subject in the country. With the reluctance so characteristic of scientists, he declines to allow his name to be attached to an informal statement but his thought on the subject is as follows:

According to the figures given out by the U. S. Geological Survey, the production of potash for the first half of this year was between 20,000 and 25,000 tons of K_2O, and it is estimated that the total for the year will reach 60,000 tons. This is about 25 per cent of our pre-war importations, and if this country is to become independent of Germany, immediate steps should be taken to develop further our own sources of supply.

The cement works and blast furnaces alone should be able to supply our total requirements, but so far these industries have done very little. By the end of 1918 about a dozen cement companies will be recovering potash as a by-product, and incidentally abating the dust nuisance. The blast furnaces are doing practically nothing, although it is generally recognized that they would benefit considerably by obtaining cleaner gas for the stoves and gas engines. The manufacturers can hardly be blamed for not putting money into the necessary additions to their plants under the present uncertainty of the whole potash question. Although the present prices are high, no one knows how long they will last, and under the proposed revenue bill, most of the profits would be taken by the Government as taxes. The manufacturers would not object to this if they were

allowed to amortize the cost of plant before being subject to any profits tax. The producers of potash should also be given definite assurance by the Government that there will be no "dumping" of German potash after the war

A source which it seems to me should be thoroughly investigated is the potash-bearing silicate rocks. There are large deposits of these running fairly high in potash, notably the greensands of New Jersey, the leucite deposits of Wyoming, and the sericites and potash bearing slates of Georgia. Although no commercially successful method of extracting potash from silicate in general has developed as yet, this problem should not be beyond the skill of American chemists and metallurgists.

Congress granted an appropriation of $175,000 in 1916 to the Department of Agriculture for an experimental plant for treating kelp, and it seems to me that the silicates offer an even more promising source of potash. I think it would be a very good idea if a similar appropriation were made to the Bureau of Mines for carrying out experiments on these silicates, as, if a successful process for extracting the potash can be developed, the supply of raw material is practically unlimited.

As a result of successful experimentation, pyrite cinder from the South is about to enter quite generally into use as iron ore. Due to the fact that this cinder is low in phosphorus and contains 50 per cent of iron, it can be used to advantage in blast furnaces.

An amplification has been made of the commodity list of articles which may be exported to Holland and Denmark. The new list contains dyes and dyestuffs and the following drugs:

Acetylsalicylic acid	Camomile	Metol
Aconite, pure	Chromic acid	Nitrate of silver
Agaricin	Diethylbarbituric acid	Opium alkaloids
Althaeae root	Digitalis	Paraldehyde
Amidol and substitutes	Eucaine	Phenacetine
Argentamine	Ferric compounds	Salicylic acid
Arsenobilin	Fruit of fennel	Sodium arsenate
Arsenous acid	Hydrobromic acid	Sodium bromide
Barium sulfate, pure for X-ray	Ichthyol	Sodium cacodylate
	Inula root	Sodium nitroprusside
Beta-naphthol	Iron, reduced	Sodium salicylate
Bromine	Kharsevan	Sulfuric acid
Butylchloralhydrate	Leaves of hyoscyamus	Veronal

An announcement made August 11 by the Department of Labor reads as follows:

Tentative findings of the preliminary survey of the chemical industries at Niagara Falls, New York, made by representatives of various federal departments acting under the direction of the Women in Industry Service of the Department of Labor were announced to-day.

The committee assembled by the Women in Industry Service went to Niagara Falls in response to an invitation from the Employers' Association. The manufacturers working on war contracts wished to introduce women in greater numbers into employment into which they have not previously entered. The committee included in its membership public health experts and consulting engineers.

It was found that the matter of approving the employment of women in the chemical industry was only a part of the entire problem of the labor supply for that region. Looking ahead, it is plain that a greater and greater demand for women workers will be experienced. Accordingly the technical experts on the committee made a quick survey of the processes in order to discover how, if possible, the industry might be made suitable for the employment of women.

The committee expects to make a continuous observation of conditions in this industry. It will assist the individual manufacturers in so arranging their processes that conditions of employment of women—and of men as well—will be improved. The Women in Industry Service is thus planning to operate as a consultant organization rather than as a bureau of research. Methods being tried out at Niagara will, if successful, be applied to other fields where the demand for women is great.

An announcement from the War Department, August 12, follows in its entirety:

Chemically treated cotton cloth, as a substitute for silk, is being tested out by the Ordnance Department.

If found practicable for ordnance uses, the discovery will effect the double result of meeting a serious shortage in silk, and of bringing about a money saving in the ordnance program estimated at between $25,000,000 and $35,000,000.

Preliminary tests already made at the Aberdeen Proving Grounds have encouraged the Department to proceed further with its experiments; and for this purpose an order for 5,000 yards of the new material has been placed with the concern responsible for developing the process of treating the cotton cloth.

At present, millions of yards of silk are required in making the bags which contain the large powder charges used in the firing of heavy artillery. These bags are inserted in the gun immediately behind the projectile, and the firing of them gives the propelling force that hurls the projectile at the target. This propelling charge is, of course, entirely distinct from the charge within the projectile that explodes the missile after it reaches the target.

Heretofore, silk has been depended upon for these bags for the reason that no other cloth material has been found that would meet the peculiar conditions required. It is essential that not a particle of the bag container shall remain after the gun is fired. Otherwise a smoldering piece of the fabric might cause a premature explosion when a new charge was inserted.

Owing to the great scarcity of silk, however, the cost of this material has increased enormously. This shortage is felt by all the warring powers, including Germany. Early in the war Germany is understood to have used a chemically treated cotton as a substitute for silk, but has since been compelled by the diminishing cotton supply to resort to other substitutes.

It is estimated that the chemically treated cotton cloth now being tried out by the Ordnance Department, if entirely suitable, could be purchased in almost unlimited quantities and at a cost far below that of the silk fabric now used.

Chemicals to the value of $14,953,083 were exported in June of 1918, according to returns to the Department of Commerce. This compares with exports to the value of $19,104,020 in June of 1917. Imports of chemicals in June 1918, amounted to $13,513,552, as compared with $16,441,353 in June of 1917. One of the striking features of the export figures is that forwardings of sulfuric acid to foreign countries increased from 4,535,681 pounds in June of 1917 to 10,053,178 pounds in June of 1918. The exports of sulfate of copper fell off more than two-thirds. In June of this year, exports were 1,195,306 pounds, as compared with 3,607,804 in June of 1917.

An agreement has been effected by the Food Administration whereby the prices of dynamite glycerin have been stabilized. Allied requirements, estimated at 7,000 long tons, will be furnished at 60 cents a pound in August and September; 58 cents in October and November; and 56 cents in December, f. o. b. production points in drums—drums included in price—deliveries to be divided into quotas of approximately one-third for each of the three periods. Sales to domestic consumers will be made on the same basis, and it is suggested that they accept the same deliveries, as nearly as possible.

It is assumed that the price of crude glycerin and chemically pure glycerin will be stabilized by market conditions to a basis conforming to the prices specified for dynamite glycerin.

The price agreement was entered into for the manufacturers by a Soap and Candle War Committee which held its first meeting at the Food Administration, June 3. This committee was appointed by the trade, and its personnel is as follows:

Sidney M. Colgate, of Colgate & Co., New York, chairman; Samuel S. Fels, of Fels & Co., Philadelphia; W. E. McCaw, of Procter & Gamble, Cincinnati; W. O. Thompson, of N. K. Fairbanks Co., Chicago; L. H. Waltke, of William Waltke & Co., St. Louis; N. N. Dalton, of Peet Brothers Manufacturing Co., Kansas City; Sidney Kirkman, of Kirkman & Son, Brooklyn, N. Y.; and George B. Wilson, of the Globe Soap Co., Cincinnati, ex-officio chairman.

The Committee and Food Administration recommend that all soap makers who manufacture soap containing more than 1 per cent of glycerin take steps at once to reduce it to that percentage. Glycerin is especially in demand at present in Great Britain and Italy, where it is used to make cordite, a smokeless powder, and in Canada for explosives.

The United States War Industries Board and the United States War Trade Board jointly announce the following rules and regulations with respect to the sale for export, and the exportation of caustic soda:

On and after August 1, 1918, manufacturers of caustic soda in the United States will not enter into any contract for the sale of caustic soda with any person in the United States for the purpose of exporting the same, unless and until advised by the prospective purchaser that a United States export license covering such caustic soda has been duly obtained and the number thereof is furnished

Manufacturers will not sell on and after the above named date, caustic soda for domestic consumption unless the purchaser agrees not to export same nor to sell same for export and if it is resold in the domestic market, to exact or cause to be exacted a similar agreement from each and every subsequent purchaser

On and after August 1 1918, the United States War Trade Board will not license for exportation caustic soda to any destination until the applicant has filed a statement showing either:

(1) That on August 1, 1918, the applicant did not own or have any interest in any contracts for the sale of caustic soda to be exported from the United States, or

(2) A list of all contracts with purchasers abroad existing on August 1, 1918, for the exportation of caustic soda which had not been exported on that date, showing, (*a*) the names of the purchasers abroad, or consignees; (*b*) the dates of the contracts; (*c*) the quantities; (*d*) the price paid or contracted to be paid therefore; and (*e*) if the applicant on August 1, 1918, owned or had any interest in the title to the caustic soda to be exported the place or places of storage on or about that date, or if in transit on August 1, 1918, from an inland point within the United States, the date of shipment from such point and port of exit in the United States to which such shipment was destined.

On and after August 1, 1918, applicants for licenses to export caustic soda will also be required to state on their applications whether or not they have acquired any title or interest in the caustic soda which it is proposed to be exported, and if the caustic soda is in existence, the place of storage in the United States, and to agree that in the event an export license is granted, not to ship or permit to be shipped under such license any other caustic soda than that specified in the application.

The foregoing requirements are supplemental to the regulations contained in circular letters issued by the United States War Trade Board under date of March 30 and May 21, 1918. For the convenience of exporters the regulations with respect to caustic soda have been consolidated and revised into one ruling (W. T. B. R. 175, issued July 26, 1918). Copies thereof may be obtained upon application to any branch office of the War Trade Board on and after July 27, 1918.

During the absence of L. L. Summers, head of the Chemical Section of the War Industries Board, A. W. Chase is acting as chief of the Section.

PERSONAL NOTES

Lieutenant Andrew P. Peterson, a member of the Chicago Section of the AMERICAN CHEMICAL SOCIETY, who had been in military service in France since September 1917, was reported in the June casualty list as having been severely wounded. Information was received indirectly a few days later that he was recovering from his wounds, but on July 15 the casualty list announced Lieutenant Peterson's death as the result of wounds received at the front.

Lieutenant Peterson was a resident of Lamberton, Minnesota. He attended the University of Minnesota, receiving the degree of Bachelor of Science in chemical engineering in 1910 and Master of Science in 1911. He entered the service of the Western Electric Company at its Hawthorne plant in the Summer of 1911, and remained in that service until the time of his enlistment at the First Officers' Training Camp at Fort Sheridan, in May 1917.

Lieutenant Peterson was a chemical engineer of unusual ability and attainment. In the service of the Western Electric Company he specialized upon the technology of the fabrication of rubber. He conducted some important industrial researches, and soon distinguished himself by the ability to put to practical use his scholarly attainment. He was not only well balanced intellectually, being quite as proficient in mathematics as in the physical sciences and philosophy, but he was unusually well developed physically, having several times carried off honors as a wrestler.

Shortly before his enlistment he had been promoted to Chief of the Research Department of the Chemical Engineering Division at the Hawthorne Works, and had been strongly urged to use his scientific training and experience in engineering service for the Government. While he admitted that he undoubtedly could be more useful in that service, he felt that because he was physically able, he ought to go into active military service. After debating for several weeks as to what was his duty in the matter, his powerful sense of the justice of the Allied cause and his duty as an American citizen forced him to enlist for direct military service. He obtained his commission at the close of the First Officers' Training Camp at Fort Sheridan, and was sent immediately to England, whence, after several weeks' training, he was sent to a point near the front line trenches for intensive training with certain British units.

He was among the first Americans to take part in the operations on the Western front during the past Spring.—F. W. WILLARD, Chicago Section.

Mr. Charles V. Bacon was commissioned a captain in the Engineer Reserve Corp on July 2 and is now stationed at the General Engineer Depot, Washington, D. C., in the Division of Investigation Research and Development, being a member of the executive committee. Capt. Bacon was formerly associated with the American University Experiment Station as Chief of Section on Flaming Liquids, and later as Chief of Section on Oil Research. Mr. Bacon's laboratory in New York City is being conducted in his absence by Mr. Ernest Molnar.

Mr. C. H. Crawford, formerly of the Nashville, Chattanooga & St. Louis Railroad, and prominently associated with the exhibit of that railway at the Third National Exposition has been appointed Lieutenant Colonel, U. S. A., and is stationed at the General Engineer Depot, Washington, D. C.

Dr. Ira E. Lee has resigned from the University of Rochester, Rochester, N. Y., where he acted as instructor of chemistry, to accept employment as research chemist with E. I. du Pont de Nemours & Co., Wilmington, Del.

Mr. John M. Sanderson, for the past several years chief chemist of the Ohio Varnish Company, has recently entered the employ of the Larkin Co., Buffalo, N. Y., as superintendent of their paint and varnish department.

Miss Jessie Y. Cann, formerly head of the chemistry department at Rockford College, Rockford, Ill., has just accepted an assistant professorship in analytical chemistry at Smith College, Northampton, Mass.

Mr. Albert J. Kraemer, formerly employed by the Union Oil Co., California, as chief chemist of the Avila Refinery, is now engaged in the Chemical Warfare Service, Research Division, in the small scale production of gas chemicals.

Professor George Borrowman has resigned his professorship at the University of Nebraska to take up research work for the Niagara Alkali Company, under the direction of Dr. John E. Teeple, in the Chemists' Building, 50 East 41st Street, New York City.

Mr. H. E. Shiver, assistant chemist, South Carolina Experiment Station, Clemson College, S. C., has accepted a position as chemical engineer with the Air Nitrates Corporation at their electrochemical plant at Muscle Shoals, Ala. He will be in a supervisory position in Unit 5 of the plant.

Mr. Cyril B. Clark, employed for the past few years in the Research Department of the General Chemical Company, 25 Broad St., New York City, has been detailed to some special work at the Bay Point Works near San Francisco. To complete this special work will take about four months, after which Mr. Clark will return to New York.

Dr. R. P. Calvert has been transferred from the position of Head of the General Chemical Division of the Experimental Station, Wilmington, Del., to that of Director of Delta Laboratory, Arlington, New Jersey. Both laboratories are under the direction of the chemical department of E. I. du Pont de Nemours & Company.

Mr. Joseph Prescott, formerly assistant superintendent in the tinning department of the De Laval Separator Company at Poughkeepsie, N. Y., is now assistant metallurgical chemist in the Ordnance Department. His work consists in supervising the heat treatment of steel, physical properties, etc.

Mr. O. L. Thomas has been transferred from the Experimental Station of E. I. du Pont de Nemours and Co., Wilmington, Del., where he acted as research chemist, to the U. S. Government Powder Plant at Jacksonville, Tenn., where he will be chief supervisor of caustic soda manufacture and soda ash recovery.

Dr. J. H. Ransom, after eighteen years in Purdue University, has been elected professor of chemistry and director of the chemical laboratories in Vanderbilt University, Nashville, Tenn.

Mr. John A. Coye has resigned his position as chief chemist with the Engineering Experiment Station of the Iowa State College, Ames, Iowa, to accept the position of assistant chemist with the General Chemical Company at their Laurel Hill Works.

Mr. J. Raymond Hess, until recently head chemist for the Ismert-Hincke Milling Co., Topeka, Kansas, is now with the Omaha Flour Mills Co., Omaha, Nebraska, acting as chief chemist.

Mr. J. Thaddeus Batson has been transferred to the Gas Defense and is now stationed at the Edgewood Arsenal, Edgewood, Maryland.

Dr. Raymond Freas has resigned as adjunct professor of chemistry in the University of Virginia to accept a commission as First Lieutenant in the Sanitary Corps.

Mr. D. L. Williams, formerly of the chemistry department of the College of the City of New York, is now in the Research Division of the Chemical Warfare Service at American University, Washington, D. C.

Mr. James B. Pratt, formerly chemist of the Southern Cotton Oil Co., Charlotte, N. C., has been commissioned captain in the Chemical Warfare Service and is stationed at Niagara Falls.

Sir Alexander Pedler, F. R. S., known for his research work in chemistry, for many years professor of chemistry in the Presidency College, at Calcutta, later vice-chancellor of the Calcutta University and minister of public instruction in Bengal, died on May 13, at the age of sixty-eight years.

Mr. M. W. Hensel, an expert in the sugar-beet industry, is now in the mountain zone of Avery, Ashe, Buncombe, Burke, McDowell, Mitchell, Watauga, and Yancey counties, North Carolina, having been specially detailed to look after the yield of the excellent syrup obtained from the sugar beet.

Mr. Jean Piccard has been promoted to associate professor of chemistry at the University of Chicago.

Mr. L. J. Pletcher, who was formerly assistant professor of chemistry at Southern Methodist University, Dallas, Texas, has withdrawn from teaching and is now associated with the Texas Refinery, Port Arthur, Texas, as research chemist.

Dr. E. C. Shorey, in charge of the Division of Chemical Investigation in the Bureau of Soils, U. S. Department of Agriculture, has resigned to accept a position with the National Aniline and Chemical Co., Inc., at Marcus Hook, Pa.

Mr. Harry C. Brill, who has acted as chief of Division of Organic Chemistry, Bureau of Science, Manila, P. I., for the past five years, resigned last February to accept the position of acting professor of chemistry at Miami University, Oxford, O. In June of this year Mr. Brill was appointed professor of chemistry and head of the department of chemistry at Miami University.

Mr. Harvey E. Wilson has been transferred from the Jersey City plant of Marden, Orth and Hastings Corporation, where he was acting as chief chemist, to the Jones Point plant of the American Potash Corporation to act as the former's special representative, and also to do consulting work on potash for the American Potash Corporation.

Mr. Charles S. Rewe, chemist of the United States Office of Public Roads and Rural Engineering for several years past, has resigned his position to enter the Research Department of the Barrett Company, 17 Battery Place, New York City.

Mr. Vilhelm Gruner has severed his connections with E. I. du Pont de Nemours and Company, Wilmington, Del., to take up work at the plant of the Monmouth Chemical Co., Keyport, N. J.

Mr. Samuel Wierman, formerly chief chemist and process manager of the citrus by-products factory of the California Fruit Exchange, at Corona, California, is now with the Societe Financiere des Caoutchoucs of Antwerp, Belgium, and London, England, as chemist in charge of their Chemical and Agricultural Department, Federated Malay States.

Mr. Sterling Temple, associate professor of industrial chemistry at the University of Minnesota until January 1918, and since then Captain, Ordnance R. C., has been stationed at Edgewood Arsenal since April 4 of this year.

Mr. Ralph A. Holbrook, chemical engineer, has recently located his headquarters at Rutland, Mass.

Mr. G. A. Armstrong, formerly employed by E. J. Loomis & Co., Philadelphia, Pa., as chemical engineer in charge of their tungstic acid and tungsten metal department, has severed his connection with this company to accept a position as chemical engineer in charge of intermediates with the Central Dyestuff and Chemical Co., Newark, N. J.

Dr. Harrison Hale, for a number of years professor of chemistry at Drury College, has resigned his position there to become head of the department of chemistry at the University of Arkansas. Associated with him will be Mr. O. B. Read, formerly assistant professor in the Iowa State Teachers College, and Mr. H. M. Trimble, of the University of Michigan.

Mr. Stiles Kennedy, who has been connected with the Northern Sugar Corporation in the capacity of chief chemist, is now acting as general manager for Henry M. Winslow, Harriman, Tenn.

Dr. Albert W. Owens, who has been working for the degree of Ph.D. at the University of Illinois, is now connected with the Division of Chemical Metallurgy of the Bureau of Standards, Washington, D. C.

Mr. Joseph B. Nichols, previous to his enlistment in the Ordnance Department, was engaged in graduate research work in organic chemistry at the University of California, Berkeley, Cal. Since his enlistment Mr. Nichols has been stationed at Edgewood Arsenal, Edgewood, Md., and assigned to organic research work.

Mr. E. P. Fager, formerly employed as chemist by the American Water Works and Electric Company at Birmingham, is now serving as a chemist in the Ordnance Department at the Edgewood Arsenal, Edgewood, Md.

Dr. R. E. Nelson has resigned his instructorship in chemistry at Purdue University to accept an appointment as assistant gas chemist in the Research Division, Chemical Warfare Service, American University Experiment Station, Washington, D. C.

Mr. F. A. McDermott, who has been doing industrial research work at the Mellon Institute, University of Pittsburgh, Pittsburgh, Pa., and has been research chemist with the Corby Co., Washington, D. C., has taken a position with E. I. du Pont de Nemours & Company at their Experimental Station, Henry Clay, Del.

Prof. Miles S. Sherrill, of the department of chemistry, Mass. Institute of Technology, has been granted a leave of absence from the Institute and has commenced work on explosives for the Ordnance Department.

Mr. G. A. Menge, formerly connected with the Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture, as a chemist in charge of condensed milk laboratory, has been transferred to New York, assigned to control of quality, both of raw material and of finished product, in the production of evaporated milk and of sweetened condensed milk.

Mr. Chas. N. Jordan, formerly instructor in chemistry, Marvin College, Fredericktown, Mo., is now engaged in chemical and metallurgical work for the Ordnance Department.

Mr. John O'Connor, Jr., one of the assistant directors of the Mellon Institute of Industrial Research of the University of Pittsburgh, has gone to Washington to assume the duties of a civilian appointment in the Plan and Scope Division of the Quartermaster General's office. Mr. O'Connor has been a prominent figure in scientific and especially in chemical circles both in Pittsburgh and elsewhere. He has been one of the leaders of the movement to eliminate smoke. In 1912 he became economist on smoke investigation in the University's department of industrial research, which later became the Mellon Institute. The following year he was appointed senior fellow on smoke investigation and in 1914 was made one of the assistant directors of the Institute. Mr. O'Connor has been secretary of the Dust and Smoke Abatement League since its organization in 1912. He is a member of the Civic Club of Allegheny County and of its Smoke Abatement Committee. He was editor of *The Crucible*, the monthly bulletin of the Pittsburgh Section of the A. C. S., and was secretary of the Society's publicity committee.

Dr. Thomas L. Watson, professor of geology in the University of Virginia and state geologist of Virginia, has been engaged for some months in cooperative state and federal work on war minerals and materials in Virginia. He is a member of the subcommittee of the National Research Council on materials for rapid highway and railroad construction behind the front, and an associate member of the War Minerals Committee.

Prof. Gerald L. Wendt has been promoted to assistant professor of chemistry at the University of Chicago.

Mr. A. Douglas Macallum, research chemist, Toronto, has been granted exemption from military service on the ground of being engaged in the manufacture of diarsenol.

Professor E. P. Schoch has been promoted to the head of the school of chemistry and chemical engineering of the University of Texas.

Mr. C. A. Nash has resigned as associate in chemistry at the University of Chicago and has accepted the position of research chemist for the Cutler-Hammer Manufacturing Company, of Milwaukee.

Mr. Donald E. Cable, a recent graduate of the department of chemical engineering, Armour Institute of Technology, is now employed as assistant chemist in the department of derived products, Forest Products Laboratory, Madison, Wisconsin.

Mr. L. Duane Simpkins, who for some time held the position of metallurgist and chemist for the American Smelting and Refining Company's Lead Plant, located at Murray, Utah, and who for a few months was a chemist in the Civil Service, is now chief metallurgical chemist and metallographer for the Peters Cartridge Co., Kings Mills, Ohio.

INDUSTRIAL NOTES

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANTS
1905	782,739	Emil Fischer, Berlin, Germany	E. Merck, Darmstadt, Germany	C,C-Dialkylbarbituric acid and process of making same	Victor Halper, 562 West 148th St., New York City
1902	711,377	Max Bazlen, Ludwigshafen, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen, Germany	Solid alkaline hydrosulfites and process of making same	Merrimac Chemical Company, 148 State St., Boston, Mass.
1905	795,755	Max Bazlen, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the Rhine, Germany	Process of making stable dry hydrosulfites	Merrimac Chemical Company, 148 State St., Boston, Mass.
1906	837,017	Carl Auer von Welsbach, Vienna, Austria-Hungary	Treibacher Chemische Werke Gesellschaft, M. B. H.	Pyrophoric alloy	American Pyrophor Company, 317 East 34th St., New York City
1910	976,760	Carl Auer von Welsbach, Vienna, Austria-Hungary	Treibacher Chemische Werke Gesellschaft, M. B. H.	Pyrophoric mass	American Pyrophor Company, 317 East 34th St., New York City
1903	718,340	Otto J. Graul, Ludwigshafen-on-the-Rhine, Germany	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany	Process of making cyanmethyl derivatives of aromatic amids	E. I. du Pont de Nemours & Co., Wilmington, Del.
1913	1,078,125	August Büttner, Uerdingen, Germany		Cellular drying apparatus	Stearns-Roger Manufacturing Company, 1718-1720 California Street, Denver, Col.

The General Pharmacal Co. has been incorporated under the laws of Delaware with a capital of $100,000. Incorporators are H. B. Thompson, Coatesville, Pa.; J. Pratt, Philadelphia, Pa.; and James A. Dugan, Wilmington, Del.

Clay deposits, said to be as fine as any in the country, have been found by Dr. Heinrich Ries of Cornell University in Tallahatchie County, Mississippi. The clay is useful for a multitude of war purposes, and it is expected that the extensive fields will be developed as soon as the report of the expert is made public from Washington. Clay of the sort located by Dr. Ries was formerly imported from Germany in large quantities, and there has been a shortage in the material since the war began.

On July 2, 50 persons were reported killed and 60 injured in a series of terrific explosions at the huge plant of the Semet-Solvay Company, located at Split Rock, a suburb of Syracuse, N. Y. Three T. N. T. plants, one nitric acid plant, the large laboratory, and a boiler house were destroyed by the explosion and the fire following, resulting in a loss estimated at $750,000 to $1,000,000.

The firm of Geisenheimer & Company has been dissolved; Mr. Geisenheimer has retired from business. The property and assets of this firm have been acquired by the Aniline Dyes and Chemicals, Incorporated. The officers of the new corporation are: *President and Treasurer*, Alfred F. Lichtenstein; *First Vice President*, W. H. Van Winckel, formerly sales manager of the Dow Chemical Co., Midland, Mich.; *Second Vice President*, Robert Hilton, Vice President of the Ault & Wiborg Co., Cincinnati, Ohio; and *Secretary*, Henry A. Dalter. The corporation will have its principal office at Cedar and Washington Streets, New York City, with branch offices in Boston, Philadelphia, and Columbus, Ga.

Within two months the Standard Sulfur Corporation of Detroit, Mich., expects to begin the production of sulfur at its plant near Orla, Texas. The daily output will be from 100 to 150 tons of refined sulfur. The officers of the company are: *President*, Alfred F. Pudrith, of Detroit; *Vice President*, Alfred Tinally, of Pecos; *Engineer*, Paola Fisher, of Chicago.

Fire which started from a motor in the duplex heater house of the Aetna Chemical Company at Mount Union, Pa., on July 2, destroyed four buildings comprising the recovery and purification departments and the main portion of the plant. About 450,000 pounds of guncotton and much valuable machinery was consumed. The loss is estimated at $900,000. There was no loss of life, but several employees were severely burned. The company announced that it would require four or five months to rebuild and that the fire would delay its plans for moving its plant at Oakdale, near Pittsburgh, to Mount Union. An explosion at the Oakdale plant recently resulted in the loss of more than 100 lives.

$5,000,000 will be required for the by-product coke plant which the Sloss-Sheffield Steel and Iron Company will build near Birmingham, Ala. 120 Semet-Solvay ovens will be installed for the manufacture of toluol, benzol, sulfate of ammonia, and other chemicals for the Government.

An explosion of T. N. T. in the plant of the Hercules Powder Co., Kenvil, near Dover, N. J., on July 5, resulted in the death of three men and property damage estimated at $25,000.

On June 29, the Badische Anilin and Soda Fabrik Works, of Mannheim, Germany, were ignited by bombs from Allied airplanes. The plant burned for many hours.

A substitute for absorbent cotton made from ground wood is likely to prove of inestimable advantage to the Government in the present emergency of absorbent cotton shortage. The Kimberley and Clark Paper Mill, Neenah, Wis., is making the product at the rate of 3 or 4 tons per day.

The War Trade Board has introduced restrictions upon the importation of chrome ore and chromite from overseas. The home supply is believed capable to meet the demand when its numerous sources are developed. Imports from Cuba, Guatemala, Newfoundland, and Brazil will be permitted to provide for the interim demands.

A new woodpulp substitute for absorbent cotton, a cellulose wadding known as Cellulosavadd, is being manufactured in Sweden. The cost of the batting in large quantities is somewhat less than $0.18 per lb., f. o. b., Swedish ports.

On July 29, A. Mitchell Palmer, Alien Property Custodian, took over the Heyden Chemical Works with its large plant at Garfield, N. J., on evidence showing that the concern, the second largest of its kind in this country, was of German ownership. The real owner of the company was Fabrik von Heyden, of Radebeul, Germany, one of the largest chemical concerns in the world. The Heyden Chemical Works has the exclusive use in this country of many valuable patents, processes, and formulas for the making of many by-products of carbolic acid. These will now become Americanized. Mr. Palmer has appointed the following directors and officers of the company: *President*, Leroy Baldwin, President of Empire Trust Co., 120 Broadway, New York City; *Vice President*, James A. Branegan, Chemist, 1421 Chestnut Street, Philadelphia; *Secretary*, F. N. B. Close, Bankers Trust Co., 16 Wall Street, New York City; *Counsel*, J. Harry Covington, former Chief Justice of the Supreme Court, District of Columbia, and Royal H. Weller, Ex-Assistant District Attorney, 31 Nassau Street, New York City.

At the present time, as the result of coöperation between the manufacturers and scientists, large quantities of optical glass of the kinds needed for military fire-control instruments are being produced of a quality equal in practically every respect to the best European glass.

The first unit of a plant for making toluol by a new process is now being installed at the works of Hiram Walker & Sons, Limited, distillers, Walkerville, Ont., and if the success of the process is demonstrated other units will probably be added.

France is experimenting with benefing, an oleaginous plant well known in French West Africa, which, it is expected, will produce an excellent substitute for linseed oil. The seed of this plant produces 37.32 per cent oil when treated with carbon disulfide. The resultant oil has an amber-yellow color, is of average fluidity, and its smell resembles that of linseed oil. The oil cake made from the seed husks after extraction of oil is sufficiently rich in nitrogenous compounds to be useful for agricultural purposes.

The British Board of Trade is taking steps approved by the Government to protect the British dye industry against German competition after the war. The principal measure proposed is that the importation of all foreign dyestuffs shall be controlled

by a system of licenses for a period of not less than ten years after the war.

The plant for the fixation of atmospheric nitrogen, to be used in the manufacture of explosives for the Navy, provided for in a Senate amendment to the naval appropriation bill, is to be located at Indian Head, Md., where the Navy has its great powder plant. Unlike the plants for the fixation of atmospheric nitrogen, which are to make nitrates to be used in explosives for the Army and for the manufacture of fertilizers, which have been located on water-power sites in Alabama and Tennessee, the Navy plant will not be a water-power plant. The Haber method for the fixation of atmospheric nitrogen, which has been used successfully in Germany for some time, will be adopted at the Indian Head plant. Coal is used instead of water power. The proponents of the plan claim that nitrogen can be extracted from the air by this method at a much less cost and outlay of money than in the case of water-power plants. The proposed plant for the fixation of atmospheric nitrogen for the Navy is expected to turn out sufficient nitrate of soda to fill all the requirements of the huge powder plant at Indian Head, which has been greatly increased in size since the war began. In the Senate amendment to the naval appropriation, the sum of $9,150,000 is provided for the establishment of the Indian Head plant and for its operation during the coming fiscal year.

The Hardaway Construction Company which is building the supplementary power dam at the American Aluminum Company's plant at Badin, N. C., suffered a loss of two months' time by a fire, due to lightning and poor fire protection, which burned its concrete-mixing plant, which had a daily capacity of 1500 cu. yds. The loss was total, with no insurance. This dam will cost about $1,500,000 and will develop 32,500 h. p. It is not built for pondage, but to use the water from the gigantic dam 180 feet high, 2 miles above, taking this water under a head of 50 feet.

The Consumers Dyewood Products Co., Mobile, Ala., has been capitalized at $300,000, and will locate at Choctaw Point for the manufacture of dyes.

The Steel Cities Chemical Company is planning to rebuild its sulfuric acid plant at Ensley, Ala., which was recently burned at a loss of $300,000.

The department for the manufacture of dyestuffs at the United Piece Dye Works has been transferred to E. I. du Pont de Nemours & Co., Wilmington, Del. The United Piece Dye Works, represented by the Messrs. Albert and Henry Blum, were among the first to undertake the manufacture of certain difficult lines of dyestuffs, and deserve much credit for the work they accomplished.

The French Minister of Commerce has decided to concentrate all importations into the hands of consortiums. The General Syndicate of Chemical Products will be the authority to form these bodies with reference to the chemical industry, and will supervise the appointment of three consortiums: (1) for heavy chemicals and fertilizers, (2) for diverse chemical products, and (3) for tannins and dyestuffs.

Women chemists are needed by the Government and also to stabilize the industries by replacing men chemists who have been called into service, according to Major F. E. Breithut, of the Chemical Warfare Service, U. S. A. This call is so urgent that he has asked the Women's Committee of the Council of National Defense to coöperate with the Army Medical Department in making a census of all the available women chemists in the country.

A report on the tannin-bearing plants and trees of Latin America issued by the Bureau of Foreign and Domestic Commerce is ready for distribution. It is the work of Dr. Thomas H. Norton. The purpose of the study is to enumerate and describe as completely as possible the known occurrence of sources of tannin in the countries in question and to show the extent to which they are already utilized, or are susceptible of easy exploitation. The sources of tanning of industrial importance to be found in Latin American countries are summarized by Dr. Norton as follows: Woods, 12; barks, 102; leaves, 9; roots, 3; fruits and seeds, 17.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

PUBLIC HEALTH SERVICE

Some Qualitative and Quantitative Tests for Arsphenamine (3,3'-Diamino-4,4'-Dioxy-Arsenobenzene Dihydrochloride) and Neo-Arsphenamine (Sodium-3,3' - Diamino - 4,4' - Dihydroxy-Arsenobenzene-Methanan-Sulfoxalate). C. N. Myers and A. G. DuMez. Public Health Reports 33, 1003–1016. Issued June 21.

Previous to the year 1914, all of the arsphenamine (salvarsan) and neo-arsphenamine (neosalvarsan) on the market was manufactured by a single German firm under the supervision of Paul Ehrlich, one of the patentees. Naturally the products were fairly uniform in their composition and properties.

Examinations made by the authors, as well as evidence presented by clinicians (Martin and others, 1916), have revealed the fact that the products of different manufacturers appearing on the market in this country are not all uniform with respect to either their chemical or their physiological properties. Even the last of the German supplies received are stated to be more toxic than the products obtained before the beginning of hostilities in Europe (Ormsby and Mitchell, 1916).

Tentative standards for these preparations (arsphenamine and neo-arsphenamine) have been adopted by the Federal Trade Commission on the recommendation of the United States Public Health Service, but these do not appear to meet all exigencies. It is for this reason and for the purpose of better defining the properties of good preparations that the following qualitative and quantitative tests have been worked out and compiled.

Dried Milk Powder. Anonymous. Public Health Reports 33, 1052–5. Issued June 28. This is a review of "Food Report No. 24" issued by the Local Government Board of Great Britain. It discusses the important conclusions on preparation, composition, and nutritive values of dried milk powder with special reference to their use in infant feeding.

The Growth-Promoting Properties of Foods Derived from Corn and Wheat. C. Voegtlin and C. N. Myers. Public Health Reports 33, 843–868. Issued May 31.

The purpose of the present investigation was to answer the question as to whether the corn and wheat products used in human nutrition exhibit similar dietary deficiencies as those of the whole grains. The bulk of the corn and wheat foods of the American dietary are derived from the wheat and corn kernel by means of a process of milling (roller mills) which is known to eliminate most of the germ and superficial layers of the grain. It, therefore, seemed to us a question of practical importance to determine whether the milling process improves, or causes a decrease in, the dietary value of the milled product. Moreover, it was desirable to decide whether or not the food additions made to flour (yeast, salt, milk) in the preparation of bread improve the nutritive value of this food.

Establishments Licensed for the Propagation and Sale of Viruses, Serums, Toxins, and Analogous Products. Anonymous. Public Health Reports 33, 869–872. Issued May 31.

Color Blindness. G. L. COLLINS. Public Health Bulletin 92. This discusses means for detecting various degrees of color blindness and summarizes a considerable number of observations on various phases of this general question.

Phosphorus as an Indicator of the "Vitamine" Content of Corn and Wheat Products. C. VOEGTLIN AND C. N. MYERS. Public Health Reports 33, 911–917. Issued June 7. The phosphoric anhydride determination of wheat and corn products yields fairly satisfactory information as to the content of these products in accessory foods. A low phosphoric anhydride content indicates that the product is poor in vitamines.

GEOLOGICAL SURVEY

Copper in 1916. General Report. B. S. BUTLER. Separate from Mineral Resources of the United States, 1916, Part I. 55 pp. Published April 22.

The copper-producing plants of the country were operating at capacity at the beginning of 1916, and under the spur of active demand and unusually high prices a general enlargement took place. There was comparatively little interruption from labor troubles or other causes, and the combined result was by far the largest output in the history of the domestic copper industry.

The average cost per pound of copper showed a decrease in 1915 from 1914, owing both to the plants being worked more nearly at capacity and to the relatively slight increase in cost of labor and material. In 1916 the cost of both labor and material had advanced and this advance was reflected in the increased cost of copper. In 1915 the average cost of copper per pound, as given in the annual reports of the companies giving this item, was about 8 cents; in 1916 the average was 11.3 cents. The figures for both years are below the actual average cost of all copper produced, but the increase in 1916 doubtless represents approximately the increase in average cost.

The average price received for copper in 1916 as reported by the selling agencies was 24.58 cents per lb., as compared with about 17.5 cents in 1915—an increase in 1916 of about 7 cents per lb. The profit per pound of copper was probably at least 3.5 cents greater than in 1915, and this was reflected in the large earnings of the principal copper companies.

The effect of the remodeling of plants to improve metallurgic practices, which has been in progress for the last few years, was shown in the recoveries in 1916. For several years prior to 1915 the quantity of copper recovered per ton of ore showed a steady decrease. This was caused by the treating of constantly increasing quantities of low-grade concentrating ore. In 1915 and 1916, in spite of large increase in the concentrating ore treated, there was an increase in the average quantity of copper recovered per ton of ore, and this in spite of the fact that some plants were operated beyond their capacity for greatest metallurgic efficiency.

SUMMARY OF STATISTICS OF THE COPPER INDUSTRY IN THE UNITED STATES

	1915	1916
Production of copper		
Smelter output, lbs.	1,388,009,527	1,927,850,548
Mine production, lbs.	1,488,071,528	2,005,875,312
Refinery production of new copper		
Electrolytic, lbs.	1,114,345,342	1,579,620,513
Lake, lbs.	236,757,062	269,794,531
Casting and pig, lbs.	36,603,119	39,337,155
Total domestic, lbs.	1,387,705,523	1,888,752,199
Total domestic and foreign, lbs.	1,634,204,448	2,259,387,315
Total new and old copper, lbs.	2,026,000,000	2,922,000,000
Total ore produced, short tons	43,415,133	57,953,357
Copper ore produced, short tons	43,404,182	57,863,365
Average yield of copper, per cent.	1.66	1.70
Average price per pound, cents	17.5	24.6
Imports, lbs.	315,698,449	462,335,980
Exports, lbs.	681,917,955	784,006,486
Consumption		
Total new copper, lbs.	1,043,497,328	1,429,755,266
Total new and old copper, lbs.	1,435,000,000	2,024,000,000
World's production, lbs.	2,346,300,299	3,106,995,660
Value of production in the United States.	$242,902,000	$474,288,000

Exports of metallic copper were larger than in 1915, but were still below those of 1914 and 1913. Domestic consumption, however, showed a large increase and, as in 1915, much of this was exported in manufactured form. As the capacity of British and French munitions plants increased, more raw materials and less manufactured products were exported.

At the end of 1916 the capacity for producing copper in the United States was larger than it has ever been and was increasing.

No systematic attempt has been made to ascertain the proportion of the copper output of 1916 used in different industries, such as electric transmission, brass manufacture, and casting, but some idea of the quantities entering the different industries can be gained from the forms in which the output of the refineries was cast. The following table shows the approximate quantity of copper cast in the different forms during 1916 as reported by the refining companies. It will be noted that the total is not the same as the refinery output for 1916.

COPPER CAST IN DIFFERENT FORMS IN 1916

FORM	Quantity, Lbs.	Percentage
Wire bars	853,028,629	37
Ingots and ingot bars	873,281,265	38
Cakes	298,399,153	13
Cathodes	192,109,762	8
Other forms	92,676,974	4
	2,309,495,783	100

It may be assumed that a large portion of the 37 per cent cast as wire bars was used in the electric industry and that much of the 13 per cent cast as cakes was used for rolling. The other forms are less easily classified. The 8 per cent cast as cathodes, together with a considerable portion of the ingots, and probably some of the cakes, entered the brass industry, and a large quantity of copper ingots was used in casting. The refinery output for 1915 was cast as follows: Wire bars, 37 per cent; ingots, 45 per cent; cakes, 9 per cent; cathodes, 6 per cent; other forms, 3 per cent. The most notable change was the relative decrease in ingots and increase in cakes.

Clay-Working Industries and Building Operations in the Larger Cities in 1916. J. MIDDLETON. Separate from Mineral Resources of the United States, 1916, Part II. 72 pp. Issued April 13.

This report deals with the products of the clay-working industries as well as with clay mining, and the tables are made up to show the output of manufactured clay products as best expressing the production of clay.

The year 1916 in the clay-working industries was one of general progress. In spite of strikes, scarcity of labor, increased cost of materials, and congestion in transportation, the output of 1916 was much larger than in any preceding year. In some sections of the country the business in brick and tile lagged during the earlier part of the year, but later was unusually active, reflecting the general prosperity of the country. The total value of all clay products marketed was $207,260,091, an increase of $44,139,859, or 27 per cent. This is the greatest value recorded in these industries and is nearly $26,000,000 more than the highest previous record.

The refractories branch of the industries, the products of which are so essential, both to modern civilization and to military operations, showed the largest increase, and was followed next in order by the great structural material, common brick. Only fancy brick and enameled brick, both minor items in the total output, decreased in value, and the decrease in these was very small.

The value of all domestic pottery marketed in 1916 was $48,217,242, an increase of $10,891,854, or nearly 30 per cent, over 1915, and of $10,224,867, or 27 per cent, over 1913, the previous year of highest value. The pottery imports decreased $1,027,501, or 16 per cent, and the ratio of production to consumption, 92 per cent, was the highest recorded.

The total value of imports of all clay products decreased $1,034,222, or 15 per cent, in 1916; in 1915, there was a decrease

of $1,806,350, or nearly 21 per cent. The total value of imports for 1916 was the lowest in 30 years, except in 1890, and was less than that of 1907, the year of maximum value, by $8,045,267, or 58 per cent. Of the imports for 1916, about 97 per cent was pottery and about 3 per cent was brick and tile.

The value of exports of domestic clay products in 1916 increased $2,150,290, or 79 per cent, over 1915. In 1915 there was a decrease of $872,765, or 24 per cent, from 1914. Of the exports in 1916, 62 per cent was brick and tile, 22 per cent pottery, and 16 per cent unclassified.

The clay sold as such in 1916 amounted to 2,932,590 short tons, an increase of 569,636 tons, or 24 per cent. This clay was valued at $5,751,774, or $1.96 per ton, an increase of $1,779,833, or 45 per cent, and of 28 cents in the average price. Every variety of clay except brick clay increased in quantity and value, and paper clay, ball clay, and fire clay reached their maximum quantity and value in 1916. Fire clay made the largest gain in production, 487,333 tons, or 31 per cent; paper clay increased 40,401 tons; kaolin, 19,692 tons; ball clay, 14,413 tons. Slip clay, which has been declining in production since 1912, made a large increase in output, 6,418 tons, or 84 per cent, in 1916, compared with 1915. Fire clay showed the largest increase in value, $1,346,527, or 57 per cent; paper clay increased $229,289, or 42 per cent; slip clay, $29,165, or 155 per cent; kaolin, $65,299, or 27 per cent; and ball clay, $89,242, or 30 per cent. Brick clay decreased 4,804 tons and $17,009. Fire clay is the chief kind, judged by production, and constituted 70 per cent of the quantity and 64 per cent of the value of the clay marketed in 1916. Paper clay ranked second in value of output, and ball clay third. The average price per ton varied but little in 1916, compared with 1915.

The Salt Creek Oil Field, Wyoming. C. H. WEGMANN. Bulletin 670. 45 pp. Paper, 15 cents. "The Salt Creek oil field, which produces daily 10,000 barrels of high-grade paraffin oil, is at present the largest proved field in the State of Wyoming. A number of fields more recently developed—such as Grass Creek, Big Muddy, and Elk Basin—are attracting much attention, but so far none of these promises to include an area so large or wells so productive."

Bauxite and Aluminum in 1917. J. M. HILL. Separate from Mineral Resources of the United States, 1917, Part I. 9 pp. Published June 21.

The quantity of bauxite marketed in the United States in 1917 was 568,690 long tons, which had a value at the mines of $3,119,058, an increase over the production of 1916 of about 34 per cent in quantity and about 36 per cent in value. The production from the Georgia, Alabama, and Tennessee field in 1917 was 62,134 long tons, an increase of about 26 per cent, and the Arkansas production of 506,556 long tons showed an increase of approximately 35 per cent.

Apparently the producers of aluminum consumed about 375,000 tons, the makers of chemicals about 82,000 tons, makers of abrasives about 110,000 tons, and the makers of refractories about 2,400 tons of bauxite in 1917.

The prices received for bauxite in 1917, as reported by producers, ranged from $4.75 to $10.50 a long ton; the average price paid for the whole of the domestic bauxite sold in the country was $5.48 a long ton at the shipping point.

The value of primary aluminum produced in the United States in 1917 was $45,882,000, an increase of 35 per cent over the value of the output in 1916. This increase is due in part to the increased price and in part to the greater output of primary aluminum in 1917. No estimate can be made at this time (March, 1918) of the recoveries of secondary aluminum during 1917, but the data at hand, though incomplete, indicate that the recoveries will not be smaller than in 1916. Information concerning this phase of the aluminum industry will be found in the chapter of Mineral Resources on secondary metals in 1917, which is now in preparation.

In the United States the quoted prices for primary or "virgin" aluminum ranged from 62 cents per lb., in January, to 37 cents per lb., in October, a price which was maintained to the end of the year. The average for the year was 51.59 cents per lb., as compared with 60.71 cents in 1916. These prices are for small lots and immediate delivery, offered in the open market, and do not represent the price received by the single producer of primary aluminum in this country.

The principal aluminum salts made in the United States are alumina, alums, usually ammonium and sodium alums, aluminum sulfate, and aluminum chloride. Alumina is largely consumed in the manufacture of aluminum and no figures of domestic production are available for publication.

Alums of various qualities are produced at 9 plants in the eastern United States, the total production of alum in 1917 being 19,714 short tons, valued at $1,017,083, a decrease of approximately 28 per cent in quantity and of 14 per cent in value from the production in 1916. The average price reported by makers of alums was $51.60 a short ton. The wholesale market quotations ranged from 4 to $5^1/_8$ cents per lb., or $80 to $102 a short ton. The quotations on lump alum were fairly constant at 4 to $4^1/_4$ cents up to May, when an increase to $4^1/_2$ to 5 cents was made. This price remained steady till November, when it dropped to 4 to $4^1/_2$ cents. Ground alum at the first of the year was quoted at $4^1/_8$ to $4^3/_8$ cents, but prices rose to $4^5/_8$ to $5^1/_8$ cents about the middle of May and remained stationary until the last of September, when they began to drop, and reached $4^1/_{10}$ to 5 cents at the end of 1917.

Aluminum sulfate is made at 24 plants, 7 of which are at municipal or industrial waterworks, which consume their entire output. The total quantity of aluminum sulfate produced in the United States in 1917 was 178,738 short tons, of which 4,947 short tons did not enter the market but was used for water purification at the place of manufacture. The quantity of domestic aluminum sulfate which entered the market, 173,791 short tons, was greater than the quantity in 1916 by approximately 18 per cent, and the total domestic production increased about 16 per cent. The price reported by makers of aluminum sulfate for the 1917 output averaged $32.15 a short ton. Market quotations for low-grade aluminum sulfate ranged from a low of 2 cents to a high of 4 cents per lb., or $40 to $80 a short ton. Low-grade aluminum sulfate was quoted at 2 to $2^1/_2$ cents per lb. until October, when quotations rose to 2 to $3^1/_2$ cents, but fell to 2 to 3 cents during the second week of November, and closed at $1^3/_4$ to $2^1/_4$ cents per lb. at the end of the year.

Aluminum chloride is used for various purposes, among which may be mentioned the refining of mineral oils. This salt was produced at 3 plants in 1917, and the total output reported to the Geological Survey was 4,702 short tons, valued at $311,900, or approximately $66 a short ton. Market quotations on aluminum chloride remained stationary throughout the year at 4 to $4^1/_{10}$ cents per lb. or $80 to $82 a short ton.

Bauxite abrasives sold under various trade names, such as alundum, aloxite, exolon, and lionite, are made by fusing bauxite in an electric furnace. These products are sold in the form of powders, cloth, grinding stones, and wheels of various shapes for a multitude of uses.

The total marketed production of artificial abrasives made from domestic bauxite in 1917 was 48,460 short tons, valued at approximately $6,970,000, or about $144 a short ton. This is an increase over the production in 1916 of 58 per cent in quantity and of 200 per cent in value. The average value is deceptive, however, in that the prices received for the product depend on many factors, among which hardness, size of grain, degree of finishing, and many others may be mentioned.

There are two classes of high-alumina refractories now on the

market. What are commonly called bauxite brick are made by mixing various proportions of calcined bauxite or high-alumina clay with a binding material such as fire clay, sodium silicate, or lime. The other class of high-alumina refractories consists of those made by the electric fusing of bauxite. These are manufactured by the companies that make artificial abrasives.

The use of high-alumina refractories seems to be expanding, particularly in the construction of copper, iron, and lead furnaces and of cement kilns. No figures are now (March, 1918) available to show the production of high-alumina refractories, though it is known that at least 2,313 long tons of bauxite were consumed in making refractories.

Strontium in 1917. J. M. Hill. Separate from Mineral Resources of the United States, 1917, Part II. 2 pp. Published June 19. "Domestic strontium ores were used by makers of strontium chemicals to a considerable extent during 1917. Prior to 1916 most of the salts made in this country were products of imported celestite. In 1917, however, the domestic deposits supplied over 70 per cent of the domestic requirements."

From the best information available to the United States Geological Survey it would seem that approximately 4,035 short tons of strontium ore, valued at about $87,700, of which about 10 per cent was strontianite (strontium carbonate) and the remainder celestite (strontium sulfate), was mined in the United States during 1917. This ore was mined in California, Texas, and Washington. By far the greatest production was made from California deposits.

Approximately 1,700 tons of English celestite was imported in 1917 for use in this country.

Prices reported by sellers of celestite ranged from $20 to $22 a short ton, but for strontianite ores prices from $35 to $90 a short ton were reported. The Foote Mineral Co. on July 14, 1917, was selling ground celestite (90 per cent $SrSO_4$) at 2 cents per lb. ($40 a ton) and ground strontianite (83 per cent $SrCO_3$) at 7 cents per lb. ($140 a ton).

Four companies in the United States reported sales of strontium carbonate and strontium nitrate in 1917, aggregating about 3,000,000 pounds or 1,500 short tons. The principal salt sold was the nitrate. A few thousand pounds of strontium bromide was sold, and several thousand pounds of sulfide, which was presumably used for making other salts.

The demand for strontium salts comes principally from makers of fireworks and night signals. Quotations on strontium carbonate have been steady throughout the year at 40 to 45 cents per lb. for technical carbonate and 55 to 60 cents per lb. for pure carbonate. Strontium nitrate was quoted at 42 to 52 cents per lb. at the beginning of 1917 but declined to 25 to 30 cents per lb. in June and remained at that figure till the end of the year.

Arsenic in 1917. J. P. Umpleby. Separate from Mineral Resources of the United States, 1917, Part I. 5 pp. Published June 19.

The production of arsenic or arsenious oxide in the United States in 1917 amounted to 6,151 short tons, valued at $1,118,313, an increase over 1916 of less than 3 per cent in quantity and of more than 101 per cent in value. The value of the output is somewhat uncertain, however, as in some returns it represents the value f. o. b. destination in carload lots and in others the value at the reduction plant. Throughout, however, the value reported by the producers is much lower than that quoted in the trade journals.

Nearly all the output in 1916 was recovered as a smelter by-product. One plant only, at Brinton, Va., began late in the year to mine and treat ore primarily for its content of arsenic.

The unusual demand for insecticides incident to increased gardening led the Government to place the industry under license late in the year. Early in 1918 the Food Administration, after exhaustive investigation during the later part of 1917, fixed a maximum price of 9 cents per lb. to be charged by producers for white arsenic in carload lots delivered in the United States. Half a cent per lb. additional is permitted for shipments in less than carload lots.

The refined arsenic produced is reported to be above 99.5 per cent As_2O_3.

The small increase in the domestic production of arsenic and the great increase in its value in 1917 are noteworthy features.

The imports of white arsenic and arsenic sulfide, or orpiment, increased from 2,163 short tons in 1916 to 3,955 short tons in 1917, or nearly 83 per cent. This increase should be compared with a decrease of 32 per cent in 1916 and is due to the resumption of production in Mexico as well as to increased imports from Canada. The Canadian output is derived as a by-product in the smelting of ores from Cobalt and adjacent silver deposits in northern Ontario.

The present demand for arsenic consumes about 12,000 short tons a year, whereas the available supply in 1917 from both domestic production and imports was only about 10,000 short tons. The supply in 1917, however, was much larger than in previous years. The average yearly supply from all sources for the period from 1911 to 1916, inclusive, was a little less than 8,150 tons. During 1918 the domestic production may be expected to increase and unless the output from Mexico and Canada finds another market the imports will also increase. On the other hand, the demand for arsenic will almost certainly increase and probably at a more rapid rate than production. It seems likely that a scarcity of arsenic will persist throughout 1918 and that the price will hold close to the maximum fixed by the Food Administration.

The deficiency in arsenic is not confined to the United States. In England and France prices even higher than those in the United States clearly reflect a shortage in the supply of arsenic, although both these countries are large producers of arsenic, England from the Cornwall deposits and France principally from the auriferous arsenopyrite deposits in the Department of Maine-et-Loire.

Antimony in 1916. E. S. Bastin. Separate from Mineral Resources of the United States, 1916, Part I. 7 pp. Published June 14.

The production of antimony ores in the United States in 1916 according to the best information available was about 4,500 short tons, valued at $40,580. The metallic antimony content of this material was about 1,770 short tons. The average tenor of the ore in metallic antimony was therefore about 40 per cent.

In contrast to the small domestic production of antimony ore—about 4,500 short tons—the total imports in 1916 amounted to 7,764 short tons of antimony ore and 9,875 short tons of metallic antimony. In the customs classification for monthly import returns antimony matte, which is liquated sulfide, and antimony regulus, which is metallic antimony, are grouped in one class, but the quarterly returns of imports for consumption differentiate between these materials and record no imports of the matte or liquated sulfide during 1916.

In 1914 normal prices were maintained until the outbreak of the war, when the price rose from an average of 7.2 cents in July to 17.2 in August.

The price at the beginning of 1916 was about 42 cents per lb., from which it rose to 46 cents in March and then declined steadily to about 11 cents early in October. Later there was a slight recovery to about 15 cents at the close of the year. The decline was the result of overproduction in China, which flooded the American market with the Chinese products. With these

the American antimony miners soon found themselves unable to compete, and the latter part of the year witnessed a great decline in antimony mining in this country.

BUREAU OF STANDARDS

Resonance and Ionization Potentials for Electrons in Cadmium Vapor. J. T. TATE AND P. D. FOOTE. Scientific Paper 317. 8 pp.

Application of Dicyanin to the Photography of Stellar Spectra. P. W. MERRILL. Scientific Paper 318. 19 pp.

Thermal Expansion of Alpha and of Beta Brass Between 0° and 600° C. in Relation to the Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type. P. D. MERICA AND L. W. SCHAD. Scientific Paper 321. 20 pp. Paper, 10 cents. The difference in the thermal expansion of alpha and of beta brass of compositions which normally are in equilibrium in such alloys as Muntz metal, naval brass, etc., has clearly been shown by the measurements made. Fundamental variations in behavior as regards thermal expansion at temperatures up to 600° C. were noted, due to the occurrence of a transformation in the beta constituent.

The effect of the local or, as they might be called, "grain" stresses, on the physical properties and service behavior has been only incompletely indicated. Tests showed that stresses of this sort produced by quenching commercial drawn 60 : 40 brass 1-in. diameter rod did not cause cracking in mercurous nitrate. On the other hand, a lowering of the proportional limit of the alloy amounting to about 2000 lbs. per sq. in. resulted from this treatment.

It would appear to the authors that further investigation into this general question of the expansion behavior of different constituents of other alloys might reveal causes of mysterious failures and weakness now considered quite obscure. Such materials as hypereutectoid steels, cast iron, type metal, and bearing metals contain two constituents. In many cases one of these constituents is brittle, a fact which would accentuate the effect of local contraction stresses. The authors hope to be able to present some data later along these lines, indicating also more definitely the physical effect of such stresses.

Effect of the Size of Grog in Fire-Clay Bodies. F. A. KIRKPATRICK. Technologic Paper 104. 37 pp. The results throw some light upon the question of the bonding power of plastic clays. The strength of clay-grog bodies in the raw state is a measure of bonding power. Since size of grog has great effect upon strength, size of grain of the clay must exert considerable influence upon this property. The size of grain of bond clays cannot at present be measured accurately. Any means for determination or indirect estimation of this property, such as viscosity of the clay slip, would be of great help in working out this problem.

Comparative Tests of Chemical Glassware. P. H. WALKER AND F. W. SMITHER. Technologic Paper 107. 21 pp.

Legal Weights (in pounds) per Bushel of Various Commodities. Circular 10, 3rd Edition. 17 pp.

Standard Specifications for Incandescent Electric Lamps, Tungsten (or Mazda) and Carbon. Circular 13, 8th Edition. 9 pp.

Radio Instruments and Measurements. Circular 74. 320 pp. Paper, 60 cents. This circular presents information regarding the more important instruments and measurements actually used in radio work. It is hoped that the treatment will be of interest and value to Government officers, radio engineers, and others, notwithstanding the subject is not completely covered. Many of the matters dealt with are or have been under investigation in the laboratories of this Bureau and are not treated in previously existing publications. No attempt is made in this circular to deal with the operation of apparatus in sending and receiving. It is hoped to deal with such apparatus in a future circular. The present circular will be revised from time to time, in order to supplement the information given and to keep pace with progress. The Bureau will greatly appreciate suggestions from those who use the publication for improvements or changes which would make it more useful in military or other service.

The methods, formulas, and data used in radio work cannot be properly understood or effectively used without a knowledge of the principles on which they are based. The first part of this circular, therefore, attempts to give a summary of these principles in a form that is as simple as is consistent with accuracy. A large proportion of this publication is devoted to the treatment of fundamental principles for the reasons, first, that however much the methods and technique of radio measurement may change the same principles continue to apply, and second, that this will make the present circular serve better as an introduction to other circulars on radio subjects which may be issued.

A familiarity with elementary electrical theory and practice is assumed.

Instruments and Methods Used in Radiometry. III. The Photoelectric Cell and Other Selective Radiometers. W. W. COBLENTZ. Scientific Paper No. 319. 30 pp. Paper, 10 cents. Issued June 17, 1918.

Photoelectric Sensitivity of Bismuthinite and Various Other Substances. W. W. COBLENTZ. Scientific Paper 322. 14 pp. Paper, 5 cents. Issued June 14. The present paper summarizes the results of an examination of various substances, to determine their electrical sensitivity to light, and describes the results of a more detailed examination of the photoelectric sensitivity of bismuthinite, Bi_2S_3, and molybdenite, MoS_2.

Some Characteristics of the Marvin Pyrheliometer. P. D. FOOTE. Scientific Paper 323. 30 pp. Paper, 10 cents. Issued June 28.

Standardization of the Saybolt Universal Viscosimeter. W. H. HERSCHEL. Technologic Paper 112. 23 pp. Paper, 10 cents. Issued June 27. It has previously been impossible to determine whether a Saybolt Universal viscosimeter gave normal readings, as neither the dimensions nor normal times of flow for any given liquids were known. Now that these data have been determined, limit gauges have been prepared, and the Bureau of Standards is now in a position to certify whether or not a given instrument is of standard dimensions.

Determination of Permeability of Balloon Fabrics. J. D. EDWARDS. Technologic Paper 113. 29 pp. Paper, 10 cents. Issued July 2. "One of the most essential characteristics of a balloon envelope is that it shall be gas tight, or nearly so. Therefore the determination of the permeability of balloon fabrics to hydrogen, which is the gas used in the modern dirigible and kite balloons, is of first importance in determining their suitability for balloon construction. In connection with a study of the permeability of balloon fabrics it has been necessary to investigate different forms of apparatus and the influence of experimental conditions in order to interpret test results intelligently. The results of the Bureau's investigation of methods of determining permeability are presented in this paper. The effect of composition, method of construction, etc., upon the permeability are not discussed in the present paper, which deals only with testing methods."

Copper. Circular 73. 100 pp. Paper, 20 cents. Issued June 25. "This circular is the first one issued on the metals; copper has been chosen for the reason that much of the accurate

information regarding copper has been obtained at this Bureau, and that, in general, our knowledge of the properties of this metal is more complete than of any other. Furthermore, commercial copper has a very high degree of purity. The data and information have been put in the form of tables and curves, the curves have been reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of a centimeter. The probable degree of accuracy of data is indicated, or implied, by the number of significant figures in the values given.

"The Bureau plans to issue from time to time circulars on individual metals or alloys, with the idea of grouping in these circulars all of the best information which the Bureau has as a result of its tests and investigations together with that available in all records of published tests and investigations of such materials.

"The circulars deal primarily with the physical properties of the metal or alloy; all other factors, except a few statistics of production, such as methods of manufacture, presence of impurities, etc., are discussed only in their relation to these physical properties; it must be realized that the physical properties of metals and alloys are often in great degree dependent upon such factors, so that the statement of values for such properties should include an accompanying statement regarding those factors by which the properties are affected.

"The endeavor in the circulars, therefore, is to reproduce only such data as have passed critical scrutiny, and to suitably qualify in the sense oudined above all statements, numerical or otherwise, made relative to the characteristics of the metal."

DEPARTMENT OF AGRICULTURE

Fertilizers from Industrial Wastes. W. H. Ross. Yearbook Separate 728. 13 pp. Paper, 5 cents. Contribution from the Bureau of Soils.

Varieties of Cheese. C. F. Doane and H. W. Lawson. Department Bulletin 608. 80 pp. Paper, 5 cents. This bulletin includes descriptions and analyses, with sources of data indicated in detail.

Effect of Varying Certain Cooking Conditions in Production of Sulfite Pulp from Spruce. S. E. Lunak. Department Bulletin 620. 24 pp. and 12 plates. Issued March 14. Paper, 15 cents.

Conservation of Fertilizer Materials from Minor Sources. C. C. Fletcher. Yearbook Separate 733. 8 pp. Paper, 5 cents. Contribution from the Bureau of Soils.

Sources of Our Nitrogenous Fertilizers. F. W. Brown. Yearbook Separate 729. 10 pp. Paper, 5 cents. Contribution from the Bureau of Soils.

Principles of Liming of Soils. E. C. Shorey. Farmers' Bulletin 921. 30 pp. Paper, 5 cents. Issued March 1918. Popular treatment for general use; a contribution from the Bureau of Soils.

Phosphate Rock, our Greatest Fertilizer Asset. W. H. Waggaman. Yearbook Separate 730. 9 pp. Paper, 5 cents. Contribution from the Bureau of Soils.

Butter Fat and Income. J. C. McDowell. Yearbook Separate 743. 9 pp. Paper, 5 cents. Popular style for general use; a contribution from the Bureau of Animal Industry.

Manufacture of Casein from Buttermilk or Skim Milk. A. O. Dahlberg. Department Bulletin 661. 32 pp. Paper, 5 cents. Issued April 9. Contribution from the Bureau of Animal Industry.

Some Common Disinfectants. M. Dorset. Farmers' Bulletin 926. 12 pp. Paper, 5 cents. A revision of Farmers' Bulletin 345; popular treatment; a contribution from the Bureau of Animal Industry.

Cottonseed Meal for Feeding Beef Cattle. W. F. Ward Farmers' Bulletin 655. 8 pp. Paper, 5 cents. Issued April 10. Non-technical; a contribution from the Bureau of Animal Industry.

Commercial Freezing and Storing of Fish. E. D. Clark and L. H. Almy. Department Bulletin 635. 10 pp. Paper, 5 cents. Issued March 9. Contribution from the Bureau of Chemistry.

Commercial Stocks of Fertilizers and Fertilizer Materials in United States as Reported for October 1, 1917. Anon. Department Circular 104. 12 pp. Paper, 5 cents. Issued February 28. Published by the Bureau of Markets.

Production of Drug Plant Crops in United States. W. W. Stockberger. Yearbook Separate 734. 10 pp. Paper, 5 cents. Contribution from the Bureau of Plant Industry.

Influence on Linseed Oil of Geographical Source and Variety of Flax. F. Rabak. Department Bulletin 655. 16 pp. Paper, 5 cents. Issued April 20. Contribution from the Bureau of Plant Industry.

Experiments on Digestibility of Fish. A. D. Holmes. Department Bulletin 649. 15 pp. Paper, 5 cents. Issued April 13. A contribution from the States Relations Service.

Studies on Digestibility of Some Nut Oils. A. D. Holmes. Department Bulletin 630. 19 pp. Paper, 5 cents. Issued April 16. A contribution from the States Relations Service.

Relative Resistance of Various Hardwoods to Injection with Creosote. C. H. Teesdale and J. D. Maclean. Bulletin 606. 36 pp. Paper, 15 cents. Published April 15, 1918. A technical description of results of experiments in injecting creosotes in various species of hardwoods.

A Physical and Chemical Study of the Kafir Kernel. G. L. Bidwell. Bulletin 634. 6 pp. Paper, 5 cents. Published April 4, 1918. A study showing that, if properly handled, kafir products might be substituted for corresponding corn products.

Articles from the Journal of Agricultural Research

Influence of Carbonates of Magnesium and Calcium on Bacteria of Certain Wisconsin Soils. H. L. Fulmer. **12,** 463–505 (Feb. 25).

Humus in Mulched Basins, Relations of Humus Content to Orange Production, and Effect of Mulches on Orange Production. C. A. Jensen. **12,** 505–18 (Feb. 25).

Digestion of Starch by the Young Calf. R. H. Shaw, T. E. Woodward and R. P. Norton. **12,** 575–8 (March 4).

Toxicity of Volatile Organic Compounds to Insect Eggs. W. Moore and S. A. Graham. **12,** 579–88 (March 4).

Effect of Nitrifying Bacteria on the Solubility of Tricalcium Phosphate. W. P. Kelly. **12,** 671–83 (March 11).

Respiration of Stored Wheat. C. H. Bailey and A. M. Gurjar. **12,** 685–714 (March 18).

Determination of Fatty Acids in Butter Fat. E. B. Holland and J. P. Buckley, Jr. **12,** 719–32 (March 18).

Studies on Capacities of Soils for Irrigation Water, and on a New Method for Determining Volume Weight. O. W. Israelsen. **13,** 1–36 (April 1).

Soil Acidity as Influenced by Green Manures. J. W. White. **13,** 171–98 (April 15).

Relation between Biological Activities in the Presence of Various Salts and the Concentration of Soil Solution in Different Classes of Soils. C. E. Millar. **13,** 213–24 (April 22).

A Study of the Streptococci Concerned in Cheese Ripening. A. C. Evans. **13,** 235–52 (April 22).

The Calcium Arsenates. R. H. ROBINSON. **13,** 281–94 (April 29).

Chemistry of the Cotton Plant, with Special Reference to Upland Cotton. A. VIERHOEVER, L. H. CHERNOFF AND C. O. JOHNS. **13,** 345–52 (May 13).

Stability of Olive Oil. E. B. HOLLAND, J. C. REED AND J. P. BUCKLEY, JR. **13,** 353–66 (May 13).

Hydration Capacity of Gluten from "Strong" and "Weak" Flours. R. A. GORTNER AND E. H. DOHERTY. **13,** 389–417 (May 20).

Boron: Its Effect on Crops and Its Distribution in Plants and Soil in Different Parts of the United States. F. C. COOK AND J. B. WILSON. **13,** 451–470 (May 27).

Destruction of Tetanus Antitoxin by Chemical Agents. W. N. BERG AND R. A. KELSER. **13,** 471–494 (June 3).

Relation of the Density of Cell Sap to Winter Hardiness in Small Grains. S. C. SALMON AND F. L. FLEMING. **13,** 497–506 (June 3).

Physical Properties Governing the Efficacy of Contact Insecticides. W. MOORE AND S. A. GRAHAM. **13,** 523–536 (June 10).

Comparative Transpiration of Corn and the Sorghums. E. C. MILLER AND W. B. COFFMAN. **13,** 579–581 (June 10).

Inorganic Composition of a Peat and of the Plant from which it was Formed. C. F. MILLER. **13,** 605–609 (June 17).

Digestibility of Corn Silage, Velvet-Bean Meal, and Alfalfa Hay when Fed Singly and in Combinations. P. V. EWING AND F. H. SMITH. **13,** 611–618 (June 17).

Effects of Various Salts, Acids, Germicides, Etc., Upon the Infectivity of the Virus Causing the Mosaic Disease of Tobacco. H. A. ALLARD. **13,** 619–637 (June 17).

A Study of the Physical Changes in Feed Residues which Takes Place in Cattle During Digestion. P. V. EWING AND L. H. WRIGHT. **13,** 639–646 (June 17).

SMITHSONIAN INSTITUTION

Atmospheric Scattering of Light. F. E. FOWLE. Publication 2495. 12 pp.

Smithsonian Physical Tables. T. GRAY. 3rd reprint of 6th revised edition, prepared by F. E. Fowle.

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Foreign Markets for Cotton Linters, Batting, and Waste. Special Consular Reports No. 80. 84 pp. Paper, 10 cents. Compilation of reports prepared by American consuls in various trading centers throughout the world and transmitted to Bureau of Foreign and Domestic Commerce during 1915 and 1916.

COMMERCE REPORTS, JUNE, 1918

A great increase in the use of **cement** and **concrete** in England after the war is predicted, including house construction, roads, railway sleepers, etc. (P. 840)

Three new plants for the manufacture of **bichromate** for tanning, have been erected in Denmark, to use Norwegian chrome ore. (P. 843)

Importation of **vegetable ivory** into the United States is permitted only on condition that all waste produced from it is delivered to the Gas Defense Service. (P. 851)

Electrical manufacturers are urging conservation of **tin** by reducing the amounts used in Babbitt metal, alloys, and solder. (P. 868)

Hull, England, is the largest **vegetable-oil** center in Europe. This industry has increased, due to demands for glycerin for explosives, castor oil for airplanes, oils for margarine, and oil cake for cattle food. The products include the following oils: Cotton, coconut, olive, palm, palm kernel, castor, linseed, rape, and soy bean. (Pp. 919–927)

The cultivation of the **Buchu plant** in South Africa is increasing. (P. 970)

Rich deposits of **bauxite** are reported from Dalmatia, of interest to Germany, which is now using inferior Austrian bauxite. (P. 1025)

Efforts are being made to develop the cultivation of **castor beans** in Malaysia. (P. 1061)

Arrangements have been made for the British Government to obtain annually from Australia 250,000 tons of **zinc concentrates** during the war, and 300,000 tons for a period of nine years after the war. The annual production is about 400,000 tons, the balance being smelted in Australia or Japan. (P. 1068)

Saccharine is now being manufactured in Great Britain in amounts sufficient to meet domestic demands. (P. 1109)

In outlining the **dyestuff** situation in England before the House of Commons, Sir Arthur Stanley, President of the Government Board of Trade, announced that loans and grants for research work would be granted especially to those desiring to manufacture special dyes, of which not many are now being made. Plans are being considered for the amalgamation of the two largest manufacturers, *viz.*, British Dyes, Ltd., and Messrs. Levinstein, to be permanently under Government control. It is expected that importation of foreign dyestuffs will be controlled by rigid licenses for a period of ten years after the war. (P. 1148)

While the **castor bean** is not native to Japan, it is raised there to a certain extent and could be produced in large quantities if in sufficient demand. (P. 1158)

A long and detailed description is given of the history and development of the guayule **rubber** industry of Mexico and Texas. The rubber is found, not in a latex, but in the cell structure of the epidermis of the wild shrub. Experiments on cultivation of the shrub are promising. The rubber may be extracted by a number of processes, some mechanical and others chemical, as, *e. g.*, by heating under pressure with caustic solution, whereby the wood fiber is destroyed. The product obtained contains about 20 per cent of resin, removal of part of which improves the quality of the rubber. Exports of guayule rubber from Mexico in 1914–15 were nearly 6,000,000 lbs. (P. 1172)

Experiments in Scotland have shown that it is possible to produce satisfactory news **print paper** by using 35 per cent of sawdust pulp, 30 per cent of waste paper, and 35 per cent imported wood pulp. (P. 1229)

SPECIAL SUPPLEMENTS

FRANCE—5*b*
SWITZERLAND—17*a*
ARGENTINA—38*b*
ADEN—49*a*
CHINA—52*b*, *c*, *d*
JAPAN—55*a*
NEW ZEALAND—61*a*
PHILIPPINE ISLANDS—80*a*

EXPORTS TO THE UNITED STATES

FRANCE—Sup. 5*b*
Camphor
Cement
Drugs
Bone fertilizers
Optical glass
Glue
Hides
Lead
Colza oil
Filter paper
Flint pebbles
Potassium cyanide
Rubber
Artificial silk
Paper pulp
NEW ZEALAND—Sup. 61*a*
Copra
Kauri gum
Hides
Tallow
ARGENTINE—Sup. 38*b*
Bones
Quebracho extract
Casein
Guano
Hides
Rubber
SWITZERLAND—Sup. 17*a*
Aluminum
Asphalt
Chemicals
Aniline colors
Artificial indigo
Electric light carbons
Glue
Artificial silk

NEW PUBLICATIONS

By IRENE DEMATTY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Analysis: Laboratory Manual of Elemental Qualitative Chemical Analysis. A. R. BLISS, JR. 2nd Ed. 8vo. 194 pp. Price, $2.25. W. B. Saunders Co., Philadelphia.

Carbon and Alloy Tool Steels. LUDLUM STEEL CO. 12mo. 155 pp Price, $1.00. The Author, Watervliet, N. Y.

Case-Hardening; A Bibliography. CARNEGIE LIBRARY. 10 pp. Carnegie Library, Pittsburgh.

Chemistry: Cours de chimie. R. DE FORCRAND. 8vo. 438 pp. Price, 14 f. Gauthier-Villars et Cie, Paris.

Chemistry: A History of Chemistry. F. J. MOORE. 12 mo. 292 pp Price, $2.50. McGraw-Hill Co., New York.

Concrete Engineers' Handbook. G. A. HOOL AND OTHERS. 8vo 885 pp. Price, $5.00. McGraw-Hill Co., New York.

Engineers' Handbook. W. H. THORN AND SON. 2 vol. 8vo. 758 pp. Price, 21s. T. Reed & Co., London.

Engines and Boilers: How to Run Engines and Boilers; with a New Section on Water Tube Boilers. E. P. WATSON. 12mo 165 pp. Price, $1.00. Spon & Chamberlain, New York.

Glass and Glass Manufacture. (Amer. Ed.) PERCIVAL MARSON. 12mo. 127 pp. Price, $0.85. Sir Isaac Pitman & Sons, New York.

Gums and Resins. E. J. PARRY. 12mo. 106 pp. Price, $0.85. Sir Isaac Pitman & Sons, New York.

Heating and Ventilation. J. R. ALLEN AND J. H. WALKER. 8vo. 305 pp. Price, $3.00. McGraw-Hill Co., New York.

Market Prices Appearing Currently in Technical and Trade Journals. 8vo. 6 pp. Carnegie Library, Pittsburgh.

Metals: Les Métaux et leurs conditions d'emploi dans l'industrie moderne. J. OBERTLE. 8vo. 271 pp. Price, 10f. Protat frères, Paris.

Mineral Enterprise in China. W. F. COLLINS. 8vo. 307 pp. Price, 21s. William Heinemann, London.

Sand, Its Occurrence, Properties and Uses; A Bibliography. 8vo. 72 pp. Carnegie Library, Pittsburgh.

Sewerage; the Designing, Construction and Maintenance of Sewerage Systems. A. P. FOLWELL. 8th Ed. 8vo. 43 pp. Price, $3.00. John Wiley & Sons, Inc., New York.

Sulfuric Acid Handbook. T. J. SULLIVAN. 18mo. 239 pp. Price, $2.50. The McGraw-Hill Co., New York.

RECENT JOURNAL ARTICLES

Acid: The Two Systems of Acid Making. H. R. HEUER. *Paper*, Vol. 22 (1918), No. 18, pp. 33–34.

Alunite: Recently Recognized Alunite Deposits at Sulphur, Nevada. I. C. CLARK. *Engineering and Mining Journal*, Vol. 106 (1918), No. 4, pp. 159–162.

Aniline Dyes: The Importance of Aniline Dyes in Microscopical Work. A. O'CALLAGHAN. *Color Trade Journal*, Vol. 3 (1918), No. 2, pp. 272–274.

Artificial Color in Food Products. ALBERT BURGER. *Color Trade Journal*, Vol. 3 (1918), No. 2, pp. 282–285.

Belts: How Far Does a Belt Slip? W. F. SCHAPHORST. *Paper*, Vol. 22 (1918), No. 21, pp. 13–14.

Bleaching Powder: The Efficient Use of Bleaching Powder. E. R. DARLING. *Textile World Journal*, Vol. 54 (1918), No. 4, pp. 35–37.

Brick: Testing and Inspection of Refractory Brick. C. E. NESBITT AND M. L. BELL. **The Blast Furnace and Steel Plant**, Vol. 6 (1918), No. 8, pp. 341–345.

By-Product Coke Ovens: Methods for More Efficiently Utilizing Our Fuel Resources. E. B. ELLIOTT *General Electric Review*, Vol. 21 (1918), No. 7, pp. 467–480

By-Product Coke Oven Pressure Regulation. C. H. SMOOT. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 8, pp. 331–335.

Cascade Method of Froth Flotation. W. A. FAHRENWALD. *Mining and Scientific Press*, Vol. 117 (1918), No. 3, pp. 87–88.

Copper: The Maintenance of High Ampere Efficiency in Electrolytic Copper Refining. M. H. MERRISS AND M. A MOSHER. *Engineering and Mining Journal*, Vol. 106 (1918), No. 3, pp. 95–99.

Copper Tuyeres for Blast Furnaces. A. K. REESE. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 8, pp. 329–330.

Dehydrogenation of Petroleum Oils and Other Hydrocarbons. A. S RAMAGE. *The Canadian Chemical Journal*, Vol. 2 (1918), No. 8, pp. 192–195.

Deresination of Rubber. A. H. KING. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 3, pp. 141–145.

Destructive Distillation of Oil Shales. J. C. MORRELL AND G. EGLOFF. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 2, pp. 90–96

Dyeing of Cotton Khaki with Special Reference to the Iron and Chrome Process. L. J. MATOS. *Textile World Journal*, Vol. 54 (1918), No. 4, p. 39.

Dyestuffs: The Fastness of Dyestuffs to Light and Ultraviolet Exposure. E. W. PIERCE. *Color Trade Journal*, Vol. 3 (1918), No. 2, pp. 267–268.

Electric Furnace for Heat Treating. T. F. BAILY. *The American Drop Forger*, Vol. 4 (1918), No. 7, pp. 257–260.

Electrochemistry: Elements of Electrochemistry. JOSEPH HAAS, JR. *The Metal Industry*, Vol. 16 (1918), No. 7, pp. 315–316.

Engineering Profession Fifty Years Hence. J. A L. WADDELL. *The Scientific Monthly*, Vol. 7 (1918), No. 2, pp. 130–148.

Flax: Influence on Linseed Oil of the Source and Variety of Flax. FRANK RABAK. *Paint and Varnish Record*, Vol. 15 (1918), No. 1, pp. 18–19.

Flotation Apparatus, Their Design and Operation. A. W. FAHRENWALD. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 3, pp. 129–134.

Fuel Analysis of a Drop Forge Plant. B. K. READ. *The American Drop Forger*, Vol. 4 (1918), No. 7, pp. 268–270.

Gold: The Importance of Gold Production. LIONEL PHILLIPS. *Mining and Scientific Press*, Vol. 117 (1918), No. 5, pp. 158–160.

Groch Flotation Machine. F. O GROCH AND W. E. SIMPSON. *Mining and Scientific Press*, Vol. 117 (1918), No. 2, pp. 53–54.

Gypsum: Influence of Gypsum upon the Solubility of Potash in Soils. P. R. MCMILLER. *Journal of Agricultural Research*, Vol. 14 (1918), No. 1, pp. 61–66.

Illumination: Fundamental of Illumination Design. WARD HARRISON. *General Electric Review*, Vol. 21 (1918), No. 8, pp. 535–541.

Limonite Deposits in Porto Rico. C. R. FETTKE AND B. HUBBARD. *The Iron and Trade Review*, Vol. 63 (1918), No. 4, pp. 210–211.

Macquiston Tube Flotation Machine. C. T. RICE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 4, p. 163.

Margarine: Modern Methods of Crystallizing Margarine Emulsion. ALAN P. LEE. *The American Food Journal*, Vol. 13 (1918), No. 7, pp. 382–385.

Materials: Requirements in Treating of Materials. J. F. BEALE. *The American Drop Forger*, Vol. 4 (1918), No. 7, p. 283.

Melting Points and How to Take Them. LOUIS BORITZ. *Color Trade Journal*, Vol. 3 (1918), No. 2, pp. 271–272.

Metallography and Heat Treatment of Metals Used in Aeroplane Construction. F. GROTTS. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 3, pp. 121–128.

Metallurgy: Notes on Recent Metallurgical Progress. E. P. MATHEWSON. *Engineering and Mining Journal*, Vol. 106 (1918), No. 3, pp. 138–145.

Mining on the Rand. H. F. MARRIOTT. *Mining and Scientific Press*, Vol. 117 (1918), No. 3, pp. 77–86.

Paper: The Yellowing of Paper. A. B. HITCHINS. *Paper*, Vol. 22 (1918), No. 20, pp. 11–15.

Para-Amidophenol. SAMUEL WEIN. *Color Trade Journal*, Vol. 3 (1918), No. 2, pp. 287–289.

Paraffins: Boiling Points of the Paraffins. G. LEBAS. *The Chemical News*, Vol. 117 (1918), No. 3052, pp. 241–242.

Potash: The Estimation of Potash. BERTRAM BLOUNT. *The Chemical News*, Vol 117 (1918), No. 3052, pp. 242–244.

Pottery: Status of American Pottery Industry. A. V. BLEININGER. *Brick and Clay Record*, Vol. 53 (1918), No. 2, pp. 125–128.

Refractory Materials in Canada. N. B. DAVIS. *The Canadian Chemical Journal*, Vol. 2 (1918), No. 7, pp. 176–177.

Research and the Industries. P. G. NUTTING. *The Scientific Monthly*, Vol. 7 (1918), No. 2, pp. 149–157.

Ruth Flotation Machine. A. J. HOSKIN. *Mining and Scientific Press*, Vol. 117 (1918), No. 4, pp. 119–121.

Silicon Carbide Useful as a Resistor. W. S. SCOTT. *The Iron Trade Review*, Vol. 63 (1918), No. 4, p. 209.

Silver-Lead Smelter: Ideal Layout for Silver-Lead Smeltery. G. C. RIDDELL. *Engineering and Mining Journal*, Vol. 106 (1918), No. 3, pp. 115–122.

Spelter Statistics for 1917. W. R INGALLS. *Engineering and Mining Journal*, Vol. 106 (1918), No. 4, pp. 176–181.

Sulfite Coal. R. W. STREHLENERT. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 30, pp. 671–672.

Wood: The Use of Wood in Chemical Apparatus. A. W. SCHORGER. *Metallurgical and Chemical Engineering*, Vol. 18 (1918), No. 10, pp. 528–531.

Zinc: Research Preparedness in the Zinc Industry. P. C. CHOATE. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 1, pp. 20–22.

MARKET REPORT—AUGUST, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON AUGUST 17, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lbs.	4¾	@	5¼
Aluminum Sulfate, (iron free)	Lb.	3¾	@	4
Ammonium Carbonate, domestic	Lb.	nominal		
Ammonium Chloride, white	Lb.	20	@	22
Aqua Ammonia, 26°, drums	Lb.	nominal		
Arsenic, white	Lb.	9¼	@	17
Barium Chloride	Ton	65.00	@	70.00
Barium Nitrate	Lb.	12	@	14
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent	Lb.	2	@	3¼
Blue Vitriol	Lb.	9¼	@	9¾
Borax, crystals, in bags	Lb.	7¾	@	10¼
Boric Acid, powdered crystals	Lb.	7¾	@	8¾
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused	Ton	22.00	@	24.00
Caustic Soda, 76 per cent	100 Lbs.	4.15	@	
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	20.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	2.00	@	3.00
Green Vitriol, bulk	100 Lbs.	1.15	@	1.25
Hydrochloric Acid, commercial	Lb.	C. P. nominal		
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	nominal		
Lead Nitrate	Lb.	C. P. 85		
Litharge, American	Lb.	8	@	8½
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	21
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	7¾		
Nitric Acid, 42°	Lb.	8½		
Phosphoric Acid, 48/50%	Lb.	35	@	40
Phosphorus, yellow	Lb.	1.20	@	1.25
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate	Lb.	46	@	46½
Potassium Bromide, granular	Lb.	1.35	@	1.36
Potassium Carbonate, calcined, 80 @ 85%	Lb.	35	@	
Potassium Chlorate, crystals, spot	Lb.	40	@	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	78	@	80
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.	Lb.	1.50	@	2.00
Quicksilver, flask	75 Lbs.	125.00	@	130.00
Red Lead, American, dry	100 Lbs.	10.79	@	12.75
Salt Cake, glass makers'	Ton	25.00	@	30.00
Silver Nitrate	Oz.	62¼	@	65
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2¼	@	2.35
Sodium Acetate	Lb.	30		
Sodium Bicarbonate, domestic	100 Lbs.	3¼	@	3½
Sodium Bichromate	Lb.	24½	@	25½
Sodium Chlorate	Lb.	25	@	25½
Sodium Cyanide	Lb.	40	@	42
Sodium Fluoride, commercial	Lb.	17	@	18
Sodium Hyposulfite	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.12½	@	5.00
Sodium Silicate, liquid, 40° Bé		2¼	@	2¾
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal		
Sodium Bisulfite, powdered		6	@	7
Strontium Nitrate	Lb.	25	@	30
Sulfur	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé	Ton	18.00		
Sulfuric Acid, oleum (fuming)	Ton	32.00		
Talc, American white	Ton	15.00		
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	28	@	30
Tin Oxide	Lb.	nominal		
White Lead, American, dry	Lb.	9½	@	10½
Zinc Carbonate	Lb.	18	@	20
Zinc Chloride, commercial	Lb.	15	@	15½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	70	@	72
Acetic Acid, 56 per cent, in bbls	Lb.	10.76	@	10.77
Acetic Acid, glacial, 99½%	Lb.	19.50	@	19.70
Acetone, drums	Lb.	25½	@	25¾
Alcohol, denatured, 180 proof	Gal.	68	@	69
Alcohol, sugar cane, 188 proof	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined	Gal.	91½	@	92
Amyl Acetate	Gal.	5.30	@	5.35
Aniline Oil, drums extra	Lb.	28½	@	30
Benzoic Acid, ex-toluol	Lb.	2.65	@	2.85
Benzol, pure	Gal.	23	@	28
Camphor, refined in bulk, bbls	Lb.	1.16		
Carbolic Acid, U. S. P., crystals, drums	Lb.	43	@	46
Carbon Bisulfide	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals	Lb.	31	@	33
Chloroform	Lb.	70	@	75
Citric Acid, domestic, crystals	Lb.	82	@	83
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	24	@	25
Dextrine, corn (carloads, bags)	Lb.	8	@	9
Dextrine, imported potato	Lb.	nominal		
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	16¼	@	18
Glycerine, dynamite, drums extra	Lb.	62	@	64
Oxalic Acid, in casks	Lb.	41	@	43
Pyrogallic Acid, resublimed, bulk	Lb.	3.25	@	3.50
Salicylic Acid, U. S. P.	Lb.	88	@	90
Starch, cassava	Lb.	—		
Starch, corn (carloads, bags) pearl	100 Lbs.	6.50	@	7.00
Starch, potato, Japanese	Lb.	13¼	@	13½
Starch, rice	Lb.	12½	@	13
Starch, sago flour	Lb.	9½	@	10½
Starch, wheat	Lb.	nominal		
Tannic Acid, commercial	Lb.	65	@	80
Tartaric Acid, crystals	Lb.	85	@	93

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63	@	65
Black Mineral Oil, 29 gravity	Gal.	22	@	23
Castor Oil, No. 3	Lb.	33	@	34
Ceresin, yellow	Lb.	17	@	18
Corn Oil, crude	100 Lbs.	17.50	@	17.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	20.50	@	21.50
Menhaden Oil, crude (southern)	Gal.	1.00	@	1.10
Neat's-foot Oil, 20°	Gal.	3.45	@	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	9¾	@	10
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	10.95	@	11.00
Rosin Oil, first run	Gal.	60	@	65
Shellac, T. N.	Lb.	65	@	67
Spermaceti, cake	Lb.	32	@	34
Sperm Oil, bleached winter, 38°	Gal.	2.23	@	2.25
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	35	@	36
Turpentine, spirits of	Gal.	73	@	75

METALS

Aluminum, No. 1, ingots	Lb.	33	@	34
Antimony, ordinary	Lb.	13	@	13¼
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	26	@	
Copper, lake	Lb.	26	@	
Lead, N. Y.	Lb.	8.05		
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	95½		
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	20.00	@	24.00
Zinc, N. Y.		8.70	@	8.90

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	7.75	@	8.00
Blood, dried, f. o. b. Chicago	Unit	6.70	@	6.75
Bone, 3 and 50, ground, raw	Ton	37.00	@	40.00
Calcium Cyanamide	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.30	and	10c
Phosphate, acid, 16 per cent	Ton	16.00	@	17.00
Phosphate rock, f. o. b. mine:	Ton	nominal		
Florida land pebble, 68 per cent	Ton	3.50	@	3.75
Tennessee, 78–80 per cent	Ton	5.50	@	6.00
Potassium "muriate," basis 80 per cent	Ton	nominal		
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	8.65	@	8.70

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | OCTOBER 1, 1918 | No. 10

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD H. K. BENSON F. K. CAMERON B. C. HESSE A. D. LITTLE A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized July 13, 1918.

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

ANNUAL MEETING AMERICAN CHEMICAL SOCIETY:
- President's Address—A Retrospect and an Application. William H. Nichols ... 768
- Council Meeting ... 772
- General Meeting ... 774

CHEMISTS IN WARFARE:
- The American Chemist in Warfare. Charles L. Parsons 776
- The Work of the Chemical Section of the War Industries Board. Charles H. MacDowell ... 780
- War Disturbances and Peace Readjustments in the Chemical Industries. Grinnell Jones ... 783
- Chemical Warfare Research. Wilder D. Bancroft ... 785
- The Place of the University in Chemical War Work. E. W. Washburn ... 786

SYMPOSIUM ON CHEMISTRY OF DYESTUFFS:
- Introductory Remarks. R. Norris Shreve ... 789
- America's Progress in Dyestuffs Manufacturing. Louis Joseph Matos ... 790
- The Development of the Dyestuff Industry since 1914. J. F. Schoellkopf, Jr ... 792
- Application of Dyestuffs in Cotton Dyeing. J. Merritt Matthews ... 794
- Natural Dyestuffs—an Important Factor in the Dyestuff Situation. Edward S. Chapin ... 795
- The Manufacture, Use, and Newer Developments of the Natural Dyestuffs. C. R. Delaney ... 798
- Photographic Sensitizing Dyes: Their Synthesis and Absorption Spectra. Louis E. Wise and Elliot Q. Adams ... 801
- The Color Laboratory of the Bureau of Chemistry. H. D. Gibbs ... 802
- Problems in Testing Dyes and Intermediates. E. W. Pierce ... 803
- On the Quantitative Analysis of Dyestuffs. Alfred H. Halland ... 804

CHEMICAL MARKETS OF SOUTH AMERICA:
- Chemical Trade of Chile, Peru, and Bolivia. O. P. Hopkins ... 805

ORIGINAL PAPERS:
- Valuation of Raw Sugars. W. D. Horne ... 809
- On the Preparation of an Active Decolorizing Carbon from Kelp. F. W. Zerban and E. C. Freeland ... 812
- The Rôle of Oxidases and of Iron in the Color Changes of Sugar Cane Juice. F. W. Zerban ... 814

LABORATORY AND PLANT:
- Methods of Analysis Used in the Coal-Tar Industry. II—Distilled Tars and Pitches. J. M. Weiss ... 817
- A Convenient Electric Heater for Use in the Analytical Distillation of Gasoline. E. W. Dean ... 823

FOURTH NATIONAL EXPOSITION OF CHEMICAL ENGINEERS:
- Permanent Chemical Independence. Charles H. Herty. 826
- The Exposition in War and in Peace. F. J. Tone ... 828
- The Importance of Practical Chemistry. G. W. Thompson ... 829
- Development in Nitric Acid Manufacture in the United States since 1914. E. J. Pranke ... 830
- Recovery of Potash from Kelp. C. A. Higgins ... 832
- Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation. Linn Bradley ... 834
- Potash from Desert Lakes and Alunite. J. W. Hornsey. 838
- Potash from Searles Lake. Alfred de Ropp, Jr ... 839
- Recent Developments in Ceramics. A. V. Bleininger ... 844
- Carborundum Refractories. S. C. Linbarger ... 847
- The Pyrophoric Alloy Industry. Alcan Hirsch ... 849
- The Ferro-Alloys. J. W. Richards ... 851
- Advances in Industrial Organic Chemistry since the Beginning of the War. Samuel P. Sadtler ... 854
- Solvents from Kelp. C. A. Higgins ... 858
- Wood Waste as a Source of Ethyl Alcohol. G. H. Tomlinson ... 859

CURRENT INDUSTRIAL NEWS:
- Iron and Steel Industry in Japan; Goods in Demand in Australia; Jute Production in China; Cranes and Transporters; Natural Indigo Industry; Refractory Material from Bauxite; Substitute for Shellac; Electricity in Silk Industry; Vegetable Oils in Japan; Aluminum; A New Heat Insulator ... 861

SCIENTIFIC SOCIETIES:
- Fifty-Sixth Meeting, American Chemical Society, Cleveland, September 9 to 13, 1918; Communication from United States Shipping Board; Committee on Organic Accelerators, Rubber Section, American Chemical Society; Division of Industrial Chemists and Chemical Engineers; Fall Meeting, American Electrochemical Society, September 30–October 2, 1918 ... 863

NOTES AND CORRESPONDENCE:
- Platinum Regulations; Platinum Wanted by the Government; Two Letters on Reproducing Beilstein's Handbuch der Organischen Chemie; Library for Edgewood Arsenal Laboratory; Ordnance Department, School of Explosives Manufacture, Columbia University; Chemistry for Soldiers in Training Camps; The Emblem of the American Chemical Society ... 866

WASHINGTON LETTER ... 870
PERSONAL NOTES ... 871
INDUSTRIAL NOTES ... 872
GOVERNMENT PUBLICATIONS ... 873
NEW PUBLICATIONS ... 875
MARKET REPORT ... 876

ANNUAL MEETING AMERICAN CHEMICAL SOCIETY

PRESIDENT'S ADDRESS

A RETROSPECT AND AN APPLICATION

By William H. Nichols

I happen to be one of the few men now living who can look back to the very beginning of the American Chemical Society, a little more than forty-two years ago. On an occasion like this, it is unavoidable that my thoughts should travel backward to those earlier and simpler days when it was a great question as to whether such a society could be formed and, if formed, whether it could be supported and produce results which would be worth while. As you know so well, it was the outcome of a suggestion of a lady who, with other chemists, had gathered at the grave of Priestley to bear silent witness to their appreciation of what that early spirit had contributed to the cause of chemistry.

The first meeting for organization was held on the evening of April 6, 1876, at the rooms of the New York College of Pharmacy in New York University building, Washington Square, since demolished and rebuilt. There were present thirty-five gentlemen, and letters of regret were received from four who approved of the object of the gathering. As might have been expected, Professor Chandler was elected Chairman of the meeting, and that brilliant man, Dr. Walz, long since passed away, recorded. In the report which he presented he said:

"A list of chemists in this city and vicinity was first made out, and though it was by no means complete, we found to our astonishment that there were nearly, if not quite, 100 chemists in this neighborhood who might properly be admitted as members of this Society."

Compare that with the present membership of the New York Section alone!

At this meeting every one was invited to speak frankly and freely, and several of our most distinguished chemists expressed the view that it was not opportune to found a chemical society at that time, although they all agreed that at some future time it would be desirable to do so. The Chairman remarked that it would almost seem as though we had met for the purpose of deciding not to organize a chemical society, and asked for further expression of opinion. The result you all know, and the American Chemical Society was launched on that evening, a constitution and by-laws adopted, and a committee appointed to nominate officers for the society. The committee reported the same evening, nominating my old preceptor, Dr. John W. Draper, that great chemist with so many attainments besides chemistry, for president, and a splendid list of vice presidents and other officers was provided. Fortunately, Dr. Draper accepted the nomination and thus became the first president of what was to become the greatest chemical society of the world. Before this result was reached, there was no division of opinion as to the wisdom of commencing at that time, and those whose objection had been most strenuous became ardent supporters and so remained.

Dr. Draper's inaugural address, which was delivered on November 16, 1876, in Chickering Hall, with a large public attendance, was a very noteworthy paper. After a few congratulatory remarks he said:

"Let us consider some of the reasons which would lead us to expect success, not only for our own, but also for other kindred societies. The field of nature is ever widening before us; the harvest is becoming more abundant and tempting, the reapers are more numerous. Each year the produce that is garnered exceeds that of the preceding. Perhaps then, you will listen without impatience for a few minutes this evening to one of the laborers who has taken part in the toil of the generation now finishing its work, who looks back not without a sentiment of pride on what that generation has done, who points out to you the duties and rewards that are awaiting you, and welcomes you to your task."

Certainly an exordium full of wisdom and prophetic vision!

The first meeting for which papers were announced was held on May 4, 1876. The first paper was by Dr. H. Endemann on "The Determination of the Relative Effectiveness of Disinfectants." It is interesting to read that

"The discussion closed at a late hour on which account the papers of Mr. P. Casamajor and I. Walz were laid over till the next meeting."

Imagine what would happen at a Section meeting today if every paper should receive similar consideration.

These early meetings of the Society were simple and, of course, there was only one Section. Intermediate meetings, or *conversaziones*, as we called them, of a less formal character were held at which various matters of interest were discussed in conjunction with beer and sandwiches and much good feeling and mutual respect engendered. I do not believe that one of the chemists who attended these early meetings had the faintest conception of what would be the outcome of the enterprise. Chemistry in those days was not considered a vital matter, as it is to-day, and the chemist himself was usually a somewhat humble member of some manufacturing staff, when he was not a professor in a college. To-day we have a membership of 12,000, still growing rapidly, and the profession is recognized as being of such great importance that it is secondary to none, and in the minds of many it assumes the first place. I believe that in the future it will be generally conceded that the chemist represents the most important of all the sciences, and that on him will depend to an increasing extent not only the welfare of the world but possibly the very lives of its inhabitants.

Looking back into that past, which is after all not so far away, we note that many things were unknown which, during the interval, have become so well known that many of my younger hearers would suppose that they have always been part of human knowledge. Take, for instance, the transportation of sulfuric acid in bulk: I can remember well when the only means of transportation of this vital material was in carboys with occasional use of drums, which were always a source of trouble. I remember the discussion with Dr. Herreshoff as to why it should be practicable to store and ship this material in bulk; and when the decision

was finally reached to make the attempt, the first container was an iron cylinder made to stand pressure and placed upon a barge, and which would hold about 50 tons of product. With great difficulty, one small oil refiner was induced to provide a storage tank of steel and receive the acid in this way, but for one whole year it was impossible to secure a second customer because of the belief that the acid would not only destroy the container but would itself become weak and unfit for oil refining. In these days when the greater part of sulfuric acid is transported in this way, by boat and car, not only for moderate distances but across the continent, it is hard for any of us to believe that so short a time ago its possibility was unknown. I do not need to enlarge upon the effects of this simple invention to show what an effect it has had upon the industries of the world.

I can also remember when, with the exception of one or two attempts, which were not successful, pyrite was not used in this country. To-day, while the subject of pyrites is so prominently before the minds of everybody from the President down, it seems hard to believe that so few years ago, comparatively, its successful use was unknown here. It had been used abroad, and it was from England that we obtained the first men to operate the first kilns that were erected here, for the reason that no one of our small staff knew how to burn it or to teach others. We all know now that millions of tons per annum are burned in this country in the production of sulfuric acid, not including zinc and copper ores in the treatment of which sulfur is a by-product.

I also remember when lead burning was such a secret that its *modus operandi* was known to a very limited circle. The first set of lead chambers I ever constructed were according to the design of a French engineer who, in addition to performing his supervising duties, undertook to teach me lead burning. I am happy to say I proved a moderately good pupil and found that of all the trades probably none was more easily learned or offered better pay. I think it is safe to say that in a very few months any man with a mechanical turn of mind can master all the intricacies of the trade, and I have always wondered why more young men did not take it up. It is vital in all chemical engineering, and offers an occupation which is far more interesting in itself, on account of its variety, than almost any other trade.

Forty years ago the copper industry in this country was a comparatively small affair. If we except the production of the Lake companies, whose ore had been refined by nature to a considerable degree of purity, the output was small, and owing to impurities, of not much value except for certain casting purposes. Most of it found its way to Wales, where it was refined after a fashion, the precious metals remaining as impurities. No accurate and reliable method of analysis was in use, and differences in results led to considerable confusion. A correct analytical method was demanded by the producers in the West, who first saw its absolute necessity as a foundation of a large industry. The electrolytic method of assaying, while practiced sporadically in certain laboratories, had made no headway as a basic method which could be absolutely relied on. I was present when this was worked out and given to the copper industries as a solution to the difficulties of their business. It did not occur to the chemist who worked it to completion that if one could deposit a gram of copper by electric current, he could just as well deposit a ton or a thousand tons. It was this last application of the discovery which evolved into the great electrolytic copper industry, which not only provides the purest copper that the world has seen, but also makes available all the precious metals which up to its introduction had been wasted, and which since have amounted to hundreds of millions of dollars. It is fortunate for the world that this analytical method was worked out, for in addition to many other uses it made possible the great electric industry, and who can say what that has meant in the development of the arts of peace and war?

Of course, there are many instances of facts which to-day are known to everyone, which forty years ago were entirely unknown, but I will not tire you by adding to the list. Forty years is not a long time in the history of the world, but it has been an age in the development of chemistry. As knowledge begets knowledge unfailingly, it is bewildering to contemplate what the next forty years will add to the knowledge of the chemists, who will be filling our places, applying what has been learned and searching out into the limitless expanse of the still unknown. Every step up the hill the view expands, but the horizon ever retreats.

Much has been written, particularly of late, on the progress of chemistry, and I am rather of the opinion that instead of searching for subjects where so many able men have preceded him, the President of this Society in his annual address should be required to give a résumé of the work and accomplishments of the past year. In the absence of this rule, however, I have been warned to keep away from that subject on the ground that it has already been sufficiently covered. Be that as it may, so much has come under my observation during the past few years, of accomplishments made absolutely necessary by new conditions, that I stand in wonder as I see how fully and admirably the American chemist has grasped the problems as they were presented, and promptly solved them, in many cases better than they have ever been solved before. It seems to have been the fashion to belittle the work we have done in the past and to apologize for it. It is great pleasure for me to say here that apologies are uncalled for and explanations can be seen in the results, which are more conclusive than arguments. For example, a great dye industry has been brought up from the foundation and is serving our textile trade with efficiency in spite of the slimy propaganda which tries to implant the impression that what has been done here may answer for a temporary affair, but that by and by we will get back the good old German dyes on which we can rely. This propaganda is treasonable. All that the dye industry needs is intelligent legislation and a sympathetic public. The brains and

the materials are here in abundance. We may not have had time to work out all of the delicate shades which the ladies in peace times admire for their evening toilettes, but we have got all the fundamentals that are necessary for a self-respecting nation and the frills will come later. This has been a great triumph and I take off my hat to the American chemists, and there are many of them, who have made it possible, through the faith and courage of American capital. The idea that they cannot go farther and do better than has ever been done before is unworthy, and everything that can be done to encourage the chemist in his work in this great field should be done. A little praise is a great stimulant. The American chemist has had altogether too little of it.

Another great work will soon be accomplished by the fixation of atmospheric nitrogen. What has been done on this side of the ocean is not in imitation of what has been done abroad. It has been worked out from the foundation, and I believe it shows a great advance. It involves not only chemistry, but also engineering of the highest type, and no one has ever yet accused the American chemical engineer of being inferior to those of any other country. From a somewhat intimate knowledge of this branch of the field, I say with confidence that in chemical engineering this country stands comparison with any other in the world, and I can do so without fear.

I have alluded to only two great steps which have been taken, but of course there are hundreds of others, possibly not as startling, but still of the utmost moment and importance. In the quiet of his laboratory, the chemist has not been found wanting, although denied the stimulus of notoriety to spur him on.

Since the early days of the Society, to which I have thought it worth while to allude, its progress has been steady and even phenomenal. Naturally, this has been largely due to the great increase in the number of men who have entered the chemical profession, but for its success we are under everlasting obligations to the great men, early and late, who have done so much in its upbuilding. The Society started with the earnest and enthusiastic support of the best men of that day, and since that time it has been fortunate in keeping that class of men active in its councils; but even with these two advantages success could not have been attained if there had been serious disagreements or jealousies among those in charge of its affairs. During all these years we have been singularly free from that element of weakness, and it is by the intelligent coöperation of all these men that we find ourselves to-day in the enviable position we occupy. It is a brilliant example of unselfish coöperation, and I shall use that fact as my text in discussing briefly the importance of coöperation in other fields, with the full belief that by it alone can the tremendous world problems of the future be successfully met and overcome.

When considering the subject of coöperation, I think we must always have in mind the object which is sought to be attained. It is said that there are two kinds of microbes—friendly and unfriendly. In the same way there are at least two purposes of coöperation—one injurious, the other beneficial. There have always been a great many instances of the former variety; in fact, they probably largely outnumber the instances of the latter.

If the world is to progress and its people are to reach that stage which all well-wishers desire, these proportions must change and instances of coöperation for beneficial purposes must largely outnumber the other variety, when it will naturally follow that those examples which lead to injury will gradually become less effective and finally tend to disappear altogether. Unless properly attended to, the weeds in the garden become the most successful plants in it. So it is with the forces of evil in a community.

Any coöperative activity whose object is purely selfish must belong to the objectionable class. It may have many good points, but the object sought to be attained qualifies them all. You will readily recognize the existence to-day of many coöperative efforts, the object of which is to attain something for some man or set of men without regard to the general good. There are rings and pools and associations of one kind and another in which exceedingly intelligent work is being done, but which are all working against the general good. The law of coöperation applies here as elsewhere, but this is not the true coöperation which I am advocating. I simply allude to it so that it may not be left out of consideration.

I have in mind that class of coöperation which looks toward the general good, not only of a community, but of the nation and the world. It has made more headway within the last three or four years than in the century which preceded. It seems as if the terrible war forced upon the world by the house of Hohenzollern and its satellites was necessary to awaken the conscience of all civilized peoples. There can be no question that in general we in this country had been following after Mammon. We might just as well admit it without argument. Anyone who will take the trouble to read the history of this country in the last century cannot fail to note the tremendous energy necessary to make first the footing and afterwards the development of the unlimited resources which lay around us everywhere. A long series of battles with nature was followed by such great success that it was comparatively easy for a man of large intellect to grasp, with or without pure motives, a way to acquire a large share of the wealth produced. Where the motives were not the best I fear it frequently happened that large fortunes were built up at the expense of others. Whether that be true or not, it naturally resulted in what is known as the capitalist class, as differentiated from the others, workers with hands or brains, or ordinary consumers. This made it easy to implant in the minds of wage earners the idea that they must organize in order to secure their share of the results, and more if possible. Like nearly all such movements, the selfish idea was apt to predominate on both sides and the result has been a species of warfare between capital and labor, which is not only unwise, but unnecessary and enormously expensive. It must be clear to everyone that without a leader an army is

lost. It is equally clear that the best leader without an army is of not much value. Coöperation, therefore, between the leaders and the army is absolutely essential before we can consider ourselves on the high road to that success which our abundant resources make possible.

At this point it would be well to look briefly at the meaning of the word "Success." A common idea is that it means the acquisition of money or other property and that these are the only counters. I believe that we will have to change our views in regard to this matter before we can embark on that campaign of coöperation which is so essential. If instead of the acquisition of something tangible it is understood that the making of all that is possible in character is our goal, we will find that the successful man is the man who has made the most of himself and that money or title or any such thing have little real value in the case. They are simply incidents. Some of the finest men I have ever known are simple, honest workers, and some of the poorest specimens I have come in contact with are among those who consider that they have made most of themselves because they have acquired a large amount of property when the opportunities offered. Now, making the most of one's self, which is the aim in view, the matter of industrial coöperation becomes much simplified if everyone does the best he can to acquire character and that success which goes with it. The capital and labor question will then solve itself. All men are not born equal, in spite of the well-known statement to the contrary. Some have greater natural ability or better constitutions than others and some have opportunities to make the most of them which others do not possess. The rights of both are alike, of course, and in any event, the coöperation of all, whether highly endowed or with small opportunities, is absolutely essential for the proper development of the future. All this may sound Utopian and unlikely of accomplishment, but I am of the opinion that the best outcome for the individual, as well as for the country, will not be reached until the large majority are working together from the highest motives. High aim is necessary for a long trajectory.

This is a democracy and those who rule over us are men of our own selection. We get exactly the class of government that we deserve, and if it does not suit us for any reason, we have no one to blame but ourselves. Why should it not be possible for this coöperation, to which I have alluded, to extend so that it includes both the Government and the people? I do not mean it in the way that the German Government calls coöperation with the people, because that did not have the right end in view. It was extremely efficient and helped enormously in the bringing of Germany to the front as a manufacturing nation, but the object was selfish and nothing more nor less than was expressed by the motto "Deutschland über alles." The kind of coöperation which we should have from our Government is assistance in every way possible in building up the kind of success to which I have alluded. Instead of looking on manufacturers as probable criminals, they must be regarded as associates whose success is of the greatest importance to the state. There are signs that this idea is being considered in Washington and I pray that this will result in friendly coöperation for all rather than in an effort to discourage intelligent initiative and to put difficulties in the way of those, both leaders and followers, who are struggling to build up the true greatness of our country.

The great world war, while probably not nearly ended, will some day be concluded and the cause of liberty and decency will surely triumph. When that time comes and the menace which has been hanging over the world for many years shall have finally and completely been destroyed, what is to prevent the widening of the scope of coöperation so that instead of applying it to single countries it should apply to the whole world? There is absolutely no reason whatever why there should be any jealousy or enmity among nations, if we once kill the greed for conquest which has been festering so long in the German heart. Every country has its own good qualities and every nation has certain forms of ability different from those possessed by any other. Why should it be beyond the range of possibility that all of these various peoples should coöperate for the general good of the whole world with the full knowledge and belief that what is good for the whole world will be good for every nationality in it. There is no necessity for attempting to make all in one mold. This cannot be done, and it would not be desirable if it were possible. Variety is a good thing. Let us take the best of every one of the peoples of the world and work with it in earnest coöperation so that we will extract the most we can of happiness and good out of our whole planet. The man in Kansas who was not afraid of the anticipated bombardment of our coast because the guns did not have long enough range to reach him, has, I hope, long since learned that "No man lives for himself alone" and that damage to the coast means damage to Kansas. Why is it not equally true, although in a somewhat different sense, that the tragedies in Armenia and Belgium and Poland and Russia are felt in every part of the world?

I am not endeavoring to sermonize. I began by calling attention to the great success of our Society due largely to coöperation of the right kind. I never saw any instance in it of anyone trying to feather his own nest. All the work which has come to my observation has been done from high motives and the result is worthy of all that has been done. I have taken the opportunity to call one force to your attention which I consider absolutely essential to the successful development of our civilization. There are thousands of applications and you can make them for yourselves. As chemists we are seekers after truth. We realize it would be the height of folly to distort facts. We have seen wonderful things happen in the last generation, and those who are to follow us a generation hence will see far greater.

Is it not probable that our first president had a vision of this universal coöperation when he concluded his inaugural address in these words:

"Let us continue our labor unobtrusively, conscious of the integrity of our motives, conscious of the portentous change

which is taking place in the thought of the world, conscious of the irresistible power which is behind us! Let us not return railing for railing, but above all, let us deliver unflinchingly to others the truths that Nature has delivered to us!

The book of Nature! shall not we chemists, and all our brother students, whether they be naturalists, astronomers, mathematicians, geologists, shall we not all humbly and earnestly read it? Nature, the mother of us all, has inscribed her unfading, her eternal record on the canopy of the skies, she has put it all around us on the platform of the earth! No man can tamper with it, no man can interpolate or falsify it for his own ends. She does not command us what to do, nor order us what to think. She only invites us to look around. For those who reject her she has in reserve no revenges, no social ostracism, no *index expurgatorius, no auto da fé!* To those who in purity of spirit worship in her heaven-pavilioned temple, she offers her guidance to that cloudy shrine in which Truth sits enthroned, 'dark with the excess of light!' Thither are repairing, not driven by tyranny, but of their own accord, increasing crowds from all countries of the earth, conscious that whatever their dissensions of opinion may heretofore have been, in her presence they will find intellectual concord and unity."

COUNCIL MEETING

In spite of the manifold activities of chemists in connection with war problems the 56th Meeting of the AMERICAN CHEMICAL SOCIETY, held at Cleveland, Ohio, September 9 to 13, 1918, was considered by all to have been one of the most helpful meetings held in recent years. Naturally, war topics were predominant.

The general meetings and the meetings of divisions were held in the Hotel Statler, the complete registration for the sessions showing a total of 586 members present. A unique tone was given to the meeting by the presence of so many of the members in Army uniform.

At the opening of the Council Meeting, held in the rooms of the University Club on Monday afternoon, Secretary Parsons read a letter from President William H. Nichols, expressing his regret at being unable to attend the meeting, because of an accident which now confines him to his room. A message of greeting and regret at his absence was telegraphed to Dr. Nichols. Telegrams of greeting were forwarded, by vote of the Council, to Dr. T. J. Parker, absent through illness, and to former President Edward W. Morley, who was prevented from attending by illness in his family.

By rising vote the Council in silence paid tribute to the memory of the late former President, John H. Long, and a committee was appointed to draft appropriate resolutions.

A communication was read from Chairman Edward N. Hurley of the United States Shipping Board, which was ordered printed in THIS JOURNAL,[1] and the President was requested to appoint a Committee on Merchant Marine. Dr. Nichols has named the following, the committee to elect its own chairman:

DR. L. H. BAEKELAND, Yonkers, New York
MR. WM. HOSKINS, Room 3009, 111 W. Monroe St., Chicago, Ill.
MR. WM. J. MATHESON, 21 Burling Slip, New York
MR. C. W. MERRILL, 121 Second Street, San Francisco, California
MR. H. S. MINER, Welsbach Light Company, Gloucester, N. J.
MR. C. W. NICHOLS, Nichols Copper Company, 25 Broad St., N. Y.
MR. G. D. ROSENGARTEN, P. O. Box, 1625, Philadelphia, Pa.

The invitation from the Philadelphia Section to hold the annual meeting of 1919 at Philadelphia, was unanimously accepted. The question of holding a spring meeting in 1919 was referred to the Directors, but the Council recommended unanimously that no spring meeting be held if the war is in progress at the time of making the necessary arrangements.

The petition of the American Defense Society to request President Wilson to suspend the publication of German newspapers was circulated informally for individual signatures, and the response was so great that extra sheets were needed to accommodate the names.

Much interest was attached to the reading, by the Secretary, of the Report of the Committee of the Rubber Section on the Poisonous Nature of Some Accelerators and Precautions Regarding their Use.[1]

All the editors and associate editors of the Society's publications were unanimously reëlected. Dr. M. C. Whitaker was unanimously reëlected a member of the Committee Advisory to the President.

The discussion of the platinum situation aroused much interest, and upon motion the following resolutions were unanimously adopted by rising vote:

WHEREAS, The Director of the U. S. Mint has, through the press, issued an appeal to citizens to relieve the shortage of platinum for munitions manufacture by contributions of platinum jewelry and scraps, either through sale to the Mint at the Government price or by gift to the Red Cross, and

WHEREAS, The Women's National League for the Conservation of Platinum, and particularly its President, Edith Taylor Spear, of Cambridge, Massachusetts, have through unremitting and intelligent efforts created a strong public sentiment in favor of the conservation of platinum for war purposes, and have by this patriotic service greatly aided the work of chemists and manufacturers of war munitions,

Be it Resolved, That we, the Council of the American Chemical Society, now assembled in Cleveland, Ohio, hereby express our deepest gratitude to the League and its President for their educative and patriotic work;

Be it also Resolved, That copies of this Resolution be spread upon the minutes of this meeting, be transmitted to the Women's League for the Conservation of Platinum, and be engrossed and presented to Mrs. Spear.

Following this action a committee consisting of Messrs. A. V. H. Mory, R. W. Neff, and C. H. Herty, *chairman*, was appointed to draft a memorandum to local sections giving the facts regarding the platinum question.

Upon motion it was recommended to the general meeting of the Society that the names of Walther Nernst, Wilhelm Ostwald, and Emil Fischer be stricken from the list of Honorary Members of the Society, as of date of August 1, 1914. A committee was appointed to draft a statement outlining the reasons which led to this action, and reported resolutions as follows:

WHEREAS, The behavior in war of the German people has dishonored them among the enlightened nations of the earth and proved them unfit to associate with civilized men and women, and

WHEREAS, Walther Nernst, Wilhelm Ostwald, and Emil Fischer have been actively associated with the German government and its people in their conduct and offenses, now therefore be it

Resolved, That the names of the said Nernst, Ostwald, and Fischer be dropped from the rolls as honorary members of the AMERICAN CHEMICAL SOCIETY, and

Resolved, That this act be construed to take effect as of August 1, 1914.

The report of the Committee on the Method of Nominating the President of the Society was adopted. Under the new procedure each local section is invited to communicate to the Secretary not later than October 15 of each year a name of any member of the

[1] Page 864, this issue

[1] For full report see page 865, this issue.

Society for consideration by the members at large in voting for nominations. The Secretary is directed to ascertain whether or not each person so suggested will accept in case of election. This list of suggestions will then be forwarded to the membership, and is to be considered simply in the nature of a suggestion. The names will be arranged alphabetically, with no indication of the section which proposed them.

The report of Chairman B. C. Hesse of the committee to coöperate with the Bureau of Foreign and Domestic Commerce in obtaining statistics on foreign commerce in chemicals was read and accepted, and a special vote of thanks given to Dr. Hesse for his able conduct of the work of this important committee. The report is as follows:

As Chairman of the AMERICAN CHEMICAL SOCIETY Committee to coöperate with the Bureau of Foreign and Domestic Commerce in obtaining statistics on foreign commerce in chemicals for the fiscal year 1913–14, and so to determine the extent of our chemical dependence, I beg to report that the work under Dr. E. R. Pickrell of the U. S. Appraisers' Stores of the Port of New York has progressed so far that the manuscript will be ready for the printer by December 1, 1918. The Bureau of Foreign and Domestic Commerce has now placed at Dr. Pickrell's disposal 24 persons; upwards of 20,000 invoices of imported chemicals have been segregated from a total of more than 500,000 general invoices from all the ports of entry (upwards of 100) in the United States, Alaska, and Insular Possessions, and these 20,000 invoices of chemicals are now being transcribed on individual item-cards at the rate of about 1000 invoices per day; these item-cards will then be suitably assembled and this assembly then transferred to manuscript form. The information thus to be given is as follows:

1—Name of chemical or material of or for chemical industry.

2—Total of pounds or other quantity units.

3—Total value.

4—Countries of origin, arranged in the order of their participation and showing the percentage of such participation.

This manuscript, which will probably deal with upwards of 4000 entries and will amount to about 300 pages, $4^1/_4'' \times 7^1/_4''$ of print, will be ready for the Government Printing Office not later than December 1, 1918; how long it will require to print cannot be foretold, but February 1, 1919, seems to be a reasonable date for its appearance; its cost to the public will probably be about 30 cents per copy.

This, therefore, concludes the work of this committee and I therefore request that it be discharged.

In the course of these activities I have made tentative plans for the elucidation of these statistics and for their periodical appearance in the future, but without definite commitments on the part of the AMERICAN CHEMICAL SOCIETY or of the various Government agencies consulted. These plans are all based upon preparation by the AMERICAN CHEMICAL SOCIETY of an analysis of these 4000, or thereabout, entries, showing for the manufactured and semi-manufactured articles the raw materials, mineral, vegetable, and animal, and the approximate quantities of each entering into their production. The Geological Survey will then prepare a succinct statement as to the location and production of the mineral raw materials and Dr. Carl Alsberg, Chief of the Bureau of Chemistry of the Department of Agriculture, has offered to enlist that Department's coöperation through its various bureaus for similar treatment of the vegetable and animal raw materials. The Tariff Commission has been approached for its coöperation in listing the industrial and commercial uses of each of these 4000 entries, with prospects not hopeless.

With such a compilation, as an appendix to the statistics now approaching completion, it should be possible dependably and rapidly to ascertain for any manufactured or semi-manufactured product the amounts imported, what raw materials and their amounts were needed, what uses it has in the arts and also, for any given raw material, information as to what finished or semi-finished products made from it were imported, their industrial uses, and the respective amounts of all and each. Domestic production of raw materials for chemical industry, semi-finished and finished chemical products should be greatly stimulated and its growth intelligently directed through such a compilation, the successful making of which is beyond the strength of any one man or group of men as has been conclusively demonstrated by occasional abortive efforts abroad. I have also considered compiling information of similar scope and character for our exports and for our domestic production and have concluded that for the present, at least, such is not only unnecessary but without merit, for these would only confuse since they do not show the extent of our dependence.

I have every reason to believe that if the AMERICAN CHEMICAL SOCIETY will appoint a committee to make the analysis of this set of statistics now nearing completion as above outlined and this committee will coöperate in the preparation of the chapters to be built up on this analysis and those statistics, the effective and enthusiastic coöperation of the Geological Survey, the Department of Agriculture, and the Tariff Commission will be forthcoming.

In the course of the past 18 months I have discussed this matter most thoroughly with many persons and I believe that the AMERICAN CHEMICAL SOCIETY should appoint such a committee and further empower it to act as a "buffer-committee" or "clearing house" to receive all suggestions from the chemists of the country as to betterments or alterations for succeeding issues, if any; to consider all such, and then, at such times as the Bureau of Commerce may request, to transmit all such suggestions to that Bureau together with that committee's recommendations for appropriate incorporation into future editions or issues, if any.

I have further reached the conclusion that this committee should have an active, but *ex officio*, nucleus with power to add to its number not only from the AMERICAN CHEMICAL SOCIETY, but to invite coöperation of other societies. The nucleus I have in mind is

Chairman: Editor of the JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY or its successor publication of the AMERICAN CHEMICAL SOCIETY. Other members: Vice Presidents of the AMERICAN CHEMICAL SOCIETY. This committee might be designated "Committee on Import Statistics."

In summary, then, I suggest:

(*a*) that the present committee be discharged;

(*b*) that a new committee as above constituted and empowered be appointed;

(*c*) that corresponding action be taken by the council at the Cleveland Meeting of the AMERICAN CHEMICAL SOCIETY,

so that firm commitments can be entered into and discharged at once.

BERNHARD C. HESSE
August 29, 1918 *Chairman*

In pursuance of the recommendations contained in the above report the following motion was unanimously passed:

That a committee, to be known as the Committee on Import Statistics, be created; that it shall be composed of the Vice Presidents of the American Chemical Society and the Editor of the JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY, the latter to be Chairman of that committee; this committee to have power to add to its number and also to invite cooperation

of persons not members of the American Chemical Society and also the coöperation of societies other than the American Chemical Society; this committee to cause to be prepared suitable analysis of Federal Government statistics and to coöperate with the Bureau of Foreign and Domestic Commerce in the editing and publishing thereof, to solicit the aid of and to cooperate with other Governmental departments, bureaus, or commissions in further elucidation of those statistics, as well as the periodical or other publication of such information in such manner as may be agreeable to the Bureau of Foreign and Domestic Commerce or any of the Governmental branches that are coöperating, all of which to be along the general lines set forth in the report of the committee to coöperate with the Bureau of Foreign and Domestic Commerce in obtaining statistics on foreign commerce in chemicals for the fiscal year 1913–1914 and dated August 29, 1918.

At a subsequent meeting of the *ex-officio* members of this committee, the name of Dr. B. C. Hesse was added to the committee.

Lieutenant James Kendall made an interesting report of progress as chairman of the committee to consider with representatives of the English chemical societies, at their request, the question of the coöperative publication in the English language of comprehensive reference works on organic, inorganic, and physical chemistry. As Lieut. Kendall has returned to this country the work has been put in the hands of Dr. H. S. Taylor, *chairman*, Professors J. H. Donnan and H. B. Baker, and Dr. George Senter, members of the American Chemical Society resident in England, who will consult with members of the English societies and later report.

A hearty vote of thanks was passed for courtesies extended by the several local committees, the University Club, and all institutions and organizations which contributed to the entertainment of the visiting members.

On adjournment the Council was delightfully entertained at dinner at the University Club by the Cleveland Section.

GENERAL MEETING

On Tuesday morning the first general meeting was held in the ball room of the Hotel Statler. Professor A. W. Smith, Chairman of the Local General Committee, welcomed the members of the Society to Cleveland, calling attention to its increase in size and industrial importance since the earlier meeting of the Society there, and to its growing importance as a chemical center.

In the absence of President Nichols, Mr. H. S. Miner, Chairman of the Division of Industrial Chemists and Chemical Engineers and senior Vice President of the Society, presided, and responded on behalf of the Society as follows:

I feel that I owe the members of the American Chemical Society assembled here an explanation and apology. Dr. Nichols, whom you had expected to see in the chair to-day, is unable to be present on account of a serious and painful accident, and a telegraphic word of greeting has been sent him by the Council, with best wishes for a speedy and complete recovery.

The senior Chairman of Divisions must, under the Constitution, preside at the general meetings in the absence of the president. So I am here through no fault of mine. About a year ago I was elected vice chairman of a division, and through the resignation of Dr. William H. Walker upon his entry into the country's service, I was automatically promoted to the chairmanship.

Conventions are important and even necessary. It had been thought that possibly conventions should be dispensed with during the period of the war, but upon sober second thought it was considered that there was an even greater need for meetings of this character than in peace times. Possibly they should not be as frequent. The Spring Meeting was dispensed with, but this Annual Meeting certainly is important, and we are glad to see so many here at the opening session. We had feared that there might not be this large attendance, but the need of mutual aid and coöperation has never been as great as at the present time. We find it necessary to know each other better and more intimately; we find it to our advantage to know how we can help each other. This need of coöperation therefore seems to me to be the reason why we are gathered in such numbers, and I am glad to see that this spirit of coöperation is so strongly in evidence. A recent writer, speaking of the enemy, stated that his intelligence is highly developed along scientific lines, but that he is utterly devoid of spiritual coöperation. I am glad, therefore, that we are showing this spirit. The Society has been known in the past for its coöperative work, but we have now added to this the spirit and desire to coöperate not only with each other, but with our Government and its Allies for the benefit of humanity. Witness the many members of this Society who are now directly connected with the Government, and the many more who are indirectly, but no less effectively, aiding in the present crisis. And I wish to say that I believe that this is at a sacrifice, I nearly said a sacrifice of personal ambition, but ambitions are being shown in an entirely different direction. We are now anxious to know what we can do, how we can do it, and do it quickly and well.

We are glad to be here in this city to-day. We are glad to be entertained in a community that is noted for its civic pride, and especially in these days are we glad to be in a community that is doing so much for our country, and we appreciate the privilege of meeting these splendid men who are serving their country here. It is not easy for a local committee to arrange for a large gathering of this kind. We appreciate that the work has been arduous, but the splendid program and the many items of interest tell us how well this work has been carried out.

Secretary Parsons announced that Assistant Secretary of War Benedict Crowell was unable to leave Washington, speaking as follows:

I am sorry to have to present to you the regrets of the Acting Secretary of War, who is unable to be here this morning. We seem to have been entirely unfortunate, but "C'est la guerre." Dr. Nichols is unable to be present. When I saw Assistant Secretary Crowell he told me that Cleveland was his home city, that he had been a member of our Society for some years past, and that he would address us this morning. I knew he hoped and expected to be here, but as Secretary Baker was then on the water, he felt that he might have urgent duties there in Washington. I will read you his wire.

"Secretary Baker is in France and certain important matters must be acted on by War Department to-morrow. It will therefore be impossible for me to join you in Cleveland as planned. Very sorry.

BENEDICT CROWELL
Acting Secretary of War"

I am sure he is not sorrier than we are that he cannot be present, and I should like to add for the information of you all that Secretary Crowell has been from the outset very influential and very sympathetic toward the work which chemists can do to help win this war, and the organization owes a great deal to Secretary Crowell for the sympathetic attention he has given to the chemical needs of the War Department.



SCENE IN THE BALLROOM OF THE HOTEL STATLER ON TUESDAY NIGHT WHEN 423 DELEGATES, MEMBERS AND GUESTS DINED TOGETHER INFORMALLY

Before beginning the reading of the papers Secretary Parsons reported the resolutions from the Council recommending the striking from the list of Honorary Members of the Society the names of Professors Walther Nernst, Wilhelm Ostwald, and Emil Fischer. Upon motion the recommendation of the Council was adopted by unanimous vote.

By another unanimous vote the general session adopted the resolutions of appreciation of the work of the Women's National League for the Conservation of Platinum.

Great interest was manifested in the series of general papers bearing upon the various phases of the chemist's share in the war program. These papers are printed in full, pages 776 to 788, this issue.

At the afternoon session attention was given to the Symposium on the Chemistry of Dyestuffs, which had been arranged by Mr. R. Norris Shreve, who presided at the meeting. A report of the papers presented will be found, pages 789 to 805, this issue. In the informal discussion which followed the completion of the symposium the consensus of opinion seemed to point to the need of organization of a Dyestuff Section of the AMERICAN CHEMICAL SOCIETY, and immediate steps will be taken to this end.

In the evening an informal dinner was held in the same room in which the general meeting had been held, 423 members and guests being present. During the dinner a telegraphic toast was read from President Nichols: "The American chemist, first in war, first in peace, and first at the top and bottom of everything," which was received with much enthusiasm.

At the conclusion of the dinner the ladies departed for a theatre party tendered them, while the men remained for the complimentary smoker, which began with the singing of patriotic songs. During the evening addresses were made by Mr. T. S. Grasselli, Mr. H. H. Dow, Colonel G. A. Burrell, Dr. Charles L. Reese, Professor C. F. Mabery, Lt. Col. W. D. Bancroft, and Dr. Dayton C. Miller, Secretary of the American Physical Society.

Throughout Wednesday and Thursday divisional meetings were held, with large attendances and active discussions. The official program of each of the Divisions is printed in the Scientific Societies column of this issue. In the afternoons the members broke up into groups and visited the water filtration plants, the Cleveland iron and steel industries, the laboratories of Oberlin College, Western Reserve University, and the Case School of Applied Science.

On Wednesday evening the President's address, in the absence of President Nichols, was read by Dr. Charles H. Herty. Following the reading of the address an informal reception was held.

The members were delightfully entertained on Thursday at dinner by the Grasselli Chemical Company, at the Country Club on the Lake Shore, and in the evening a visit was made to the Cleveland Museum of Art, which was courteously opened to the members of the Society by its Director.

With the regular program completed, Friday was devoted to excursions to Akron, Ohio, where the plants of the Goodrich Rubber Co., the Knight Chemical Stoneware Works, and neighboring potteries were visited. Another Friday excursion consisted of a visit to Wadsworth, where the plants of the Ohio Brass Works, the Ohio Salt Works, and the Ohio Match Works were inspected, the latter company tendering a complimentary luncheon to the visitors.

As we look back upon the delightful week spent in Cleveland it seems clear that this meeting of the Society, held in the midst of such critical times, has been well worth while. It showed a harmonious working together of American chemists; it demonstrated the vigorous life of the AMERICAN CHEMICAL SOCIETY; it stimulated in all the determination to give to this country the utmost within the power of its chemists.

CHEMISTS IN WARFARE

Papers presented at the 56th Meeting of the AMERICAN CHEMICAL SOCIETY, Cleveland, September 10, 1918

THE AMERICAN CHEMIST IN WARFARE

By CHARLES L. PARSONS
Chairman, Committee on War Service for Chemists

It was the fortune of the writer in the latter part of 1916, a few months before the United States entered the war, to be sent by the Ordnance Department to study in England, France, Italy, Norway, and Sweden certain chemical processes, particularly those having to do with the fixation of nitrogen.

On this trip many chemical plants were visited. In all of them the same story was told of depleted chemical personnel owing to the loss of chemists in the trenches and the consequent handicap under which all of these plants were laboring in their attempts to furnish the armies with the sinews of war. The whole munitions program had been retarded owing to lack of technical men, chiefly chemists, and the statement was everywhere made that the greatest mistake that the Entente countries had made had been in giving too little attention to brain power and too much to physical strength. On the other hand, it was pointed out that Germany had carefully conserved her chemists for the development of the new and terrible forms of warfare she was forcing on mankind. Science was being used as it had never been used before, to aid a relentless power, and the only means of combating the new form of warfare was with its own weapons.

Already France, England, Italy, and Canada had withdrawn all chemists remaining in the service for chemical duty at home, but many had already been lost and their loss was seriously felt. France had drawn so far as possible on the chemists and engineers of Norway, and England drew on her colonies. Indeed, the chemist who perhaps more than any other in England is responsible for the success of England's munitions program is an American; and several English chemists who were living in America returned to England for chemical duty.

With this example in mind, the Director of the Bureau of Mines and the Secretary of the AMERICAN CHEMICAL SOCIETY called on the Director of the Council of National Defense, and after consulting with him, at his official request, undertook to obtain a census of American chemists for use in the war that was already imminent. This census was started in February 1917, and has been kept up uninterruptedly to the present time. By July 1917, some 15,000 chemists had sent in full data as to their address, age, place of birth, lineage, citizenship, dependents, institutions from which graduated, chemical experience, experience in foreign countries, affiliations with technical societies, military training, publications, research work performed, and other data of importance. The list has been continually added to, questionnaires being sent to every new name of a chemist that could be obtained. While the list is not complete, owing to the fact that some chemists, no matter how carefully followed up, will not reply to letters, nevertheless, the data are comprehensive and as complete as they can be made.

The cooperation between the Bureau of Mines and the AMERICAN CHEMICAL SOCIETY was perfect. The Bureau furnished its whole statistical force and the Society put special clerks at work. The data obtained were indexed and cross-indexed on some 28,000 cards. When America entered the war every chemist was directed to keep the Society informed as to his military status, and continual correspondence was carried on by the Society direct with officers and privates in order that the chemists of the country might serve the country in the best possible manner. To-day the list consists of some 17,000 filled out questionnaires, 12,020 membership cards of the AMERICAN CHEMICAL SOCIETY, and some 3,000 cards of *bona fide* chemists actually in war service, most of them in uniform. A card list is kept of officers and enlisted men who are graduate chemists in the United States Army in America; another list of those in France, including both those in chemical service and in the Army and Expeditionary Forces not yet transferred to chemical service, and another list of those in the Navy. It is believed these lists are reasonably complete and up to date.

This work has involved an expenditure of many thousands of dollars, the writing of over 10,000 personal letters, and the sending of over 50,000 circular communications to the chemists of the country.

Already in the early part of February 1917,[1] the President of the AMERICAN CHEMICAL SOCIETY, Dr. Julius Stieglitz, had offered without reservation the services of the members of the AMERICAN CHEMICAL SOCIETY to President Wilson in any emergency that might arise and had received an appreciative reply. On February 15, 1917, a similar communication was addressed, by direction of the President, by the Secretary of the Society to the Secretary of War; and on April 11, 1917, at the Kansas City meeting of the AMERICAN CHEMICAL SOCIETY, the following resolutions were passed, which were widely circulated, and had a profound effect on the mental attitude of American chemists:[2]

Resolved, That we reaffirm the tender to the President of the United States of the services of the members of our Society in all the fields in which we are qualified to act.

That the security and welfare of the country demand the organization of all the men and facilities of the United States, so as to insure the greatest possible service and value for each.

The progress of the war thus far principally teaches us that modern warfare makes extraordinary demands upon science, food supply, and finance.

For the protection and success of our men under arms we recommend the use, in their respective fields, of all trained chemists, physicists, and medical men, including advanced students of these subjects.

To this end, in collaboration with the United States Bureau of Mines, we are preparing a census of chemists. With no desire to avoid field service for men of training in the professions named, we urge that those of special ability be held to the work they can best perform. Thus we may avoid unnecessary loss from lack of control of the tools and requirements of war.

We hold that the use of platinum at this time in the production of articles of ornament is contrary to public welfare. Therefore, we recommend that an appeal be made to the women of the United States to discourage the use of platinum in jewelry and that all citizens be urged to avoid its use for jewelry, for photographic paper, and for any purpose whatever save in scientific research and in the making of articles for industrial need.

A committee consisting of Dr. W. H. Nichols, Dr. M. T. Bogert, Dr. A. A. Noyes, Dr. Julius Stieglitz, and Dr. C. L. Parsons had, in June 1917, drawn up and presented a report on "War Service of Chemists" and "A Plan for the Impressment of Chemists and for the Preservation of the Supply of Chemists."[3] Several important editorials by Dr. Chas. H. Herty and communications to the chemists of the country advising them as to their procedure had appeared in THIS JOURNAL, Vol. 9 (1917), pp. 332, 730, 826, 1085, and 1128; Vol. 10 (1918), pp. 2, 3, 95, 234, 235, 580.

That the wisdom of carefully listing the chemists of the country more than warranted the expenditure and effort has been apparent from the first. The war had scarcely begun when the growth of the Ordnance and other departments developed a tremendous demand for chemists, first to obtain chemical information from the other side, and soon to develop information on this side. A large part of the chemists now in war work were obtained and classified from this list. The offices of the Bureau of Mines and of the AMERICAN CHEMICAL SOCIETY were the scene of continual conferences regarding chemical personnel and the development of chemical warfare.

[1] THIS JOURNAL, **9** (1917), 224.
[2] *Ibid.*, 444.
[3] *Ibid.*, 639.

Practically all of the chemists who early entered the Ordnance Department in a commissioned capacity were either obtained through the AMERICAN CHEMICAL SOCIETY or passed upon by its officers. When the Bureau of Mines began its investigation on gas warfare the list was invaluable, and representatives from practically all of the bureaus and departments in Washington consulted it from time to time as their needs increased.

When the chemists were later drafted into the Army this census served as a basis for determining their qualifications, which later, through the far-sighted assistance of Assistant Secretary Crowell, resulted in chemists being withheld for chemical service.

From the first the chemical personnel of the Army and Navy and the civilian bureaus was partly civilian and partly military. As the war progressed the proportion of chemists in uniform naturally increased as the men were taken from the Army and assigned to chemical duty. The question is still a disputed one —to be settled probably only when the war is over—as to whether a chemist can serve best in a civilian or a military capacity. Certainly in both capacities the demand for chemists has been unprecedented and the development of chemistry in modern warfare to those in touch with the advancement made seems almost a fairy tale.

The first requirement for chemists in quantity in Washington was in connection with gas work organized by Director Van. H. Manning and carried on by the Bureau of Mines with its own funds until July 1917, after which, steadily increasing funds were furnished to it by the Army and Navy. The gas research work was located at the Bureau of Mines Experiment Station some 4 miles from the center of the city of Washington.

A branch laboratory of the Bureau of Mines was also established at the Catholic University, Washington, and other branch laboratories and coöperative research work carried on at such institutions as Johns Hopkins, Harvard, Yale, Princeton, Ohio State, Wisconsin, Washington, Kansas, Michigan, Columbia, Cornell, California, Rice Institute, Iowa State College, Bryn Mawr, Massachusetts Institute of Technology, Worcester Polytechnic, etc. Also special problems were undertaken by the National Carbon Company and the National Electric Lamp Association, as well as by chemists and laboratories of many of our other important chemical corporations.

One of the most interesting features of this work was the spirit shown by American chemists and the immediate response made by practically every chemist in America to the call to duty. The organization was rapidly built up and contained the names of the most prominent chemists in the country, as well as those of hundreds of young chemists who will later become prominent.

When this organization was taken over by the Chemical Warfare Service in June 1918, there were over 700 chemists at work on problems having to do with gas warfare, the design of gas masks, protection against toxic gases, development of new gases, and the working out of processes for those already used, the details of incendiary bombs, smoke funnels, smoke screens, smoke grenades, colored rockets, gas projectors and flame throwers, thermal methods for combating gas poison, gases for balloons, and other materials directly or indirectly connected with gas warfare.

This body of chemists reporting to Colonel G. A. Burrell had nearly 1100 helpers in the way of clerical force, electricians, glass blowers, engineers, mechanics, photographers, and laborers, so that when it became a part of the Chemical Warfare Service some 1800 persons were transferred, of whom over 700 were chemists—among them the leaders of the profession. At the same time the gas defense operations of the Medical Department under Colonel Bradley Dewey, consisting chiefly of the large scale manufacture of gas masks and gas mask chemicals, the gas offense proving grounds under Major William S. Bacon, and the gas defense training under Major J. H. Walton were also transferred to the new Chemical Warfare Service. The story has been told in detail in the September number of THIS JOURNAL and need not be repeated here.

Shortly after this work of the Bureau of Mines was begun the development of the Ordnance and Medical Department created an additional demand for chemists. The Chief of the Trench Warfare Section, Lt. Col. E. J. W. Ragsdale, early called for chemists to go to England and France in a commissioned capacity to obtain necessary information. Soon other chemists were required for the planning and building of gas plants and the manufacture of chemicals. The Trench Warfare Section continued this work in greatly increasing personnel until the early part of 1918, when the Chief of the newly formed Chemical Service Section was transferred to the Ordnance Department and given charge of the production of chemicals for gas warfare. A new arsenal known as Edgewood Arsenal was established for this purpose. Hundreds of chemists and engineers were employed, and the Arsenal had become almost a city in size, with enormous plants ready for operation, when it too was transferred from Ordnance to the newly organized Chemical Warfare Service, in June 1918.

It was a real epoch in the history of chemistry in warfare when, as a result of conferences held at the Bureau of Mines with officers from the Medical Corps, War College, General Staff, Navy, and civilian chemists, the Chemical Service Section was established as a unit of the National Army, with Lt. Col. Wm. H. Walker, formerly of Massachusetts Institute of Technology, as chief of the American branch reporting to Colonel Potter of the Gas Warfare Division, and Lt. Col. R. F. Bacon as chief of the Chemical Service Section in France reporting to Col. A. A. Fries, head of the Gas Warfare Division overseas.

This was the first recognition of chemistry as a separate branch of the military service in any country or any war.

Later, Col. Walker, as before stated, was transferred to the Ordnance Department, and was replaced by Lt. Col. M. T. Bogert. The latter was in charge of the American branch of the Chemical Service Section at the time this Section, together with all of the gas research laboratories and personnel of the Bureau of Mines, and the plant and field operations of the Ordnance and Medical Departments pertaining to gas warfare, were united under Major General William Sibert, under the new title of Chemical Warfare Service.

It cannot be brought out too strongly that the Chemical Service Section of the National Army was the first organized military body established for the sole purpose of relating chemistry to warfare. It took as an insignia the old alembic of alchemy joined with the theoretical benzene ring which has so greatly accelerated the development of modern chemistry. It further adopted for its colors those of the AMERICAN CHEMICAL SOCIETY—cobalt-blue and gold.

The Chemical Service Section was of very great service, especially in systematizing the regulations of the War Department in regard to chemical personnel, and the status of chemists was ably defined through its influence, in the Order of May 28, 1918. On account of its historical importance this Order is quoted here.[1]

1—Owing to the needs of the military service for a great many men trained in chemistry, it is considered most important that all enlisted men who are graduate chemists should be assigned to duty where their special knowledge and training can be fully utilized.

2—Enlisted chemists now in divisions serving in this country have been ordered transferred to the nearest depot brigade.

3—You will make careful inquiry into the number of graduate chemists now on duty in your command and report their names to this office. The report will include a statement as to their special qualifications for a particular class of chemical work, and whether they are now employed on chemical duties.

[1] THIS JOURNAL, **10** (1918), 580.

4—Enlisted graduate chemists now in depot brigades, or hereafter received by them, will be assigned to organizations or services by instructions issued from this office. The report called for in paragraph 3 herein will be submitted whenever men having qualifications for chemical duties are received by depot brigades, or replacement training camps, or by the training camps organized by the various staff corps.

5—Enlisted men who are graduate chemists will not be sent overseas, unless they are to be employed on chemical duties. Prior to the departure of their organization for overseas duties, they will be transferred to the nearest detachment or organization of their particular corps.

6—The Chief of the Chemical Service Section will be charged with the duty of listing all American graduate chemists, including those in the Army and those in civil life.

7—Whenever chemists are needed by one of the bureaus or staff corps, request will be made on the Chief of the Chemical Service Section for recommendation of a man having the qualifications necessary for the particular class of work for which he is desired. If men having chemical qualifications are wanted for only a short period of duty, they will be temporarily attached to the bureau or staff corps; where the duty is of a permanent nature, instructions covering their transfer will be issued. Whenever the chemists, thus attached or transferred, are no longer needed for purely chemical duties, a report will be made to the Chief of the Chemical Service Section in order that they may be assigned to chemical duties at other places.

By order of the Secretary of War
ROY A. HILL
Adjutant General

These regulations have since been enlarged so that at present chemists may be furloughed back from the Army to colleges for instruction purposes or to industrial works for essential chemical production. Students may be continued in chemical courses to meet the future need for chemists, and any chemists in the Army may be assigned to war work wherever needed. All this has been done not for the sake of the chemists but on account of the scarcity of trained chemists and the great need of the country for their services as chemists to help win the war. Without chemistry to-day the continuation of the war would be impossible.

A summary, necessarily brief, of the departments and bureaus utilizing chemists may be taken up in the following order:

I—ARMY

A—GENERAL STAFF

Executive Division, Chemical Warfare Service—This branch of the service established by General Order No. 62, already published in the chemical journals, is in command of Maj. Gen. William Sibert of the Engineers. It has, according to the Order above referred to, full charge of all phases of gas warfare, including research, manufacture, shell filling plants, and proving grounds. It also continued the functions of the Chemical Service Section with increased authority.

All newly drafted chemists are assigned to the Chemical Warfare Service to be detailed or transferred or furloughed where needed. It is charged with the "responsibility of providing chemists for all branches of the Government and assisting in the procuring of chemists for industries essential to the success of the war and Government."

It has an authorized personnel of 45,000, of which any portion may be chemists if needed. At present there are approximately 1400 graduate chemists in the Chemical Warfare Service. It is unnecessary at this time to speak fully regarding the personnel or work of the Service, as this has been published in some detail in the September issue of THIS JOURNAL.

B—ORDNANCE DEPARTMENT

(*a*) *Engineering Division, Explosives Section*—Under the direction of Col. J. P. Harris, this Division has 10 commissioned and 6 civilian chemists. This Section concerns itself with the solution of all engineering problems connected with propellants, the loading of high explosives into shells, trench warfare containers, primers, the research in high explosives, the investigation of explosives submitted for testing, efficiency of methods of manufacture, and the carrying out of tests for developing substitutes.

(*b*) *Procurement Division, Raw Materials Section*—The Chemical Branch of this Division under the direction of Maj. W. H. Gelshenen utilizes the services of 5 officers whose experience has been chiefly on the commercial side of chemical industry.

(*c*) *Inspection Division, Explosives Section*—The chemical work of this Division is under the direction of Maj. Geo. B. Frankforter, who has a personnel of somewhat more than 1000 chemists under his direction. Maj. Moses Gomberg is supervisor of special process work. The chemists are divided into three grades —"inspectors" who are responsible for all powders meeting specifications; "analytical chemists" who analyze and test all powders and report results to inspectors; "linemen" who are control chemists having charge of certain steps in the process of manufacture.

These chemists are employed throughout the United States at explosives plants, chiefly inspecting processes of manufacture and the finished product. The Section maintains an Officers' Training School at Carney's Point for training for inspection, testing, and process control of explosives. Graduates of the school are, in a few instances, commissioned; otherwise they are retained in a civilian capacity. There is a tendency to place all men in uniform as rapidly as possible. There has been such a demand for chemists that most of them have not finished the training before being given experience in the plants, so that they are obtaining their training and experience at the same time, with the expectation of returning to the school for more theoretical work before graduation.

The school at present has 150 chemists taking training with from 6 to 10 instructors. The training consists of an extensive review of organic and inorganic chemistry, chemical engineering, including mechanics and plant operations; also a review of physics and a special study of the chemistry of explosives both in the laboratory and in the plant. The school has good laboratory facilities and a school day of 10 hours. Civilians who are taken into the school are paid at the rate of $1500 to $2000 from the time they enter.

Recently a supervisory and control laboratory with 20 chemists has been established in Philadelphia for the purpose of making control analyses and investigating certain problems having to do with the inspection of explosives.

(*d*) *Inspection Division, Metallurgical Section*—This Division employs 79 chemists, 23 being in uniform. The work is in charge of Major A. E. White, and laboratories are maintained at 25 of the leading steel plants of the country, with the central control laboratories in the buildings of the Bureau of Mines at Pittsburgh. Also, two chemists are working in the laboratories of the Bureau of Standards for this branch of the service. With the exception of the central control laboratory and the work at Standards, the work of this section consists chiefly of the analyses and control of ferrous products.

(*e*) *Production Division: (1) Explosives Section; (2) Raw Materials Section*—This work is under the direction of Major E. Moxham, with Major C. F. Backus in charge of the Explosives Section and Major M. S. Falk in charge of the Raw Materials Section. The Section numbers among its personnel 18 chemists or chemical engineers engaged in executive and administrative work on the production of smokeless powder and high explosives. The Section has no laboratory facilities, the work accomplished being chiefly in facilitating increased production through specializing in the various works on manufacturing problems.

The Division has been concerned with the investigation of new processes for the production of raw materials, some of which have been put into operation, especially the production of toluene by the cracking of petroleum. The Raw Materials Section arranges for the production and distribution of raw materials, such as nitric acid, sulfuric acid, benzene, phenol, ammonia, and

sodium nitrate. Besides investigating new processes, the section studies increased production and distribution of supplies. For the main part the chemical personnel is on duty at various plants investigating production and processes.

(*f*) *Nitrate Division*—Colonel J. W. Joyes is in charge of this Division, with Lt. Col. A. H. White in charge of the Research Technical Section. The Nitrate Division was organized shortly after war began with the special duty of installing plants for the fixation of air nitrogen. It now has a personnel of 130 chemists and chemical engineers, enlisted and commissioned. It has only a few civilian chemists in its employ. It has coöperated with and received help from the laboratories of the Massachusetts Institute of Technology, the Geophysical Laboratory, the University of Michigan, the Bureau of Soils (Arlington), the Bureau of Standards and the Bureau of Mines. It has built extensive works at Sheffield, Alabama. It has a small experimental plant at the Georgetown Gas Works, and another at Greene, R. I. In coöperation with the Bureau of Mines, it carried on experiments on ammonia oxidation at Syracuse, N. Y., and at Warner's, N. J. The Division is one of the most important from the chemical development standpoint that has been established for war purposes. It has very large appropriations at its disposal and it has two nitrate plants in Ohio in preliminary stages of erection. It contemplates other activities in nitrogen fixation.

The Ordnance Department also runs four arsenals—Picatinny, Watertown, Frankford, and Rock Island—in all of which chemists are regularly employed. The number of chemists in the arsenals has been largely increased since the war began. No figures are at the moment available.

C—QUARTERMASTER'S CORPS

The chemical work of the Quartermaster's Corps involves the testing and analyses of materials, foods, leather, paper, etc., the making of specifications, and the control of materials to find if the specifications are complied with. The Corps has few chemists in uniform, as the work has been done chiefly in the laboratories of the Bureau of Chemistry.

The filtration plants at the various Government camps and cantonments are also under the control and direction of the Quartermaster General.

D—SURGEON GENERAL'S OFFICE

Food and Nutrition Division, Medical Department, Sanitary Corps—This division has 91 food and biological chemists who are in uniform. In each camp there is stationed one nutrition officer who is preferably a food expert with as much physiological, biological, and sanitary training as possible. His duty is to inspect all food, mess halls, refrigerators, etc., with the object of maintaining a high degree of sanitation. He has full authority to see to it that meat, for example, is destroyed if dropped upon the ground in hook worm territory; also any other food that could in any way injure the health of the men. There are 3 survey parties in the Sanitary Corps whose duties consist in going from camp to camp getting information regarding garbage and collecting data on nutrition problems. This is put in the form of curves in the Washington office. The work is part of an extensive nutritional study and is expected to give important results for future use as well as for present Army needs.

Research, with reference to the physical properties of various proteins, creatin, etc., is being carried on for the Corps in the laboratory at Cambridge under Dr. Henderson. Research relative to rope disease in bread, catalytic action in relation to yeast activity, etc., is progressing, from which valuable results are already in sight. At the Harriman Research Laboratory the special problem is meat spoilage. It is hoped it will be possible to detect incipient spoilage by chemical means. At the Bureau of Chemistry, Department of Agriculture, members of the Sanitary Corps are working on garbage research and making a survey of all food furnished to the various camps. An examination is made of all garbage cans in order to determine how much of the food finds its way into the stomachs of the men. This has resulted in a great saving of food material.

At the University of Rochester investigations have been made as to the effect of temperature in desiccated vegetables, as it is thought high temperatures used in desiccation may tend to induce certain diseases, such as scurvy, pellagra, beri beri, etc. A safe temperature is being studied. Independent investigations bearing upon the work of the Sanitary Corps are being carried out in the Bureau of Chemistry.

The Sanitary Corps maintains a school for the training of nutrition officers at Fort Oglethorpe, in connection with the Medical Officers' Training School. Men sent to this school are selected from the standpoint of training and experience in food and nutrition work, together with biological training. Frequently the men are commissioned before entering the school, if they have had sufficient training, although in certain instances privates have entered the school and been granted commissions later.

E—AIRCRAFT PRODUCTION

This Bureau now requires the services of 51 chemists in two sections. There is the Section of Chemical Research under Dr. H. D. Gibbs, who has 18 chemists (13 in uniform) engaged specifically in research problems, plant operations, study of new materials, chemical processes, methods of making new chemicals required in airplane construction, etc. Interesting studies are also being conducted on certain photographic sensitizing dyes to be used in airplane photography. This Bureau also maintains in Pittsburgh an inspection and control laboratory employing 33 chemists, 5 in uniform and 28 civilians. This laboratory has 60 technical men, of whom 30 are chemists. These chemists were afforded space in the Bureau of Standards until April 1, when they were removed to the home of the Pittsburgh Testing Laboratories, Pittsburgh, Pa. The work is in charge of Dr. H. T. Beans. The laboratory has general control of all products purchased by the Aircraft Production Board; it develops specifications for new materials and sends chemists into the plants to get the grades of materials wanted.

II—NAVY

The Navy also requires chemical aid in warfare, and at the present time has approximately 200 chemists engaged chiefly in control work and plant operation. Each of the Navy Yards has a control laboratory and the Ordnance Bureau has about 100 chemists, of whom approximately 20 are commissioned, 35 enlisted, and 50 civilian. These are utilized in much the same capacity as in the Army Ordnance.

From the first the Navy has immediately transferred to Chemical Service the names of all chemists enlisted in the Navy, where the names and qualifications have been made known to them. While of course the total number is small, the proportionate need has apparently been greater, for there are still several hundred graduate and experienced chemists and chemical engineers, both officers and men, in the Navy, a large proportion of whom have expressed their willingness to serve as chemists if needed, but who are still in the fighting branch or whose duties have no relation to chemical service.

III—CIVILIAN BUREAUS

The Bureau of Chemistry, the Forest Products Laboratory and other Bureaus of the Department of Agriculture, the chemical laboratories of the Bureau of Mines, Bureau of Standards, and of the Treasury Department have all coöperated with their full force in any war problems presented to them. Many of these problems have originated and been carried to a successful conclusion within the bureaus themselves. The civilian personnel of the bureaus has been depleted in almost every

instance by the war, but men have been assigned by the War Department to assist in war problems. For example, the Bureau of Standards at present has 70 men in uniform assigned to it from various branches of the Government. These are for the main part engaged on studies of new methods of analysis, research on analysis of special materials, analysis of Government supplies, and development of airplane dopes, and study of new and improved specifications on Government supplies. The studies of electroplating with reference to Government needs and the study of the physical characters of alloys have been taken up.

The truly extensive chemical work of the civilian bureaus and their relations to war work will be published in detail at some future time.

IV—COMMITTEE ON CHEMICALS. CHEMICAL ALLIANCE WAR INDUSTRIES BOARD

In the very early days of the war, the Committee on Chemicals, headed by Dr. Wm. H. Nichols, president of our Society, and consisting of the leaders of our chemical industries, gave unstinted and invaluable service to the Government in coördinating the country's chemical manufacturing resources, in increasing the output of our chemical plants, and in allocating and fixing prices to the Government of the finished product.

The value of these services cannot be over-stated, although comparatively little has been written about them.

When the various war committees of the Council of National Defense were discontinued and their functions absorbed by the War Industries Board, the Chemical Alliance was formed to serve as a clearing house of the chemical manufacturers in their dealings with the Government through the War Industries Board. It was organized primarily at the request of the Department of Commerce to assist in clearing up business questions in connection with the importation of pyrite, but later it became a regularly organized trade association, without any official Government connection, to which the War Industries Board can turn for expert advice.

Some of the directors at first were original members of the Committee on Chemicals, with Dr. Nichols as president. Later Dr. Nichols retired and Mr. Horace Bowker, vice president, was made president of the Alliance.

The War Industries Board has been active in the chemical field since its inception. It has well-organized committees to deal with chemical trade matters, especially with the allocating of material, fixing of prices, study of contracts, and a clearing of orders for both the Army and Navy.

V—NATIONAL RESEARCH COUNCIL

The National Research Council early organized a chemistry committee, of which Prof. M. T. Bogert was made chairman. When later Professor Bogert was appointed Lieutenant Colonel in the Chemical Service Section, Dr. John Johnston was put in charge of this work for the National Research Council, and continues in that capacity.

A meeting of prominent chemists takes place in Washington in the rooms of the National Research Council twice weekly, and the conferences serve as a clearing house of research work going on in Washington and in the country. The National Research Council has from the first served as a valuable feeder and intermediary on research between the universities and the Government. The Council has suggested and cleared many research problems both in this country and abroad.

VI—GEOPHYSICAL LABORATORY

The Geophysical Laboratory, under the direction of Dr. Arthur L. Day, has engaged in important war work since the beginning of the war. The developments which this laboratory have made in optical glass are well known and have had an important bearing on the war's progress. The laboratory has been assisting on the nitrate investigations and other problems. The high standing of its corps of chemists is well known to all members of our Society.

VII—THE WAR TRADE BOARD, SHIPPING BOARD, FOOD ADMINISTRATION, TARIFF COMMISSION

These important Government departments all require chemists and utilize chemists in a consulting and directing capacity.

The War Trade Board has as a member, Dr. Alonzo E. Taylor, who is assisted in passing upon chemical matters by Dr. A. S. Mitchell, Mr. B. M. Hendrix and Dr. R. P. Noble.

The chemical work of the Shipping Board has been under the direction of Dr. W. B. D. Penniman, who, while shutting off the importation of certain products, has helped produce excellent substitutes therefor.

The Food Administration has been guided in chemical matters chiefly by Dr. Alonzo E. Taylor and Mr. Charles W. Merrill.

The chemical work of the Tariff Commission is under the direction of Dr. Grinnell Jones, who this morning gives you a full description of the information being gathered by the Tariff Commission on chemical matters to guide it in its recommendations to Congress, both during and after the war.

. . . . . .

Many departments of the Government have been in constant communication with our Allies on research and industrial chemical matters. Chemical liason officers have been sent from the Army and Navy and some of the civilian bureaus to keep in touch with foreign development and practice, and their services have been invaluable. In this connection it should be particularly pointed out that not all of the development of chemistry in this country is our own accomplishment, for we have obtained information of the highest importance through the efforts of these liason officers. On the other hand, chemical information of the highest importance has been sent from America to Europe.

War, the destroyer, has been on the other hand the incentive to marvelous chemical development with a speed of accomplishment incomprehensible in normal times. Discoveries made in the search for instruments of destruction are already in use for the development of chemical industry. Many others, unpublished as yet, and to remain unpublished until the war is over, will prove of the utmost benefit to mankind. The same agencies that add to the horror of war to-day, the same reactions which are used in the development of explosives and poisonous gases on the one hand, and in counteracting their effect on the other, will find immediate and useful application in the years to come.

The war has been prolonged by chemistry. The German chemist, apparently working for years with war in view, has supplied the German armies with the means for their ruthless warfare, but the chemists of America and our Allies have met them fully in chemical development, and when the chemical story of the war is written where all can read, it will be the verdict of history that the chemists of America were not found wanting.

The chemical program of the United States Army and Navy has been at all times ahead of our trained man power and the mechanical devices necessary to apply what the chemists of America have produced.

THE WORK OF THE CHEMICAL SECTION OF THE WAR INDUSTRIES BOARD

By Charles H. MacDowell

Director, Chemicals Division, War Industries Board

Mr. Hoover says that Food will win the war. Mr. Garfield opines that Fuel will win the war Mr. Hurley knows that Ships will win the war. Mr. Raplogle thinks that Steel will win the war. After hearing Dr. Parsons' address I am sure you all feel that Chemicals will win the war. Of course it is the sum total of effort that will win the war.

The chemical industry is a war industry; the chemist, a war worker. Both the industry and the chemist have been contributing their facilities, education, training, and ability to defeat their enemies.

The German chemical industry has been the best advertised industry in the world. Its personnel has been charged with arrogating to itself the possession of most of the world's chemical ability, crediting but little of the sum total of chemical accomplishments to outsiders. This extreme claim of superknowledge and ability is disputed in many quarters, and it is even intimated that their chemical success has come more from their ability to exploit the ideas of the Anglo-Saxon and the Latin mind than from inherent chemical imagination and creative powers, and that much of their original work is the accomplishment of the Jewish rather than the Teutonic mind. Be that as it may, the Germans, through methodical work, aggressive trade exploitation, careful patent manipulation, and a clear chemical vision, have developed a war chemistry which has contributed enormously, through ruthless application, to their war success as far as they have achieved success.

Modern war calls for much that is useful in peace times. Agricultural chemistry in its development has contributed in no small way to the forging of the sword. Nitrogen compounds, sulfur, sulfuric acid, phosphorus, potash—all feeders of food and clothing crops—also feed the cannon, the trench grenade, the gas shell.

Germany, through developments of this industry, had it in reserve for use in carrying out her daring political and trade plans. Her development of by-product coking and aggressive maintenance of her dye monopoly covered the accumulation and a large immediate production of war chemicals. The development of her potash industry gave her large production of chlorine, bromine, and alkalies, and tied in closely with her government salt monopoly. Her work in ferro-alloys, as well as her manufacture and sale of armament, camouflaged a large production of special cannon, armor plate, and other steel products. Even in optical glass she had a substantial monopoly, and the more or less innocent snapshotter contributed to her war purposes. The Diesel engine, the efficient gasoline motor developed by automobile racing and readily adapted for aeroplane work, were both available for war use. Haber's nitrogen fixation method was developed and working, and connected with Ostwald's work, hastened the decision to go to it.

The Germans appreciated fully the significance of the old negro saying, "White man's lazy." They knew that it was easier for most folk to buy rather than to make, and they pitched their price to the end that they would make and others would buy. They did not, however, give full credit to the latent powers of other people and what others would do to keep from getting licked. The Allied world has found itself chemically, and has been happily surprised at its chemical ability. What has been done in chemical, scientific, and mechanical accomplishment will be of benefit long after the war is over.

When our country entered the fight, we were confronted with the necessity of starting a big business at the top—always a difficult task. We were credited with rather an unusual ability for organization, standardization, and "get together," and we had to draw heavily on this credit. War material is a substance and not a theory. Ore had to be dug and shipped. Machinery had to be built. Articles had to be made. Vision had to be enlarged. We were asking much of our peace-time war organization. Our immediate political accomplishments were remarkable as evidenced by the draft law, the marshalling of our man power. The American mind is a direct mind. It is too near pioneer days to be otherwise. It has, however, a peculiar conceit somewhat akin to that possessed by the young man who wants to find out for himself rather than follow his father's counsel. In some directions we were unwilling to accept British and French practices as a foundation and improve by experience. We thought we could do better than they to begin with, and lost valuable time in consequence. In organization we have had to get the round pegs into the round holes, and this has taken time. On the whole, our progress has been remarkable. Our public has naturally been impatient, not always fully appreciating the enormity of the task, and this impatience has at times tended to force premature action. On the whole, constructive criticism has been very beneficial. The public have responded promptly to all calls made on them for financial help, both for direct and indirect war purposes. The discipline of the country has been splendid and the people have responded willingly to every request calling for self-denial. The various scientific associations have answered quickly all calls, and their members have contributed largely, both in a military and civilian capacity, to the results which have been obtained.

It was the task of the Council of National Defense, and later of the War Industries Board, to marshal the industrial forces of the country and the raw materials of the world that we might assemble, manufacture, and distribute what was needed. At the start the call for raw materials was relatively small, as manufacturing facilities were not sufficient to make for large production; but as the months have gone by production has increased and with it the need for greater supplies. This demand, coupled with the growth of our military forces, has borne down hard on many industries which normally have their right to full production but which must now be more or less dislocated and reduced in output or converted to direct war manufacture. The War Industries Board is endeavoring to handle these questions with as little injury as possible to the industries. Sacrifice is called for on the part of industries as well as individuals. It has been a source of great satisfaction to the Board to note not only the willingness but the desire of the industries to assist in carrying out its work even though great sacrifice were entailed. All they needed was to have the problem clearly stated and to have an understanding of the necessities.

Before the formation of the War Industries Board, the Chemicals Committee of the Advisory Commission of the Council of National Defense, under the chairmanship of your president, Dr. Nichols, laid the foundation for much that has been accomplished. The chemical needs of the country were foreseen, and plans were laid for supplying them. When the Chemicals Committee was dissolved, along with other committees, the Chemicals and Explosives Division of the War Industries Board assumed in part the duties of the Chemicals Committee, the Chemical Alliance, Inc., as a war service committee representing in large part the chemical industry.

Mr. L. L. Summers, who had been acting in a technical advisory capacity for Messrs. Morgan and Company, of New York, on Allied buying, had come to Washington at the beginning of the war and was associated in a similar capacity with Mr. B. M. Baruch, now Chairman of the War Industries Board, Mr. Baruch at that time handling raw materials. Later Mr. M. F. Chase joined the ranks working on the explosives program. Your speaker was commandeered about the first of November, taking charge of nitrates and general chemicals.

At this time plans were arranged for the building of smokeless powder plants, nitrogen fixation plants, new by-product coke plants, gas-stripping plants, chlorine, and other needed facilities. Mr. Chase joined with Mr. D. C. Jackling, who acted as special agent in arranging for the erection of the smokeless powder plants. All of this work was done in coöperation with the War Department and the Navy. Dr. Marston T. Bogert joined the staff in November as its technical chemical adviser. In those days the organization was far from complete and every one acted as his own office boy; the hours were long and the work varied

Owing to the need of wood distillation products for aeroplanes, propellants, etc., the production of wood distillation plants throughout the United States was taken over and the product distributed. Platinum was also taken in hand. Arrangements were made for the international control of nitrate of soda and for its importation and distribution.

This is in part the early history of the Chemicals Division of the War Industries Board.

Mr. Baruch has been charged by President Wilson with the securing of new facilities for making war, with the conversion of existing facilities to war work, with the exercise of priorities, and has been termed the "official eye" of the Government to view the entire field of war needs and arrange for procurement. In carrying out this work as Chairman of the War Industries Board, which is no longer directly connected with the Council of Defense, he has continued as far as possible the organization existing at the time he took hold. The Board is composed of members, directors of divisions, chiefs of commodity sections, a Priorities Division, a Price Fixing Committee, a Conservation Division, and a Requirements Committee.

This latter committee meets each morning, its membership consisting of representatives of the Army, Navy, War Industries Board, Allied Buying Commission, Emergency Fleet, Fuel and Food Administrations, Department of Commerce, etc.

Present and future requirements for the different commodities handled by the War Industries Board are submitted from time to time and distributed to the various divisions and commodity sections handling the different commodities. In this way a reasonably correct idea of the present and future requirements is obtained. These are studied and from this suggestions are made as to the best method of procurement. If new facilities are required, the best way of obtaining them is studied and recommendations are made.

While the Price Fixing Committee of the War Industries Board fixes maximum prices on many products, the actual buying of material needed for war purposes is carried out by the various procurement divisions of the Army, Navy, Emergency Fleet, and so on.

The Conservation Division of the Board studies the possibilities of economies in industries, the substitution of more available materials for scarcer ones, the standardization of products as to packing, sizes, varieties of output, etc. It has frequent consultations with the industries before asking that their manufacturing procedure be modified in any way.

The Priorities Division studies the subject of preference in raw materials, supplies, machinery, finished articles, etc., issuing to manufacturers priority orders of different grades in accordance with the need for the article desired. The Priorities Committee has recently issued a list of certain industries entitled to priority in accordance with their importance to the war program; industries in this list carry an automatic priority according to their classification. Certain industries not listed in this general classification have priority as to specific plants. This classification will be changed from time to time as necessity dictates.

There has recently been organized a new Facilities Division, which passes on all new facilities from the standpoint of building materials, fuel, power, transportation, etc., after consultation with the different sections interested in these particular subjects. The Board has what is known as a "Clearance List." Where articles are in short supply or where special reasons exist for keeping a close control, clearance for purchase is secured by the various Government departments before finally closing contracts.

Before the Allied governments can negotiate for business, either for war purposes or for the use of their nations, clearance must be secured.

The line-up of the different divisions and sections follows generally the organization of the Chemicals Division, which I will describe briefly.

This Division at present has twenty commodity sections, each headed by a commodity chief. Your speaker is Director of the Division. Mr. Marsh F. Chase, after finishing his work with Mr. Jackling, returned to the Board and has become Director of Explosives. The following is a list of the Sections and commodity chiefs:

Alkalies and Chlorine Products	Mr. H. G. Carrell
Tanning Materials	Mr. E. J. Haley
Inedible Fats, Oils and Waxes	Mr. Prosser, Associate
Paints and Pigments	Mr. R. S. Hubbard
	Mr. Atwood, Associate
Acids and Heavy Chemicals	Mr. Albert Brunker
Sulfur, Pyrites, and Alcohol	Mr. Wm. Woolfolk
Coal-Gas Distillation Products	Mr. J. M. Moorehead
Creosote	Mr. Ira C. Darling
Artificial and Natural Dyes	Mr. J. F. Schoellkopf, Jr.
Fine Chemicals	Mr. A. G. Rosengarten
Refractories and Clays	Mr. Catlett
Ferro-Alloys	Mr. Hugh Sanford
Electrodes and Abrasives	Capt. DuBois
Chemical Glass and Stoneware	Mr. R. M. Torrence
Asbestos and Magnesia	Mr. R. M. Torrence
Wood Distillation Products	Mr. C. H. Conner
Platinum	Mr. C. H. Conner
Mica	Dr. Leith
Nitrates	Mr. C. H. MacDowell
Technical	.....

These sections work with the chairman and heads of the different sub-divisions of the Chemical Alliance, Inc. Officers of the Army and Navy, and representatives of the Emergency Fleet, Fuel, Food, and other administrative bodies, have been assigned to membership in these commodity sections. This personnel constitutes the section.

The technical staff of the Chemicals Division consists of Dr. E. R. Weidlein, Dr. H. R. Moody, Dr. Thomas P. McCutcheon, and Dr. Staley. These men keep in touch with the research facilities of the country and are in constant contact with manufacturers. The facilities of the Mellon Institute of Industrial Research are at the disposal of the Chemicals Division, and interesting work is being carried on at that Institute. Of necessity the work is of a secret nature, and cannot be discussed at this time.

A number of commodities handled by the commodity sections of the Chemicals Division are allocated by the chiefs of the sections, notably chlorine and its products, alkalies, sulfur and pyrite, wood chemicals, toluol, platinum, nitrates; and a control is exercised over the distribution of acids, electrodes, tanning material, and other commodities. The task is to secure in time the materials needed by the Government, by our Allies, and by our people.

Mr. Baruch has asked me to assure you that the War Industries Board appreciates fully the splendid coöperation which has been extended by the chemical industry and by the chemists to the solving of the problems of the Board and of the Government as a whole.

As we approach higher efficiency in the manufacture of war materials it will be necessary to restrict the production of many articles normally required by our people. There is not sufficient raw material, steel, power, labor, or transportation to take care of all industries.

In following out this maximum production program it may be necessary to ask the chemical industry to forego in part or in whole the manufacture of many less essential articles. The cause is worth the sacrifice, and Mr. Baruch feels sure that as an industry and as a personnel you all will understand the real reason for such curtailment, and that it will only be asked after careful study and with every desire to cripple industry as little as possible.

There is an old saying that "A little knowledge is a dangerous thing." The Germans, through their knowledge and through

their instinctive desire to make use of this knowledge to carry out an ambitious and brutal war program, have built a Frankenstein monster which bids fair to destroy them.

WAR DISTURBANCES AND PEACE READJUSTMENTS IN THE CHEMICAL INDUSTRIES

By Grinnell Jones

Chemist on the staff of United States Tariff Commission

When peace is restored the competitive strength of the nations in all industries will have been profoundly altered. Chemistry and machinery have played a larger part in this war than in any previous war, and therefore the greatest changes may be expected in the metal working and in the chemical industries. Moreover, our new American cargo ships will make us more than ever interested in foreign trade. The Tariff Commission is actively studying these war disturbances in order to assist in the readjustment and reconstruction that must follow when peace comes.

Among the chemical industries, the first to feel the stimulus of war was the explosives industry. The expansion of American smokeless powder plants was sufficient to prevent a German victory in France and Russia in 1915. It is not revealing military secrets to say that there has been some growth since 1915. We all hope that the peace terms will be so satisfactory that the military explosives plants themselves will no longer be needed. Nevertheless, there will be a permanent increase in the competitive strength of the American chemical industries through the growth of the subsidiary industries which now supply the raw materials to the explosives industry.

Our production of sulfuric acid is at least twice what it was before the war. The growth has been largely in contact acid, and therefore when the demand for explosives disappears, the American chemical industries will have available large supplies of pure and concentrated sulfuric acid. Moreover, the growth of the acid industry has been made possible by a great increase in the production of American sulfur and by a smaller, although significant, increase in the mining of pyrites.

The nitric acid industry has grown relatively more than the sulfuric acid industry. The output of nitric acid from Chilean niter is now more than ten times as great as it was before the war.

The significance of this growth of the sulfuric and the nitric acid industries to our dynamite, dyestuffs, and pyroxylin plastic industries need not be emphasized here.

Of greater significance than this stimulus to industries already well established has been the birth of new industries. We have a new synthetic ammonia and nitric acid industry. Plants have been built and, during the war at least, will be operated by the Government. When the full story of these plants can be told, it will reveal that American chemists have, under the pressure of war needs, been able to devise substantial improvements upon the Haber and Ostwald processes developed by the Germans before the war. These processes were the result of nearly two decades of work on these problems as a part of their military preparedness. It is not improbable that after the war nitric acid made from synthetic ammonia may prove to be cheaper than nitric acid made from Chilean niter. In any case, American agriculture will assuredly have a new large source of nitrogenous fertilizer materials.

In 1914 our production of crude light oil would have been sufficient for the production of only about 4,500,000 gallons of benzol and of about 1,500,000 gallons of toluol, and only a part of this was distilled. As is shown in our forthcoming report on the production of American dyes and coal-tar chemicals, in 1917 our output of benzol was 40,200,000 gallons, of toluol, 10,200,000 gallons. In 1918 further substantial growth is to be expected through the installation of stripping plants at city gas works. The toluol is now going almost entirely into explosives as is also a considerable fraction of the benzol. When the demand for explosives disappears, it is to be expected that the prices of benzol and toluol will drop to the point where it will be profitable to add them to gasoline for motor fuel. A similar condition will probably exist abroad and, since America has the greatest known natural resources for the production of gasoline, benzol and toluol should be as cheap or cheaper here than abroad. Therefore the industries consuming benzol and toluol may be assured of ample supplies of these materials at favorable prices.

Before the war we had no synthetic phenol industry, whereas in 1917, as is shown in our forthcoming report, 15 plants produced 64,146,499 lbs. of phenol valued at $23,715,805, most of which was used in making picric acid. If this new industry is to survive, there must be a greater consumption of phenol in the industries for peaceful purposes. Fortunately, phenol is used as an intermediate in the manufacture of some representatives of every class of finished coal-tar chemical products, including dyes and lakes, photographic developers, medicinals, flavors, perfume materials, synthetic resins, synthetic tanning materials, and explosives. Leaders in the chemical industries are already making plans for the industrial development of the uses of phenol when the phenol is no longer needed for explosives.

Another war-baby is monochlorbenzol, which was made during 1917 by eight American firms, with an output of 24,624,099 lbs., valued at a little less than $5,000,000. The dye industry will use a part of this productive capacity permanently, but new discoveries by American chemists will probably be needed to utilize the total productive capacity. Incidentally, this product furnishes a new outlet for chlorine, a new by-product source of muriatic acid, and raises a new problem in the utilization of dichlorbenzol, an unavoidable by-product.

Before the war there was but one producer of aniline oil in the United States. In 1917 there were twenty-three producers with an output of 28,806,524 lbs., valued at $6,758,535. As only a relatively small proportion of this substance goes into explosives, the peace readjustments will not be complicated by a collapse of a military demand, but will depend primarily on the competitive strength of the American industry.

The war has also stimulated the production of mercury for the manufacture of fulminates. The American production has been about doubled since the beginning of the war. Formerly we had a balance of imports—now we have a larger balance of exports.

Poison gas warfare is also destined to have a permanent influence on the chemical industries. Although there is no reason to expect that uses will be found for phosgene and mustard gas on a scale approaching the present and prospective military use, the plants erected for their manufacture need not prove a total loss when the military demand ceases. Nearly all of the noxious substances used in poison gas warfare require chlorine for their manufacture, and an increase in the production of chlorine in the United States is therefore certain. There is much hope that some of the substances produced as intermediate steps in the manufacture of the poison gases may be utilized for purposes other than warfare, but these are matters not yet to be discussed. Phosgene, except for the dangers attending its use, is an excellent reagent for many processes involving chlorination or dehydration and for making Michler's ketone. Fortunately, the risk in using phosgene is greatly minimized by the development of the new gas mask. The intensive work which hundreds of American chemists have been and are doing to improve the design of the gas mask will undoubtedly prove a blessing to workmen exposed to noxious fumes in chemical factories throughout the world when peace is restored.

Still another industry which has been stimulated by a direct war demand is the manufacture of acetone, which is used as a

gelatinizing agent in the manufacture of the explosive, cordite; as a solvent for airplane dopes; and in the manufacture of poison gases. Before the war, acetone was obtained entirely as one of the products of the wood distillation industry, but there are now at least four new processes in commercial operation in the United States or Canada for the manufacture of acetone.

It has been found that glucose can be fermented by a suitable organism to give acetone directly. Butyl alcohol is a by-product of this fermentation and becomes commercially available in appreciable amounts. The development of uses for butyl alcohol is an attractive problem.

The other processes for making acetone produce acetic acid or an acetate as an intermediate step, and may therefore permanently affect the acetic acid industry. The most obvious and perhaps the simplest of these processes depends on fermenting molasses to alcohol, which is then converted into acetic acid by the rapid vinegar process. The conversion of acetic acid into acetone is an old and well-known process but the details have been improved.

Another process depends on making acetylene from calcium carbide. By the aid of a suitable catalyst, the acetylene is made to combine with water yielding acetaldehyde which may be readily oxidized to acetic acid. Still another process depends on fermenting kelp under such conditions that sodium acetate and potassium salts are secured.

The war has stimulated the production of many other products, a few of which may be briefly mentioned: castor oil for lubricating airplane motors; phosphorus for incendiary bombs and smoke screens; barium and strontium nitrates for signal rockets. The output of soda ash has increased by 68 per cent since 1914, and the output of caustic soda has more than doubled.

New conditions in the chemical industries have also been created by the curtailment of imports. As a direct consequence of this stoppage of imports from Germany, a new American dye industry has been established. It is true that some dyes were being made in the United States before the war, but the makers relied on Germany for the necessary intermediates, with the exception of a small amount of aniline made here by a single producer. During 1917, 134 different intermediates were made by 118 firms. One firm made 53 different intermediates. Dyes were made by 81 firms. The total production of dyes in the United States during 1917 was approximately equal in gross weight to the annual importations before the war. The exports of American dyes exceeded in value, although not in quantity or variety, our imports before the war. The dye industry is not dependent on any imported raw material except sodium nitrate from Chile. Many important dyes are still lacking, but indigo and alizarin are now on the market in significant amounts, and the vat dyes for cotton derived from anthracene are coming.

A new potash industry has also arisen, but its future does not seem so promising as the future of the new dye industry. Here Germany has an inherent geological and geographical advantage. Although shipments from Germany ceased early in 1915 and although prices have advanced to about ten times the pre-war prices, the American production during 1917 was only about 13 per cent of our pre-war consumption. This relatively small production was obtained from many sources and by many processes. There is an excellent prospect that the recovery of potash as a by-product of cement will survive German competition and ultimately supply about one third of our needs. In addition, significant amounts will probably be secured as a by-product of the pig iron blast furnace. That the other branches of the potash industry can survive German competition is open to serious question.

Within a few months after the outbreak of the war, imports to the United States from Germany and her Allies came to an end. As the months went by, it became increasingly difficult to obtain cargo space for imports from any part of the world. Now the limiting factor in the American participation in the war is shipping for our troops and their supplies, and therefore ships are no longer free to seek the most profitable cargo and route, but are being assigned to routes and cargoes by the Shipping Board on the basis of military needs rather than profits. The Shipping Board has organized a Division of Planning and Statistics, which is making a study of world commerce and the military and civil requirements, for the purpose of utilizing available shipping in a way that will contribute most to the winning of the war. Military requirements make it essential that an abnormally large proportion of the world's shipping shall be used in the North Atlantic. This has made it necessary to curtail imports from other parts of the world to essential requirements.

The chemist on the staff of the Shipping Board is W. B. D. Penniman, of Baltimore. He must decide what chemicals need not be imported at all, and the amounts of others which must be imported to supply essential needs. The importance of this work can perhaps best be made clear by an example. The Shipping Board, after consultation with the Food Administration, decided that ships could not be spared for the importation of tapioca from Java and the Straits Settlements. The War Trade Board accordingly announced that licenses for the importation of tapioca would not be granted. Efforts were immediately made to secure a modification of this order on behalf of one of the manufacturers of nitro-starch for the Army and on behalf of manufacturers of mucilage for the Post-Office Department. Nitro-starch has been improved until it is now one of the safest of all explosives to handle and finds important military uses. Until a few months ago it was being made from tapioca. Penniman, however, succeeded in convincing the officers of the War Department and the manufacturers that a satisfactory product could be made from cornstarch. The details of the manufacture have been worked out coöperatively by the starch producers, the manufacturers of nitro-starch, and the experts of the War Department with such success that nitro-starch from corn is not only better but more economically produced than nitro-starch from tapioca. The Post-Office Department also readily agreed to use some locally available material instead of tapioca for mucilage on stamps. The shipping saved on this one item of tapioca for nitro-starch is sufficient to transport and sustain in France more than twenty-five thousand fighting men. Mr. Penniman's services to the nation on questions of this character deserve to be better known and appreciated. Imported materials for the time being should be used with the utmost economy and only for essential needs. American chemists can render valuable public service by finding substitutes for materials which must be imported from overseas.

It seems probable that many of the discoveries in regard to the use of substitutes for imported materials made under this pressure of war needs will prove of permanent value and have a permanent influence on international trade.

A third source of war disturbances in the chemical industry has been due to the diversion of materials from their customary use to war uses. The fertilizer industry has probably made the greatest sacrifices of this sort. Sodium nitrate and ammonia are required for the manufacture of explosives in such large quantities that the amounts left for use in fertilizers has been and will be much reduced. Raw phosphate rock has of course been plentiful but the acid used in the manufacture of acid phosphate has been largely diverted to making explosives. The relatively small supplies of potash have been very high in price and normal amounts have not been available at any price. The peace readjustments may, however, be expected to bring compensation to the fertilizer industry. Large new supplies of nitrogenous fertilizer materials will be available from the new nitrogen fixation plants. The new and enlarged sulfuric acid

plants must again find the chief outlet for their product in the making of fertilizers. Finally, the German monopoly of the potash market is likely to be broken through the French control of Alsace and the new developments in America and Spain. It is therefore reasonable to expect a large increase in the manufacture and use of fertilizers with a resulting benefit to all producers and consumers of food.

Chlorine also is likely to be diverted from its normal uses to the manufacture of poisonous gases to a considerable extent. In spite of the erection of new plants we may all be asked to use paper lacking in the whiteness to which we have been accustomed. Chemists in industries using chlorine should prepare to facilitate this diversion now, and plan to use more chlorine later when the military demand ceases.

It is evident that the *status quo ante* cannot be reëstablished in the chemical industries any more than it can be reëstablished in international relations. Peace will bring new conditions of international competition and radical readjustments in industry from a war basis to a peace basis.

The Tariff Commission is endeavoring to secure and have ready for immediate use all information likely to be helpful to Congress in determining the part which the tariff is to play in these readjustments. We desire information in regard to the industrial development and technical progress of industries throughout the world; in regard to the sources of their raw materials and the uses of their products; and in regard to any changes in conditions likely to have a permanent influence on costs of production or the competitive strength of industries here and abroad. The assistance and coöperation of manufacturers, importers, and consumers in the collection and interpretation of this information is desired.

CHEMICAL WARFARE RESEARCH

By Wilder D. Bancroft

Lieutenant Colonel, Chemical Warfare Service, U. S. A.

As Dr. Parsons has told you, the Bureau of Mines started a research laboratory in gas warfare about a year and a half ago. On July first that was taken over by the War Department, but the organization as it stands at present is practically the same as that developed by the Bureau of Mines. The outward signs of the change are that Major General Sibert is the official head instead of Mr. Manning, and that Mr. G. A. Burrell is now Colonel Burrell. On the other hand, Dr. E. P. Kohler, who had charge of all the offense problems, holds the same position in the new organization without having put on a uniform.

Instead of running over the various sections and outlining their duties, it seems to me that it would be a good deal more interesting, though perhaps less thorough, if I described the procedure in regard to any given war gas.

The term "war gas" is a flexible one. The substance may be a liquid, a solid, a vapor, or a true gas. However, it must have some pretty striking characteristics: it must be poisonous; or produce tears (lachrymatory); or must give rise to nausea, sneezing, or blisters; have a foul smell, though otherwise harmless; or be a smoke with obscuring powers. Of course it may have any or all of these properties combined. Under any of these circumstances we call it a war gas. It must also have certain other characteristics. It must be pretty good in its class. Nowadays no one would consider as a toxic substance anything which did not kill dogs in 30 min. at a concentration of 1 mg. per liter. It is that effective concentration which is overlooked by people who suggest new gases or methods of using old ones. In the case of lachrymatory substances they should be effective at concentrations as low as 0.01 mg. per liter. The best are much better than that.

Another determining factor in the use of any gas is the availability of raw materials. Where thousands of tons may be needed, there is no use in considering a substance of which the available output per year is a gram, a ton, or a hundred tons.

A good method of manufacture should be at hand. If the substance is good enough, it will be made by any method, however wasteful; but this is not true in most cases. I could cite an instance where a substance would be used if a good method of manufacture were available. The present method of making this substance is so wasteful that its good qualifications do not counterbalance the disadvantages, and it is not used either by our Allies or by ourselves.

A substance must be stable, or fairly stable. It must not polymerize rapidly, hydrolyze too rapidly, be too inflammable, or go to pieces on detonation. Our problem is different from that of the Allies because the Allies can use their material within 2 or 3 months after loading the shells, whereas in our case shell loading here must take place from 3 to 6 months before firing, and consequently our limits as to stability against polymerization must be more rigid than those of the British and French; and as a matter of fact the French are using certain substances which we shall not use, just because of those conditions.

How do we start with any given substance? We may take a substance already used by the Germans or the Allies, or we may get a suggestion from outside, or the staff may think up something from a search of the literature, from analogy, or from pure inspiration. Then steps are taken to see whether it can be considered as a toxic substance. First, the Offense Research Section, under Dr. Lauder Jones, makes the substance. If it is a solid, it is sent to the Dispersoid Division, Dr. R. C. Tolman in charge, and they work out methods of disintegrating it.

When this is done, or if it is a liquid or vapor, it is sent to the Toxicological Section, Dr. A. S. Loevenhart, and tested to determine degree of toxicity, concentration producing lachrymation, or any other of the delightful characteristics. If their report is favorable, the substance is turned over to a number of different sections.

The Offense Research Laboratory works to improve the laboratory method of making. After they have worked this out on a laboratory scale, the substance is turned over to the Chemical Production Section, Mr. W. S. Rowland, and they work it out on a larger scale, from 50 lbs. to a ton, depending entirely on the nature of the substance. It then goes outside of the Research Division, either to Large Scale Production (Colonel Dorsey) for further development, or direct to Colonel Walker, at Edgewood, for commercial production either there or to be assigned to some manufacturer somewhere in the country. While the Offense Research Section is working out an improved laboratory method, the substance is sent to the Analytical Section, under the charge of Mr. A. C. Fieldner. They develop methods for determining its purity. They also analyze mixtures in air. It is sometimes difficult to determine substances at the dilution in use. They also make tests to find out whether the canisters will stop the substance.

It is also sent to the Pyrotechnic Section under Mr. G. A. Richter to determine stability when fired in shells, that is, whether it goes to pieces under the detonating charge.

At the same time the Defense Research Section, under Dr. A. B. Lamb, is working to determine whether any change in the ingredients put in the canister is necessary. If the substance is not absorbed, some new mixture or compound must be developed which will stop it. This Section also takes up the question of methods of detecting toxic substances in the field. That might be considered to be a problem for the Analytical Section, but our whole system is pretty flexible, and as a matter of fact that work has been done by the Defense Research Section, of course working in coöperation with the Analytical Section.

The Defense Research Section also develops ointments to protect against the effect of the action of the toxic or blistering gases of the skin.

At the same time the substance will be referred to the Mechanical Research Section under Mr. Fogler, because a change in the ingredients may make it necessary to change the type of canister. That becomes important if dealing with smokes instead of vapors. The question of protective clothing may have to be taken up.

The defensive results are then transmitted by Dr. W. K. Lewis, in charge of all defense problems to the Gas Defense Division, which is not a part of our Division, but is under Colonel Dewey, and has charge of the commercial production of all defense materials.

While all this is being done, the same substance is sent to the Pharmacological Research Section under Dr. E. K. Marshall, and they study the question of the effect produced and the general question of susceptibility. Certain men may be 100 times as susceptible as are other men. It is very desirable to make preliminary tests, and to keep out of the factory men who are extremely susceptible, because they are sure to be casualties.

The substance is also studied by the Pathological Section under Dr. Winternitz, and they go into painful details as to the way in which the various organs are attacked by war gases.

At the same time it is sent to the Therapeutic Section under Dr. Underhill, of Yale, and they take up the desirable but very difficult task of finding methods of treatment to revive men who have been gassed more or less severely.

While all this is going on, all these various sections are making reports twice a month on all the substances that they are working with, so that you can see that there is an enormous amount of pseudo-literary material piling up. All of this material comes to the Editorial Section, of which I am in charge. We condense it as much as possible, and get out semi-monthly reports, which are sent to a selected list of people in this country and abroad. These reports deal with many different topics, and if someone wanted to look up about a certain substance he would have a fearful task ahead of him. Consequently, as fast as possible we are writing monographs on each particular gas, canister ingredient, etc., which shall contain everything that is known in the literature, everything that we have been able to get from the Allies or from captured German reports, and everything that has been done in this country. We hand out the desired monograph to the inquirer, and tell him to read it. Of course he does not do it, but the thing is indexed pretty thoroughly, and he can look over the various sections which interest him more particularly, and thereby post himself on what is known in regard to that substance in a relatively short time. In this way the information in our files is made fairly accessible.

Now this whole system of handling toxic substances is a very flexible one. Whenever necessary we increase or decrease the number of sections. At one time Dr. J. F. Norris was in charge of all the chemical research. That grew to be more than one man could possibly handle. The Offense Research was left under Dr. Norris, and the Defense Research was given to Dr. Lamb. Since other sections were interested in the offensive work, it became necessary to tie things together again, and Kohler was put in charge of all the problems of Offense.

We began with one Physiological Section. Now there are Pharmacological, Pathological, and Therapeutic Sections, and the Pharmacological Section has recently been subdivided into testing and research.

The Mechanical Work was split into two sections. When conditions changed, this work was put back into one section. Any section can be changed or rearranged in any way desirable to get results, and this has worked well in practice.

THE PLACE OF THE UNIVERSITY IN CHEMICAL WAR WORK

By E. W. Washburn

Vice Chairman, Division of Chemistry and Chemical Technology, National Research Council

In normal peace times, so far as chemistry is concerned, the university has two main functions, first, the training of chemists, and second, the prosecution of research in pure and applied chemistry. In war times these still remain the principal functions of the university, but as has happened in so many other cases, these two functions must be modified to accord with war needs, and it is on the subject of what these modifications should be that I wish to speak to you this morning.

THE TRAINING OF CHEMISTS

A few weeks ago the War Department's Committee on Education and Special Training requested the National Research Council to make an analysis of the Government's needs for chemists, and to make recommendations covering the steps which should be taken to provide as far as possible to supply these needs. In order to obtain the necessary data a questionnaire was sent to all Government agencies employing chemists, asking them to state the number of chemists, kind of training (*i. e.*, organic, metallurgical, etc.) desired, the increase in each of these classes of chemists which they estimated would be required during the coming year, and any changes in educational methods which they thought desirable in order properly to meet their needs.

From the answers received to this questionnaire the Research Council was able to determine approximately what the needs of the Government are with respect to the different kinds of chemists required. With regard to the number of chemists now in service in different Government departments, the data already given you by Dr. Parsons are in accord with those obtained as a result of the questionnaire referred to, and it will therefore be unnecessary to repeat these figures. As to future requirements, the data collected indicate that something over 2000 chemists will be needed by the Government during the next year in addition to the numbers now in service. These figures take no account of industrial requirements, but it is safe to say that the additional chemists required for necessary war industries will at least equal the number of those required by the Government. We may conclude, therefore, that something over 4000 additional chemists will be needed for necessary war work during the coming year. This number is considerably in excess of the normal output of the colleges, and we cannot hope to provide all of the chemists called for. The problem is, therefore, to make provision for training, as quickly as possible, the maximum number of chemists which the educational facilities of the country can take care of.

The source of supply of the additional chemists required by the Government and by the war industries will for the immediate future be those students in the Students' Army Training Corps who are preparing themselves for Chemical Warfare Service. While provision can be made in training camps for training the rank and file of certain other branches of the Army, this is not true in the case of Chemical Warfare Service. Most of the men in this service must be trained as chemists, and this training can be given them only at the colleges and universities.

The analysis of the Government requirements for chemists indicates that, in general, the chemists needed may, for purposes of consideration, be divided into three classes as follows:

1—Analytical chemists: that is, men who have received sufficient training in chemistry to enable them to carry out routine analytical work under direction.

2—Chemists with a good general training in all of the fundamental branches of the subject, and with some degree of further

instruction in one of the following: (*a*) physical chemistry, including electrochemistry and metallography; (*b*) organic chemistry, including the chemistry of explosives; (*c*) food and sanitary chemistry; (*d*) physiological chemistry; (*e*) chemical engineering, including ceramic engineering, petroleum, textile, rubber, leather, etc., technology, and metallurgy.

3—Chemists qualified to carry on research work intelligently in some one of the fields listed under Class 2.

Approximately one-third of the total number of chemists required will be in Class 1, and will be employed in routine analytical and control work.

The National Research Council, at the request of the War Department, has drawn up a set of recommendations embodying a 3 years' curriculum in chemistry and a 3 years' curriculum in chemical engineering, each curriculum being based upon a year composed of 4 terms of 12 weeks each. Under this scheme the first group of chemists required can be trained in one year, the second group in two years, and the third group in three years.

These curricula are intended for institutions having a unit of the Students' Army Training Corps organized in accordance with the following statement recently issued to the colleges of the United States.

The man-power bill pending in Congress definitely binds the country to the policy of consecrating its entire energy to the winning of the war as quickly as possible. It fixes the age limits as 18 to 45, both inclusive. It places the nation upon a war basis. The new military program, as outlined by the Secretary of War, calls for the increase of the Army by more than two million men by July 1, 1919. This will probably necessitate the mobilization of all physically-fit registrants under 21, within ten months from this date. With respect to students, since they are not to be made in any sense a deferred or favored class, this means that they will practically all be assigned to active service in the field by June 1919. The only exceptions will be certain students engaged in technical studies of military value, *e. g.*, medicine, engineering, and chemistry. Under these conditions it is obvious that schools and colleges for young men within the age limits of the new law cannot continue to operate as under peace conditions. Fundamental changes must be made in college and school practices in order to adapt them to effective service in this emergency.

The following statements outline the general plan under which the Students' Army Training Corps will operate under the changed conditions produced by the revision of the Selective Service Law:

1—All young men who were planning to go to school this fall should carry out their plans and do so. Each should go to the college of his choice, matriculate, and enter as a regular student. He will, of course, also register with his local board on the registration day set by the President. As soon as possible after registration day, probably on or about October first, opportunity will be given for all the regularly-enrolled students to be inducted into the Students' Army Training Corps at the schools where they are in attendance. Thus the Corps will be organized by voluntary induction under the Selective Service Act, instead of by enlistment as previously contemplated.

The student, by voluntary induction, becomes a soldier in the United States Army, uniformed, subject to military discipline, and with the pay of a private. They will simultaneously be placed on full active duty, and contracts will be made as soon as possible with the colleges for the housing, subsistence, and instruction of the student soldiers.

2—Officers, uniforms, rifles, and such other equipment as may be available will be furnished by the War Department, as previously announced.

3—The student-soldiers will be given military instruction under officers of the Army and will be kept under observation and test to determine their qualification as officer-candidates, and technical experts such as engineers, chemists, and doctors. After a certain period, the men will be selected according to their performance, and assigned to military duty in one of the following ways:

(*a*) He may be transferred to a central officers' training camp.
(*b*) He may be transferred to a non-commissioned officers' training school.

(*c*) He may be assigned to the school where he is enrolled for further intensive work in a specified line for a limited specified time.

(*d*) He may be assigned to the vocational training section of the Corps for technician training of military value.

(*e*) He may be transferred to a cantonment for duty with troops as a private.

4—Similar sorting and reassignment of the men will be made at periodical intervals, as the requirements of the service demand. It cannot now be definitely stated how long a particular student will remain at college. This will depend on the requirements of the mobilization and the age group to which he belongs. In order to keep the unit at adequate strength, men will be admitted from secondary schools or transferred from Depot Brigades as the need may require.

Students will ordinarily not be permitted to remain on duty in the college units after the majority of their fellow citizens of like age have been called to military service at camp. Exception to this rule will be made, as the needs of the service require it, in the case of technical and scientific students, who will be assigned for longer periods for intensive study in specialized fields.

5—No units of the Students' Army Training Corps will, for the present, be established at secondary schools, but it is hoped to provide at an early date for the extension of military instruction in such schools. The secondary schools are urged to intensify their instruction so that young men 17 and 18 years old may be qualified to enter college as promptly as possible.

6—There will be both a collegiate section and vocational section of the Students' Army Training Corps. Young men of draft age of grammar school education will be given opportunity to enter the vocational section of the Corps. At present about 27,500 men are called for this section each month. Application for voluntary induction into the vocational section should be made to the Local Board and an effort will be made to accommodate as many as possible of those who volunteer for this training.

Men in the vocational section will be rated and tested by the standard Army methods and those who are found to possess the requisite qualifications may be assigned for further training in the collegiate section.

7—In view of the comparatively short time during which most of the student-soldiers will remain in college and the exacting military duties awaiting them, academic instruction must necessarily be modified along lines of direct military value. The War Department will prescribe or suggest such modifications. The schedule of purely military instruction will not preclude effective academic work. It will vary to some extent in accordance with the type of academic instruction, *e. g.*, will be less in a medical school than in a college of liberal arts.

8—The primary purpose of the Students' Army Training Corps is to utilize the executive and teaching personnel and the physical equipment of the colleges to assist in the training of our new armies. This imposes great responsibilities on the colleges and at the same time creates an exceptional opportunity for service. The colleges are asked to devote the whole energy and educational power of the institution to the phases and lines of training desired by the Government. The problem is a new one and calls for inventiveness and adaptability as well as that spirit of coöperation which the colleges have already so abundantly shown.

From this statement it will be seen that the colleges are facing a variety of very difficult problems in making provision for the large number of students who will enter the Students' Army Training Corps. The president of one of the large western universities, in starting the plans for housing and feeding the large numbers of students which they expect to take care of, asked the supervising architect of the institution if he could make such provision in time for the institution to open on its regular date, which was about the middle of September. When the architect replied that it would be impossible, the president expressed his disappointment and reminded him that he had never before failed in a crisis. To this the architect replied: "Mr. President, this is not a crisis, it is a revolution; the crisis will come on the day the university opens."

I think this statement fairly expresses the conditions which the colleges and universities are facing. Under the new regula-

tions any properly equipped high school graduate may now enter the college of his choice. He will be provided with quarters, mess, light, heat, equipment, and free instruction, and will be paid $30 a month. Throughout the time he is in college he will be under strict military discipline. At the end of every 12 weeks his record will be scrutinized and if his work is in any way unsatisfactory, he will be immediately taken out of college and assigned elsewhere, probably in many cases to one of the cantonments. Former college students will find college life an entirely new proposition. Doubtless many of you have seen on the walls of fraternity houses such mottos as the following: "Never permit your studies to interfere with your regular college work." The student who follows any such motto as this under the new conditions will find himself neatly and with great despatch removed from his academic surroundings. Such customs as petitioning the Faculty for another trial, or for a special examination, and all other hallowed customs of this kind will pass out of existence. The student either makes good or he doesn't; he either passes or he fails. The lame duck species of college student is about to become extinct. The men who remain in college after the first 3 or 4 terms will be only those students who have displayed exceptional ability for some special line of training.

The statements received from the various Government agencies concerning desirable modifications in the training of chemists may be of some interest. As might be expected, all agencies of the Government emphasized the need of more thorough training in the fundamental branches of the science, that is, in inorganic, organic, and physical chemistry. In addition, certain special subjects were mentioned by a number of different Government agencies. For example, the various arsenals emphasized the need of more men well trained in metallurgy and metallography. The Navy Department pointed out that many of their men apparently had received no definite instruction in methods of using chemical literature or in proper methods for drawing up specifications. As might be expected, many branches of the Government also pointed out the need of special courses in the chemistry of explosives. Additional numbers of (1) pharmaceutical chemists were called for by the Bureau of Chemistry and by Chemical Warfare Service; (2) physiological chemists by the Surgeon General's Office and by Chemical Warfare Service; (3) food and sanitary chemists by the Surgeon General's Office and by the Bureau of Chemistry; (4) ceramic chemists by the Bureau of Standards and by the U. S. Fuel Administration.

RESEARCH ON WAR PROBLEMS

Under normal conditions every research laboratory is confronted with more problems than it can take care of. Since the war the personnel of many of the Government laboratories has been increased many fold, and it might be thought that with this greatly increased personnel these laboratories would be in a position to care for all of the problems which now exist. Such, however, is not the case. It is true that the Government now provides, as it must necessarily provide, for the investigation of all the larger and more urgent problems with which it is confronted, but nevertheless, most of the Government laboratories are overcrowded with work, and have trouble in securing certain classes of equipment and the services of sufficient numbers of adequately trained men. It is true that more men might be obtained if laboratory space could be provided for them, but such additional numbers could only be secured by further depletion of the staffs of educational institutions, and such action would result in completely shutting off the supply of chemists for the future.

Although the Government is providing in its own laboratories and under its own direct control for the investigation of the important research problems connected with the prosecution of the war, there are many important problems still unsolved or only partially solved. For example, many of the problems which the Government has had to solve have been problems connected with the production of some new material or the development of some new process to fill an urgent need. As soon as a material or process has been obtained which meets this need more or less satisfactorily the laboratory in charge has then found it necessary to transfer its attention to some other urgent problem. As a result there are many processes and materials which have received only that amount of study which was necessary to insure their operating sufficiently well to accomplish the desired end. In other words, output of *something which would do* has been the sole purpose and result of the research work. It thus happens that in many cases there has been no opportunity to ascertain just why certain things tried have worked, or why certain others have failed; or just why certain conditions seem to be more favorable than others; or just what occurs at this or that stage of the process; or why some other method might not give a higher yield or a better quality of material than the one which is actually employed because it has been found to work; or whether certain cheaper or better raw materials might not be available; or just what is the relation between factor *A* and factor *B* which enter into some part of the operation, etc., etc. There are indeed many auxiliary problems of this character which have arisen in connection with the research work, and which are worthy of the careful scientific study which they can receive only in some laboratory not working under the high pressure which prevails in many of the Government laboratories. This is where the universities may be of great service in supplementing and completing the research work of the Government.

In addition to supplementary problems of the kind just described, there are other problems, in the solution of which the research resources of the universities can be of great assistance. It frequently happens that a search of the literature demonstrates that the physical chemical or physiological properties of certain important materials are very inadequately known, the data in the literature being very fragmentary, or of doubtful accuracy, or both. The Government laboratories have neither the time nor, in many cases, the equipment for making the necessary measurements to secure the desired data. Here again many of the universities have exactly the equipment required and can secure the data desired.

It is hoped that the investigators of the country will be willing to lay aside for the present the lines of work in which they have been interested in the past, and to take up some war problem of a character which they can handle with the equipment and assistants at their disposal. The National Research Council is undertaking to secure as many of these problems as possible which are suitable for assignment to universities. It will also endeavor to secure from all available sources in Washington all of the unpublished information concerning the work which the Government has already carried out in connection with each problem, and to transmit such information to the investigator to whom the problem is assigned. Where special materials or chemicals are involved arrangements will also be made as far as possible for supplying such materials to the investigator. Many of these problems will be found suitable as thesis subjects for graduate students or for seniors in a chemistry curriculum.

If any investigator who is in a position to give a substantial part of his own time to work of this character or who has adequate assistance in the way of students or research assistants will make known to the National Research Council the facilities at his disposal and the nature of the problem (whether organic, physical, physiological, or analytical, etc.) which he prefers, the Council will endeavor as far as practicable and as soon as possible to submit to him through the authorities at his institution a war problem for investigation.

SYMPOSIUM ON CHEMISTRY OF DYESTUFFS

Papers presented at the 56th Meeting of the AMERICAN CHEMICAL SOCIETY, Cleveland, September 10, 1918*

INTRODUCTORY REMARKS

By R. NORRIS SHREVE, of the Calco Chemical Company

This Symposium on Dyestuff Chemistry has been arranged with the aim in view that such discussions will contribute to the complete establishment and full development of the dyestuff industry in America.

During the past few years, over which time the American chemists have become so much engaged with the problems connected with the chemistry of dyestuffs, it has been a foregone conclusion that sooner or later these chemists would naturally gather together for the mutual discussion and elucidation of their problems. I myself have always felt that such gatherings ought most appropriately to come within the fold of the AMERICAN CHEMICAL SOCIETY, and it is hoped that out of this Symposium there will arise a Section or Division of Dyestuff Chemistry that will meet at the regular gatherings of the AMERICAN CHEMICAL SOCIETY, and that this division or section will be active and helpful to this industry and to chemistry in general. My own feeling is that the contemplated Division of Dyestuff Chemistry should include not only the coal-tar dyes but also the naturally occurring dyes.

Notwithstanding the fact that we are at war, and that consequently the primary business before us all is to win the war, yet there never has been a time more particularly opportune for that emphasis to be placed on the chemistry of dyestuffs in all its phases, without which the industry cannot become the integral part of American life that lies so opportunely before it.

The war has awakened American business men and American bankers to the importance of the entire chemical industry and the financiers and business men in particular have given ungrudging support to the coal-tar dyes. As a matter of fact, some financial men have been badly bitten already by reason of venturing into this most complex field without adequate understanding of its problems and ramifications. Right here seems to me to be a field wherein the chemists can be of great service to themselves and also to the industry by guiding the American business men along the sound lines of investment, and also of development, without which the integrity of the primary investment cannot be preserved.

The dyestuff industry is one that cannot stagnate and live. It must develop or retrograde, and this development must depend absolutely upon the original research work of the chemists. As an editorial in the *Textile Colorist* (May 1917) says, "The dyestuff factory cannot progress, or even exist, upon the cast-off products of other factories. The history of the dyestuff industry shows that financial success follows the research laboratory, and the research laboratory only; the other path leads to failure and disaster." I feel sure that these points are apparent to any chemist who has studied this industry, but it is through the chemists that these facts must be brought home to the business men and the financiers who are directing our industry, and who, in too few cases in our country, have had chemical training and experience.

To be sure, the American business man adequately realizes that by increasing the yield and quality of products he is now manufacturing, he places his business in a position to earn greater profits or to meet more rigorous competition, but the men who are directing our industry must be brought to know that future security will come to those factories only which maintain and follow the creative work of their research chemists

American directors of dyestuff enterprises must be brought to a realization of this most important point, and to see that dollars spent researching into the unknown along the lines shown by trained experience to be most promising will reap a golden harvest. Such has been the lesson of the past. The convincing of the managers of the dyestuff industry of this fact is as much a part of the work of our chemists as is the carrying out of the laboratory or manufacturing procedure.

The relative condition of the industry in Germany in comparison with England and other countries just before the war demonstrates the importance of this creative research work absolutely and finally.

It was not the lack of chemists in England that prevented her dyestuff industry, with its favorable start, from developing as Germany's did, for the lack of these chemists would have been supplied immediately had the demand for them appeared. Englishmen directing their dyestuff industry simply did not recognize the paramount importance of the creative research work for the permanence and development of the industry, and from being initial pioneers, they became content largely to trail behind the German effort.

Since the war England has been going ahead on a more rational basis, and we here in America must take to heart the experience of the past in Germany and in England and carry through into full growth the industry of the coal-tar dyes.

I feel that by meetings of those chemists interested in dyestsuff under the auspices of the AMERICAN CHEMICAL SOCIETY we can go a long way toward furthering the permanent growth of coal-tar dyes in all their complex ramifications here in America. I do not mean to infer that the accomplishments of the American dye manufacturers and American chemists in recent years, and in the years since the war, have not been worthy of pride—far from it—but I do not feel that we have been pioneers except in a most occasional instance. To be sure, the pioneering must be done along business as well as scientific lines. What may be good business for one factory with certain classes of products and by-products might be very bad business for another factory with different products and by-products.

This development of by-products is a most important one, and one that in the haste to turn out a given intermediate or dye, the American manufacturer is prone to neglect. Dr. Hesse lays great emphasis on by-products, and writes of them as follows:[1] "Broadly speaking, the entire coal-tar industry is a complicated maze and network of interlocking and interlacing products and by-products; these are great in number, but, in most cases, small in volume individually. *In numerous instances the very existence of the by-products was the sole directing cause for the invention of new dyes and classes of dyes.*"

The American manufacturer has always tended to bulk production and this has also been true in England. This is undoubtedly the best policy to a certain extent, but our manufacturers, especially of dyestuffs, must realize that they must have and offer a fairly complete line or else the same thing will happen in America as Dr. F. M. Perkin stated happened in England, that is, the Germans came along with a newer, bigger, and more complete line and took the business away from the domestic manufacturer. Therefore, this is another way in which the chemists can contribute, namely, by so designing the plant and processes for those dyestuffs which have only a small market that they can be manufactured on a relatively smaller scale in a profitable manner. The economic laws of supply and demand, coupled with that amount of reciprocity that the law allows, will undoubtedly centralize the manufacture of those dyestuffs which have a limited market in the hands of one or two

*The address by Grinnell Jones, not printed, was a résumé of the "Census of Dyes and Coal-Tar Chemicals, 1917, Tariff Information Series No. 6," in press at the time of the meeting, but obtainable now by applying to the U. S. Tariff Commission, Washington, D. C.

[1] THIS JOURNAL, **6** (1914), 1013.

manufacturers, who will, in turn, exchange or sell these products for others of the same class manufactured in some other plant.

From time to time, here and elsewhere, with regard to the general policies of chemical plants, the remark is made, "What does it matter if we are making money?" This policy is suicidal in the long run, for continued success will only come to those manufacturers who are always looking ahead and who view planning for the future as an important part of the daily task.

The Germans, in the conduct of their very successful dye plants, entrusted their direction largely, even up to the Board of Directors, to technically trained men. England did not pursue that policy in the time prior to the war, although she has changed somewhat since 1914. We must not forget the old proverb, and neglect to learn from our enemy. In my own opinion, this is an important reason for the German successes, and it behooves the owners of our dyestuff industries to call into their councils continuously their technically trained chemists and engineers, and this should be carried even up to their Board of Directors.

In addition to the scientific work that the AMERICAN CHEMICAL SOCIETY can do for the dyestuff industry in America, it can also keep this industry before the public in the proper light so that when the time comes when it is essential to establish the adequate tariff or other legal protection, the American public will be in a receptive mood to pay the necessary price, slight though it may be, to protect the industry until it reaches the same scientific and financial growth as its largest rival.

The chemists of America can show the close connection between the explosives industry and the dyestuff and pharmaceutical industries, and also that as a phase of national protection, it is necessary to have dyestuff plants. It has often been remarked that dyestuff plants and personnel can, in time of war, give great aid in manufacturing of munitions. I know of instances in which dyestuff plants are manufacturing munitions for the Government now that America is in the war, and I further know that their dyestuff program has been set back by such munition manufacture, but this is as things should be.

All in all, the work that lies before the dyestuff chemists of America is promising as to the future, judging by accomplishment of the past, and especially of the last few years. I trust that this Symposium and its successors will contribute useful stimulus to the continuous growth and development of the industry of dyestuffs.

AMERICA'S PROGRESS IN DYESTUFFS MANUFACTURING

By LOUIS JOSEPH MATOS, Chemist, National Aniline & Chemical Co., Inc.

For centuries the peoples of the world have been addicted to the use of coloring matters to produce variegated effects, not only for raiment but for other decorative purposes. From the earliest times there is ample evidence that the coloring matters employed were of three chief classes, *viz.*, animal, vegetable, and mineral. As a matter of fact, the coloring matters of animal origin were very few in number, and included dyes obtained from certain varieties of shell fish, insects, and charred bone. From shell fish has been obtained one of the most beautiful of colors, namely, Tyrian purple, which, however, must not be confounded with another ancient and interesting color that has for years attracted the attention of chemists, *viz.*, purple of Cassius, a tin-gold compound. Two other important dyes belonging to the group of animal dyes are obtained from the cochineal, an insect that thrives in the tropics. They are the scarlet made famous by the uniforms of British soldiers in times back, and carmine, a pigment used for ink making and in printing.

The vegetable kingdom has for centuries supplied the major portion of the dyewares which have been handed down to us, and which have played, even in recent times, a most important part in the coloring of textiles. The various vegetable products include—first in importance, indigo, a native of the tropics; madder, which yielded Turkey red and a small number of other important shades; gall nuts, which the dyer of old used to produce blacks and other colors and shades; catechu or cutch, a native of both the West and East India tropics, and which produces a shade of brown that has been duplicated with difficulty by dyes of coal-tar origin; fustic, a tropical yellow wood of importance; turmeric; quercitron bark and osage orange, the latter two being natives of America; and logwood, probably the world's most important source of black for wool and silk. Our list can be augmented by the names of a number of other natural coloring matters that have played their part in the production of a number of shades of lesser fastness and brilliancy, but a sufficient number has been named to indicate the wealth of material the dyer of the old school had to draw upon.

With a very limited number of exceptions, the great majority of the natural dyewares have, in the course of time, been gradually displaced by products that possessed a more uniform quality, greater tinctorial strength, and vastly superior properties. It is, however, only a question of time when these few exceptions will be likewise displaced. In 1856 the world was startled by the discovery of a coloring matter obtained from aniline by a young man in England, William Henry Perkin. The discovery which the world knew at that time as mauve or Perkin's violet was ultimately destined to revolutionize the entire dyeing industry and to mark the beginning of an epoch in industrial chemical research and pure chemistry. The impulse given to chemistry at that time has been constantly gaining momentum as is evidenced by the great number of very far-reaching discoveries, not only in dye chemistry, but in the chemistry of products that have found wide use in medicine, photography, and other branches of science. After the discovery of Perkin's violet other chemists promptly took up the investigation of aniline and other substances obtained from coal tar, with the result that from 1856 upwards there was a rapid increase in the number of dyes obtained from tar.

It is needless for me to give in detail the list of these products, but it might be interesting to again record the most important discoveries along this line that were made subsequent to the discovery by Perkin: magenta, discovered in 1858; the production of aniline black on the fiber by Lightfoot, an English chemist, in 1862; in this same year the discovery by Nicholson of the blues that bear his name; Poirrier's discovery of the methyl violets in 1866; the discovery of alizarine in 1868, in which Perkin again played a most important part. Great credit is due to the two chemists, Graebe and Lieberman, for the discovery of the fact that alizarine was a derivative of anthracene and not of naphthalene as chemists formerly believed, yet it was Perkin who was responsible for the first successful commercial process for producing this most valuable dyestuff, the discovery and manufacture of which marked the downfall of the madder industry. A study of the statistics of the period will show that subsequent to 1869 the shipments of madder root were consequently lessening until a time was reached when this natural product in either the raw or ground state could be obtained only with difficulty, in fact, the product itself had reached the position of being but little more than a botanical curiosity. Of far-reaching importance was the discovery by two Frenchmen in 1873 of the first sulfur color, known as Cachou de Laval, which was the beginning of the development of an industry that has reached very wide proportions. From time to time chemists added to the list of sulfur colors various shades of black and various colors, the use of which, in a number of instances, has enabled the dyers of cotton fabrics to inaugurate new and important lines of goods. Methylene blue followed in 1877, the azo scarlets came upon the market in 1878, and their introduction marked the beginning of the downfall of the cochineal industry. The discovery

of propiolic acid in 1880 marked the beginning of what has gradually developed into a most important industry, the story of which reads like a romance. I refer to the production of synthetic indigo. Tartrazine, the first fast acid dyeing yellow, appeared in 1885, while two years later Professor Green in England gave to the world the most important range of so-called ingrained colors of which primuline was then and is now of considerable importance. This group of dyes has been from time to time gradually increased so that at the present time a very wide variety of shades is available to the dyer. Rhodamine, an extremely valuable coloring matter, enabling the dyer to produce a very wide variety of pink shades, was produced in 1893, while the sulfur black previously alluded to was produced in 1895, being the discovery of a French chemist. This brief outline of some of the important dyes is given solely for the purpose of emphasizing the important stages in the progress of this particular industry.

From the beginning of the coal-tar dye industry in 1856 until the outbreak of the war in August 1914 the dyers of America were at peace with themselves and the world, there was no difficulty in obtaining whatever dyewares were needed to keep their mills going. Compound or mixed shades required by fashion were obtained without difficulty and with the active coöperation of chemical experts and colorists in the service of the various dye-importing establishments of this country accurate matches on various fabrics were promptly made and delays in the dyehouse were seldom encountered. When the war broke out, the dyers, color makers, textile printers, mill owners, and superintendents suddenly realized that the great bulk of the dyestuffs they were then using and which they had obtained with so little trouble came to this country from Germany, and with Germany at war with half the world they were further brought to a realization that many of the raw materials that entered into the dyes were not likely to be obtained with any greater facility, when the fact was considered that these same raw materials were made use of by manufacturers of explosives. The dyestuff importers, confronted with these stern facts, were besieged for information as to the probable situation. The story is briefly told how the importers even went to the extent of chartering ships for the purpose of bringing over dyes separate from any other cargo. During the early months of the war small supplies of dyes were landed, including some brought by submarines. As the supplies of imported dyes gradually became less, the situation became proportionately acute. Confusion was paramount and at this time many inquiries were made by the dye-consuming industries as to what had become of the American dye industry, since it was believed by many that dyestuffs had been made somewhere in the United States. What did become of these American manufacturers? The principal plant in the United States at that time was located at Buffalo, N. Y., and while it is true that many dyes had been produced at that plant, it is likewise true that the raw materials and intermediates of which those same dyes had been made had regularly been imported from Germany. Consequently, the circumstances were that while finished dyes had been imported from Germany, the dyes made in America up to that time were manufactured from German-made raw materials.

This situation put the American chemists to the test. Long before the United States entered the conflict, the demand became incessant for certain dyes that were very difficult or impossible to obtain, and which were sorely needed to keep a number of our textile mills in operation. This condition rapidly aroused the interest of chemists and financiers so that eventually the two came together with the result that a number of intermediate- and dye-manufacturing plants sprang up throughout the country. A number of these plants were devoted exclusively to the manufacture of aniline and carbolic acid. The aniline was used in various ways, but large quantities of it were consumed in dye houses operating exclusively in the production of fast black hosiery and other cotton goods. Much of the carbolic acid found its way into picric acid plants, where it was converted into that essential explosive. Other quantities of carbolic acid were used in the manufacture of formaldehyde condensation products, as well as for the manufacture of salicylic acid. The dyestuff industry was compelled to get along with few intermediates, mostly derivatives of benzol or naphthalene. Toluol, owing to the war necessities, was entirely lacking, as every pound of that product was consumed by the manufacturers of explosives.

From time to time as the industry of the crudes increased in this country, that of the intermediates likewise increased, so that at the present time quite an imposing array of these latter products are produced in this country. It should be kept in mind, however, that even in the early days of the war, had there been an abundance of some of the refined crudes, there was not the necessary skill, either chemical or engineering, to proceed at once with the work of turning out the much-needed raw materials for the dye maker. Many of us were familiar with the laboratory production of a few grams of some of these highly complex organic bodies, but when the practical application of our laboratory knowledge was put to the test, upon even a semi-factory scale, the results were not very promising—reactions did not work out as the books assured us they would, yields likewise failed to materialize, and it was only after close application and many repetitions that a clue was obtained which gave an indication as to where the process in hand was weak. Gradually these obstacles were overcome; while it is not intended to imply that in every instance perfection has been achieved, yet very great progress has been made, yields have been increased, impurities of doubtful identity have been gradually eliminated, the finished products have gradually increased, we see less and less of high spots and low spots in our diagrams. On the whole, the situation is gradually clearing up and with the unselfish coöperation of both chemists and chemical engineers the manufacturing operations are becoming stabilized.

Let us not for a moment lose sight of the fact that the manufacture of almost each intermediate used by the dye maker constitutes an industry in itself. For example, the manufacturer of amidonaphtholdisulfonic acid, H-acid, is such a lengthy operation and involves so many stages that those who are engaged in its manufacture must give their whole time and attention to it. The same remark applies to the manufacture of amidonaphtholsulfonic acid, γ-acid. I mention these two acids in particular because a large number of dyestuffs are obtained from them in combination with other intermediates and the processes involve almost every important operation made use of in industrial organic chemistry. In the early days of their production in this country some phase of the work was not clearly understood and it required prolonged experimentation to locate the trouble, which sometimes was found either in the filtration of certain solutions, in the melts, or in the drying.

I wish to draw your attention to the list of those products now manufactured either by the National Aniline and Chemical Company, Inc., directly, or in some of its affiliated plants; I am sure you will agree with me that the list is imposing and were you to take the time to go through the chemical and mechanical operations involved in producing on a manufacturing scale the items named you would realize that it has been no mean undertaking. The list is as follows:

Benzol	Betanaphthol
Oil of Murbane	Gamma Acid
Dinitrobenzol	R Salt
Rectified Aniline	G Salt
Aniline Salt	Potash G Salt
Paraphenylenediamine	Amido G Salt
Thiocarbanilide	Schaeffer Salt
Metanitraniline	Metanilic Acid
Toluol	Picramic Acid
Nitrotoluol	Amido Salicylic
Orthonitrotoluol	1,4-Oxy Acid

Paranitrotoluol	Koch's Acid
Dinitrotoluol	Naphtholic Acid
Metatoluylenediamine	Sulfanilic Acid
Orthotoluidine	Orthonitroanisidine
Paratoluidine	Dianisidine
Mixed Toluidines	Nitro Cleve Acid
Xylidine	Amino Cleve Acid
Xylol	Acetamino Cleve Acid
Nitroxylol	Carbazol
Cumidine	Crude Anthracene
Diphenylamine	Refined Anthracene
Naphthalene	Anthraquinone
Dinitronaphthalene	Alpha Naphthol
Nitronaphthalene	Dimethylaniline
Hydroquinone	Ethyl Benzylaniline
Metol and Rubber Accelerator	Nitroso Dimethylaniline
H-Acid Dry	Diazo 1,2,4-Acid
Distilled Benzidine	Purified Diethylaniline
Nitrobenzol	Anthraruffin
Dinitrochlorbenzol	Resorcine
Paraamidoacetanilid	Phthalic Acid
Paraaniline	Dinitrophenol
Chromotropic Acid	Monochlorbenzol
Cleve's Acid	

The basis of the dye-making industry is the foregoing, for without the intermediates the dye maker is unable to proceed. Fortunately at the Marcus Hook Works, Buffalo Works, and Brooklyn Works a staff of chemists and workmen were already in a position to undertake and carry on the dye-making operations as soon as the American factories were able to deliver the intermediates, and this work has continued, uninterrupted, to the present time. At the moment, owing to the war situation, certain much needed derivatives of toluol are not to be obtained for the reason previously mentioned. Certain small amounts of toluol, however, are permitted to be used for the manufacture of some few dyestuffs necessary for soldiers' uniform material, but the general public is for the time being debarred from using dyes in which toluol constitutes an important ingredient.

Almost every dye chemist and colorist has been asked what progress American chemists have made, whether we are looking to the production of dyestuffs better than the Germans formerly made or whether we are devoting our attention to the production of new dyes. Answering the queries it might be well to state at once, that we produce dyes in every respect the equal in shade, strength, and working qualities of the pre-war type. This the American dye manufacturer has been successful in doing. He has not been able to produce every dye formerly imported, but with a catalogue of about 175 dyes actually made in the United States to-day from American raw materials and intermediates, in quantity and variety sufficient for the wants of the textile industry, one can regard the progress made as being remarkable. Referring to the second question, the American chemist has not had the time nor the opportunity during the high pressure period of the war to devote his energies to discovering new dyes, his whole time has been devoted to devising successful methods for producing intermediates and dyes, the chemistry of which required little or no further investigation.

Among the important dyestuffs that have been made in the United States may be mentioned direct black, a product of great interest to cotton dyers and useful for many purposes. This dye has been manufactured at the Buffalo Works of the National Company in immense quantities, and since the war commenced, entirely from domestic raw materials. Another dye of great technical value is chrome blue, applicable chiefly to wool. This dye possesses in a marked degree properties of extreme fastness to light and weather, and therefore is almost exclusively employed for dyeing sailors' uniform fabrics.

The dyes now being manufactured number about 175 and include members of all the groups of colors used in American mills prior to the outbreak of hostilities. This list is being added to from time to time as progress is made in the production of necessary intermediates

In addition to the foregoing the manufacture of synthetic indigo is not to be omitted. At one of the Works of the National Company it is being produced and as rapidly as present conditions of labor and material permit, the plant is being expanded to a size that will deliver a quantity of indigo equal to, if not exceeding, over half the requirement of the American market.

Another product of importance is alizarine. This is now being produced from American anthracene at the Brooklyn Works, in quantities equal to the total requirement of the market, and is of a quality equal to any alizarine in paste form that was ever imported. The manufacture of alizarine is an industry within itself. When it was suggested that it be produced in this country, the problem at once arose as to the source of anthracene, since none of this raw material had ever been recovered from domestic tars. It was known that anthracene existed in our tars, but it was not until the necessity of supplying our dyers with alizarine arose that steps were taken to isolate the crude anthracene and refine it. This required a complete revision of our usual mode of procedure, but it was successfully accomplished. There is no doubt but that the alizarine industry will be permanent.

THE DEVELOPMENT OF THE DYESTUFF INDUSTRY SINCE 1914

By J. F. Schoellkopf Jr. of the War Industries Board

The idea of the present conference seems to me an especially happy one, coming as it does just now when we are in the midst of the greatest war in history and inclined to give attention to those matters only which are directly concerned with the production of material necessary to win the war. It is, of course, but right and proper at this time that the production and chemistry of war materials should have the first place in the minds of all chemists, but it is well, at times, if conditions permit, to sit back and think of what will, or may happen, when we are no longer at war. I say this because I firmly believe that the problems which the American chemist will have to face in the after-war period will be greater by far than any he has been confronted with since 1914, and you all know of what magnitude and complexity these have been and how well they have been met. Because of these remarkable achievements of American chemists during the past few years, I look forward to the future with confidence and venture to prophesy that the place which America occupies to-day in the field of chemistry, which is at the head of the procession, will be maintained hereafter.

The chemistry of dyestuffs which we are discussing to-day is, it must be admitted, still in its infancy in this country and the reasons for this will presently become clear. Germany, as is well known, assumed the lead in this branch of chemistry some forty years ago and has up to the present time held this, largely due to tariffs "Made in Germany," and not as a result of superior chemists. Why, you will ask, does this condition still exist after we have had an almost unsurmountable tariff wall for nearly four years? The answer is simple. For four years our chemists and chemical engineers have been engaged in the work of "catching up" with Germany, a task which is nearing completion, and one which has been done in a remarkably short time, considering the difficulties encountered.

For the benefit of those who are perhaps familiar only in a general way with conditions confronting the industry during the past four years, it may be well to state as briefly as possible what some of these difficulties were and how they have been effectively overcome. It must be remembered that in 1914 there were only seven manufacturers of dyestuffs in the United States and every one of these was dependent upon a foreign supply of intermediates. The total production was less than 6,000,000 lbs., this representing approximately 10 per cent of the consumption. Furthermore, due to the cut-throat competition of the Germans on those products made in this country, aided by an unfavorable tariff, the industry had made practically no progress whatsoever during the preceding ten years and just before the war came upon us its condition was going from bad to worse.

When, therefore, in August 1914 the tremendous and sudden

demand for dyes came, the industry was in no shape to meet it, especially as regards personnel, the working organizations of the companies, as a necessary economic measure, having been stripped to the bone. Most of us thought at that time that the war would be a short one and hastily erected improvised buildings in which it was attempted to produce some of the more important intermediates such as beta naphthol, paranitraniline, H-acid, etc. As a result, early in November, these products were being made in fair-sized quantities, sufficient at least to make considerable quantities of the more staple dyes. The situation in the fall of 1914 was not so serious, because the imports from Germany had not ceased and large stocks were still in the country, although these were largely in the hands of speculators.

Previous to 1914 between 300 and 400 different dyes had been imported into this country by the Germans, approximately 120 of which had been produced by American manufacturers. On January 1, 1915, we were only making about 16, so that you can see what a big job was ahead of us.

In March 1915, the English blockade prevented further imports from Germany and the real developments of the industry may be said to date from that time. This brought home forcibly, both to consumer and manufacturer, the fact that if we were ever to become independent of Germany the opportunity was now here. This opportunity was seized upon and immediately the construction of new and modern plants was begun. In less than six months these plants were producing, but it was soon found that their capacity was entirely inadequate, although they had served to more than double the pre-war production of the country, and had enabled manufacturers to produce about 40 different colors by January 1, 1916, as against 16 the year before. During the year 1916 older plants increased their facilities tremendously, and the production of those who had newly entered the field also began to be felt with the result that in the early part of 1917 the ordinary needs for dyes were being met in a satisfactory manner. The number of dyes produced by the end of the year had increased to over 150, in other words, we were producing a greater variety than was produced before the war, and all raw materials and intermediates were of American manufacture. According to figures prepared by the Tariff Commission the production for 1917 was nearly 46,000,000 lbs., approximately eight times the pre-war figure, and the value was over $57,000,000 as against $2,500,000 in 1914. Truly these figures are remarkable and show better than words can what has been accomplished.

Do not forget that all the men to build and operate these plants had to be trained. It was impossible, as in the case of other industries which have developed as a result of the war, to obtain the services of experienced men by hiring them away from competitors by inducements of a financial nature, or otherwise. This was one of the greatest difficulties to contend with, but was rendered comparatively easy by the remarkable adaptability and ingenuity of the American chemist, engineer, and mechanic. Considerable difficulty was also experienced in obtaining the proper equipment for the plants, the design of which was in most cases new and entirely different from anything previously made by our foundries and machine shops. Here also, through whole-hearted and intelligent coöperation, our burdens were reduced to a minimum

Up to a short time ago, owing to the incessant demand for dyes, the one idea of all manufacturers was quantity of production, quality being more or less of secondary importance. Now that the urgent needs of consumers are being filled, the pressure is relaxing and it is possible to develop the various processes in order that they may be made competitive. That is the big problem we are facing at the moment, and one which is of the utmost importance for the future of the industry. To meet this the larger companies have established research laboratories which will undoubtedly bring about the desired results, and at the same time train men for original work to be done in the future. I do not mean to imply by this that our research laboratories are not doing any original work now. They are. But until the processes for well-known dyes and intermediates are fully as efficient as those of our foreign competitors, it is manifestly more important that these be given preferential attention.

As a result of this work the quality of American dyes is continually improving, in fact, I do not believe that there are many to-day which fall short of the former German standard. Naturally, until the line of dyes made in this country is more complete, there will always be complaints of a certain nature, but the quality of the dyes made in this country is usually not at fault. The cause of over 90 per cent of the complaints which are registered is faulty application of the dyes. If the dictators of fashions would take into account the dyes which are available, all would be well, but they do not, for in order to produce some of the prescribed shades, dyes not yet made in this country should be used. The result is that unsatisfactory substitutes must be used and complaints against the quality of American dyes immediately arise.

As the complete and full development of the industry will, in my opinion, require a period of at least another five years, it is important that as much publicity as possible be given this particular phase of the situation. So much that has appeared in the press during the past few years regarding dyes has been absolutely futile and erroneous. What a pity it is this space could not have been used to better advantage. It is interesting to note that one of the large manufacturers is conducting an active campaign along these lines, which is undoubtedly a step in the right direction, counteracting as it does the insidious propaganda against the quality of our dyes.

An important factor in the development of the industry is the progress now being made in alizarine and vat dyes. The most important of these, especially the latter, are covered by German patents which have some years to run before they expire. By an Act of Congress the Federal Trade Commission has been given the power to issue licenses under these patents to domestic manufacturers, which fact has been taken advantage of, with the result that this class of dyes may be expected on the market within a short time. The importance of these dyes cannot be over-emphasized, and only with their production in this country will we be truly independent of Germany. It is for this reason that it is imperative that a change be made in our present tariff law which classes these dyes, as well as indigo, separately, and provides no specific duty as in the case of other dyes. It is my understanding that the Tariff Commission which has made a study of the industry during the past two years will report its findings to Congress in the near future. I do not know what will be recommended, but I do know that unless materially higher duties, than called for in the present law, are placed on dyes, when peace does come it will place the industry in great jeopardy. I make this statement because from experience I know how costly it is to develop new processes and work experimentally on a large scale. Unless we can do this regardless of expense for at least a period of years, our progress will be slow indeed. Given, say a period of not to exceed ten years of very high duties, I believe the industry will then have grown and developed to such an extent that no further duties of any kind, or at the most only very much reduced duties, will be necessary. Why should not that be the case? We have all the raw materials in this country and certainly our chemists are the equal, if not the superior, of those of any other land. I could talk on about the tariff indefinitely, but believe that I have covered the important points and have demonstrated its importance with regard to the future of the industry.

In closing, I wish to pay special tribute to the untiring energy and industry of those chemists and engineers who composed the nucleus of the organizations which existed prior to the war. It was upon them that the burden of all that has been accom-

plished during the past four years rested most heavily and how well they have borne it is not generally known and therefore should be given special mention. The dean of these men is Dr. R. C. R. Taggesell, chief chemist of the National Aniline & Chemical Company, Inc., whom the writer has worked with and known intimately for a long period of years. I can state frankly that it is my opinion that without his superior knowledge and untiring efforts the industry would not stand where it does to-day. I am glad the opportunity has presented itself to publicly proclaim this fact, knowing full well that the modesty of the man would prevent it from becoming known in any other way.

APPLICATION OF DYESTUFFS IN COTTON DYEING

By J. Merritt Matthews
Consulting Chemist, New York City

Cotton has become one of the principal textile fibers of the world and now ranks alongside of wool and silk as the three great sources of clothing material to meet the needs of the human race. A great many will probably consider that cotton has always been in a very important position in this respect, but this is not the case. It has been only during the last century that cotton has come to the front, and this has been brought about by the mechanical improvements in ginning, spinning, and weaving, and to a great extent also by the manufacture of dyestuffs capable of readily dyeing the cotton fiber.

Before the introduction of the coal-tar dyestuffs, the dyeing of cotton, like the dyeing of wool or silk or linen, was dependent on the use of the natural dyes and certain mineral pigments. As most of the natural dyes require to be combined with a metallic mordant before they yield useful and serviceable colors, and as the cotton fiber has very little power of combination, or so-called affinity, for metallic salts, the dyeing of cotton was attended with many difficulties which were not present in the case of wool, as this latter fiber readily combines with many metallic salts that serve as useful mordants. In order to prepare the cotton with a satisfactory mordant of metallic salt it was frequently necessary to carry out very devious and complicated operations, the very complexity of which caused the results to be uncertain and exceedingly difficult to maintain uniform. This is readily manifest on referring to some of the old recipes employed for the dyeing of cotton with the vegetable dyes.

With the advent of the coal-tar dyes it was soon discovered that many of them could be applied to cotton by relatively simple and effective methods. The basic colors which were first introduced, it is true, still required a mordant in their application to cotton, in this case the mordant consisting of tannic acid fixed in the fiber by the use of a metallic salt, such as tartar emetic. However, even this method of dyeing was a great advance in simplicity and a person of average intelligence and resourcefulness could soon master the art of dyeing by this means. The acid colors which soon came into the market, it is true, were only adapted to wool and silk, and found little application to cotton, but when the benzidine or direct cotton colors were introduced a new field in cotton dyeing was opened up and the widespread use of dyed materials was much stimulated.

These colors, however, though varied and pleasing, were limited in fastness, and this naturally restricted the utilization of cotton fabrics. The introduction of aniline black as a specialized feature in cotton dyeing, however, greatly helped to extend the use of dyed cotton materials by providing an extremely fast color.

The later introduction of various sulfur dyes also stimulated the use of cotton material by providing a number of fast shades. With the advent of the so-called vat dyes, however, permitting of the production on cotton of a wide range of beautiful shades of the highest possible qualities of fastness, cotton fabrics were lifted out of their previous rather low-grade class and elevated to the rank of fabric aristocracy. At the present time, therefore, it may be said that cotton materials are used for high-grade fabrics, and in consequence demand the application of high-grade colors.

In the application of dyestuffs to cotton we must consider several factors of prime importance. In the first place, the form in which the cotton is dyed will have much influence in the selection of the dyestuff. Cotton may be dyed in the form of raw stock or loose unspun fiber, as cotton sliver; or in a partially manufactured condition, as yarn (either as skeins or hanks), as warps, or as yarns on cops or tubes. Or the cotton may be dyed in the fabric form, either as a woven piece or as a knitted fabric. Dyestuffs that are suitable for raw-stock dyeing may not be suitable for dyeing woven cloth or knit fabrics, and *vice versa*. Cotton warp dyeing requires special consideration as to dyestuffs. Cops and tubes are dyed in special machines and the method of dyeing imposes certain restrictions on the kind of dyestuffs to be used. It will be seen, therefore, that the man who contemplates manufacturing and marketing cotton dyestuffs must be more or less familiar with the processes of cotton manufacture to be in a position to properly select the products that are the more desirable.

Another consideration that is important in selecting cotton dyes is the kind of material into which the fabric will be manufactured and the eventual use to which it will be put. This will determine the qualities of fastness of the dyestuff to be employed. Cotton goods go into all kinds of materials at the present time; we have shirtings for men, blouse and skirt material for women. These are more or less in fancy colors, but as a rule the amount of color is only a small proportion of the total fabric. These goods are subject to repeated washing and laundering, and they must also stand exposure to light and perspiration, so it can readily be seen that the colors must be fast to these agencies and a high class of dyestuff is required. Before the war the vat dyes were being largely used for these goods and the public was being educated to expect a color that would last even longer than the fabric under the severe conditions of laundering, especially as most modern laundries now employ strong bleaching agents, such as hypochlorite of soda, for the rapid whitening or bleaching of the cotton goods. Under the present conditions there are practically none of these vat dyes available, as they are not being manufactured in this country and it is to be presumed that all the old stocks on hand have been used up.

We also have ginghams and fancy cotton goods which have become quite popular as dress fabrics during the past couple of years, replacing light weight woolens and worsteds, and even silk to a considerable degree. The dyeing in this case is also chiefly in fancy colors and should possess about the same degree of fastness as just related, for these are all wash fabrics.

Next we have cotton denims used so extensively for overalls and similar garments. Though this class of fabrics is perhaps not so much before the eye of the general public as some others, it is one of the great staples of the cotton business and very large amounts of dyestuffs are used in them. The principal color used is blue, the fancy shades being negligible in amount, and the chief dyestuff used is indigo—in fact, this is where the great bulk of indigo is used. The color has to withstand very severe usage and repeated washings. Logwood can be used to approximate the shade, but the fastness is very inferior. Sulfur blues can be used with good advantage, and there are some who may be inclined to maintain that sulfur blue is as satisfactory for this work as indigo. Hydron blue, which may also be classed as a sulfur dye, though in reality it is a vat dye, is eminently satisfactory, in fact, in many respects it may be considered as superior to indigo. But the trade has long been accustomed to indigo and it will probably stick to it for a long time to come.

Cotton hosiery is another form of manufactured product which takes a large quantity of dyestuff. Of course, the chief color here is black. Formerly most of the hosiery was dyed with aniline black, a color developed on the fiber from aniline itself, but now sulfur black is the principal dye used with also a goodly quantity of direct black. There are also a number of colors dyed on hosiery, such as tan, blue, and a relatively small line of fancy shades. The logical and best dye to use in such cases are the sulfur colors.

For cotton warps, used largely for cotton worsteds and for cotton-effect threads in other lines of woolen fabrics, the sulfur colors are also best, as they stand the cross-dyeing operation of dyeing the wool in the woven piece. Certain of the substantive colors may also be used.

It is not my purpose to go into all the different varieties of cotton dyeing, as this would require too much detail, so I have simply touched the chief points, as it were, to indicate the wide variety of uses of dyestuffs in cotton dyeing. It will be easy to understand why a number of different classes of dyes are required and why a few restricted colors cannot be applied to all forms of cotton materials. Piece goods are largely dyed with the direct colors, and these are also used on various lines of specialties where a great fastness to washing is not required. The basic colors are also used to a considerable degree on certain cotton materials for bright fancy shades, and even in a few cases some of the acid dyes are so employed for bright shades of good fastness to light but of no required fastness to washing.

As to the relative proportion of the different dyes used, this is very difficult to ascertain with any degree of accuracy and only a crude approximation can be given. As may be understood from what I have already said, black is the chief dye used, with blue in the second place. If we include the blacks dyed on cotton with logwood and aniline black probably the following would approximately represent a fair proportion:

Color	Per cent
Blacks	60
Sulfur Black	
Direct Black	
Aniline Black	
Logwood	
Developed Black	
Blues	25
Indigo and Vat Blues	
Direct Blues	
Basic Blues	
Sulfur Blues	
Acid Blues	
Reds	5
Congo Red	
Benzo Purpurine	
Direct Fast Reds	
Alizarin Red	
Primuline Red	
Para Red	
Vat Reds	
Fancy Colors	10
	100

A consideration of these figures will immediately show us why our dyestuff industry has spent most of its energy so far on the production of certain lines of dyes and why a large number of the fancy shades have not been touched upon as yet. Of course, these relative proportions at the present time are considerably thrown out of the normal by the tremendous demand for Government cloth, which is chiefly in khaki, olive drab, and navy blue. The Army requirements, of course, have sent up the proportion of brown colors for cotton goods to an enormous degree, and sulfur brown, for instance, which normally is not a dye of very large tonnage, at the present time is one of those produced in largest amount. In this connection we must also not forget that quite a high percentage of heavy-weight cotton goods are dyed with mineral or pigment colors to produce the khaki brown. This color is obtained with a mixture of chrome and iron salts by simple precipitation of the oxides in the fiber. Sometimes manganese salts are also used, but at the present time these are scarce and of high cost. In respect to tonnage of cotton dyed, this mineral khaki brown forms a very important item, as the cloth dyed in this way is mostly heavy canvas for tent material, wagon covers, tarpaulins, etc.

In the selection of dyestuffs for cotton from the dyestuff manufacturer's point of view, the first consideration is the quantity of the dye consumed by the trade. If this is only small and represents but an insignificant turnover during the year, it does not appeal to the business sense as an attractive proposition. Before the war the various German dyestuff houses had on the market quite a large number of direct cotton colors—one would believe almost too many for profitable production. Many of these varied very little in shade and properties, and the consumption of many was relatively small. It is hardly to be presumed that our American manufacturers are going to bring out all these various brands of dyestuffs. The most sensible procedure would be to fix on those which offered the most advantages with respect to quality of color and fastness, and if there are several very near duplicates of one another, select for manufacture the one most economical to produce. We must also bear in mind that many of the direct cotton colors have a serious lack of fastness to washing, and while they are extremely simple and easy to apply and give good clear colors in combination, yet fastness to washing is being more and more required for colored cotton goods, and dyes which do not possess this fastness will have a very limited use.

It is believed that in the dyeing of cotton the sulfur dyes will have a greater development in this country than they ever had before. It is true they are somewhat limited in range of shades, but blacks, blues, browns, yellows, green, and orange are within the list. They also have the limitation that they are rather dull in tone. But their good fastness to washing is greatly in their favor; also their fastness to acids allow of their use in cross-dye work which much extends their field of application. A large number of useful shades can be obtained by combinations of the sulfur dyes, although the want of a satisfactory red and green dye in this class seriously limits the possibilities for the production of fancy shades.

NATURAL DYESTUFFS—AN IMPORTANT FACTOR IN THE DYESTUFF SITUATION

By Edward S. Chapin
Consulting Chemist, Boston, Massachusetts

"Natural dyestuffs" is a term so broad and covers so many interrelated fields of investigation and practice that it will be possible in the brief space of this paper to treat only certain aspects of the subject in a fragmentary way. I shall be happy if I can draw attention to the importance of the study of natural dyestuffs, and if this may result in an increased interest in and attention to these products on the part of American science and industry.

On the basis of the data of the past, the study of natural dyestuffs should lead to new and important developments in dyestuff chemistry and to results of high value to industry.

A little over a century ago, in 1810, M. Chevreul remarked before the Institute of France: "When we consider the progress that chemistry has made in recent years, we are astonished at the small amount of exact knowledge in existence concerning the coloring matters of the vegetables, and at the little attention that has been paid to their study." This celebrated investigator attacked the subject with characteristic thoroughness.

A century of chemical research and development has rolled by, and to-day there is in existence a considerable amount of exact knowledge concerning natural dyestuffs. Among the chem-

ists who contributed to this development should be mentioned Professor Graebe of Geneva, Professor Kostanecki of Berne, Professor Herzig of Vienna, and of particular interest to dyestuff chemists, Professor A. G. Perkin, and Professor W. H. Perkin, Jr. It is of special significance that the illustrious son of the distinguished discoverer of coal-tar dyestuffs spent over a decade, 1896–1908, in the study of brazilin and hematoxylin, the coloring principles of the natural dyestuffs known in the trade, respectively, as hypernic and logwood.

Just prior to the present war, scientific thinkers were turning with ever greater frequency and deepening interest to the study of natural products; indeed some even were so bold as to state that the trend of all the scientific development of the past half century was to bring chemical science in humility to learn of Mother Nature.

Witness the conclusions of Professor Ciamician as voiced at the Eighth International Congress of Applied Chemistry, in New York, September 1912.

"The plants are unsurpassed masters of—or marvellous workshops for—photochemical synthesis of the fundamental substances. They also produce the so-called secondary substances with the greatest ease. The alkaloids, glucosides, essences, camphor, rubber, coloring substances, and others are of high commercial value.

"The chemistry of benzene and its derivatives does not now constitute the favorite field of research as it did during the second half of the last century. Modern interest is concentrated on the study of the organic chemistry of organisms, *i. e.*, plants or animals. This new direction in the field of pure science is bound to have its effect on the technical world and to mark out new paths for the industries to follow in the future."

Witness further the conclusions of Dr. Arthur D. Little in an address delivered in Baltimore in 1908, before the Division of Industrial Chemists and Chemical Engineers:

"And this brings me to the main point of my thesis. A great German chemical company tells us, in an attractive book just issued, that it employs 218 chemists, 142 civil engineers, 918 officials, and nearly 8,000 workmen. It covers an area of 220 hectares, has 386 steam engines, 472 electric motors, and 411 telephone sub-stations. Its plant represents the highest development which industrial chemistry has reached, but none the less, it cannot produce an ounce of starch which a potato growing in the ground fabricates from water and carbonic acid gas under the influence of sunshine.

"Professor Wheeler has defined so clearly a thought which has been in my own mind for years, that I cannot do better than quote his words. He says:

" 'The vegetable cell is a laboratory in which are carried out a most remarkable series of chemical reactions. As we contemplate the immense number of organic compounds of all degrees of complexity which are formed within the wall of the plant cell, we are convinced that this is the chemical laboratory par excellence... We are led to wonder whether forces exist with which we are not acquainted or whether we are merely unable to control the forces already familiar to us. It will be granted that investigation into the activities of the cell is of profound importance. In fact, it has been said that it is in the plant cell where synthetical operations are predominant, that we have to look for the foundation of the new chemistry.' "

Into the midst of this peaceful and reasonable development ruthlessly came the world war with its quick dislocations and disturbances. At first it was fondly imagined that these would be only for a short time, and that somehow, though nobody could tell how, in a few months or at the most in a year, the war would be over and supplies of dyestuffs would again come from Germany as heretofore, and chemical science and technics would again take up their orderly development beginning at the point at which they stood before the war. This, however, was not to be. The war continued with an ever widening grasp and intensity, dragging ultimately our country, our industries, and our science into the frightful vortex.

A most significant chapter of American industrial history occurred during what has been called the dyestuff famine period of 1915–16, before the American artificial dyestuff manufacturers had reached volume production and when supplies of synthetic dyestuffs in the country were either low or exhausted. It was predicted freely that for lack of synthetic products the mills of the country would be forced to shut down, industry would stagnate, and thousands upon thousands of workers forced into idleness. The natural dyestuffs saved the day. Natural dyestuffs were used for all sorts of purposes. Results were, as a mattter of course, good, bad, and indifferent. With experience and improved methods of application, superior results were secured. The prophecy, that for lack of artificial dyestuffs the mills would be forced to shut down, has long been discredited; but this dire catastrophe would have occurred if it were not for the yeoman services performed for American industry in the critical period 1915–16 by the natural dyestuffs.

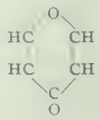
It has been a matter of surprise and even of some incredulity to many chemists that the natural dyestuffs were able to perform this notable service. The reasons are not far to find. So much more work has been done on the study and the development of synthetic products, there were so many more synthetic products of such varying and wonderful properties, these products had been so widely, assiduously, and cleverly advertised, and it was such a source of pride and gratification to try to improve on Nature, that the majority of chemists confined their attention solely to synthetical products, and knew nothing about natural dyestuffs and the possibilities in industry from their scientific application to fibers and materials.

As a matter of fact, even just prior to the war more than one hundred thousand tons of dyewoods were used annually in American industry. These products were used in spite of the unwearying efforts of an aggressive propagandism to displace them with synthetical products and used because the results from the natural dyestuffs were more economical or superior.

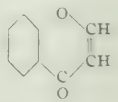
These unrivaled results from natural dyestuffs were due to certain definite chemical groupings or complexes, or to certain special methods of their application to materials and fibers.

Among the natural dyestuffs that have performed notable special services in the past few years and that were in considerable use prior to the war, may be mentioned logwood and hematine, fustic bark or quercitron, flavine, hypernic, archil or cudbear, sumac, catechu or cutch, and gambier. During the war osage orange has been added to this list.

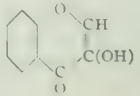
All of the above mentioned dyestuffs, except archil and sumac, derive their chemical significance from a parent body known as γ-pyrone, $C_5H_4O_2$. The γ-pyrone ring has a configuration as follows:



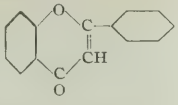
The monophenyl ortho condensation of γ-pyrone is called chromone and has the configuration



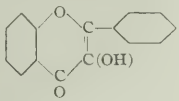
The oxy derivative of chromone, called chromonol, is represented as follows:



Phenylated chromone, called flavone, is:

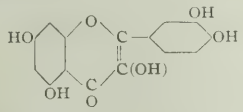


Phenylated chromonol, called flavonol, is:

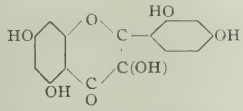


The actual coloring principles of the natural dyestuffs are more complicated in structure and in some instances controversy concerning their exact configurations has been long continued and voluminous.

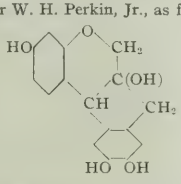
In 1893–1894 it was decided that quercetin, the coloring principle of quercitron extract, is constituted as follows:



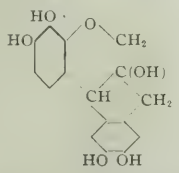
The morin of fustic followed in 1896–7, represented by:



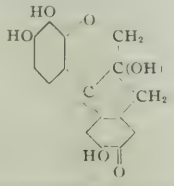
Brazilin, the coloring principle of hypernic, was formulated finally in 1908 by Sir W. H. Perkin, Jr., as follows:



Hematoxylin of logwood was represented similar to brazilin, with one more hydroxy grouping:



The researches of Perkin, Herzig, and Kostanecki on brazilin and hematoxylin are classics of chemical investigation. The oxidation of hematoxylin yields hematine, to which Sir W. H. Perkin, Jr., gave the formula:



These various derivatives of the oxygen-containing γ-pyrone ring are different in properties from their more widely known all-carbon-ring brothers and sisters. These differences are well summed up by Reim.[1] He says that hematoxylin cannot be nitrated. Hesse has shown that it cannot be sulfonated. It gives no useful substitution products with chlorine or bromine. It is attacked by phosphorus pentachloride, but it is impossible to isolate from the result a pure compound. It does not take up hydrogen either with sodium amalgam or zinc and sulfuric acid. It gives no compounds with hydriodic acid or hydrobromic acid. With potassium chlorate and hydrochloric acid it yields resinous non-crystallizable products. It gives with zinc dust crystalline bodies, but these cannot be isolated.

The question naturally arose whether this sensitive compound could not be protected in some manner from too rapid decompositions. Before going further it will prevent confusion to state that brazilin and hematoxylin behave similarly toward reagents and chemical processes. Brazilin, as already noted, contains one less hydroxy group than hematoxylin. Brazilin as being the simpler body was first studied by investigators. The reactions developed were applied to hematoxylin. In the course of an extensive series of studies, Prof. C. Schall and Chr. Dralle[2] discovered methyl brazilin. Trimethyl brazilin and tetramethyl hematoxylin are relatively stable products, and from these protected brazilin and hematoxylin compounds, in the course of two decades of intensive investigation, a numerous list of derivatives has been prepared, of which we have time to mention only the more noteworthy.

The methylation of hematoxylin under certain specific conditions forms a tetramethyl hematoxylin. This substance oxidizes to a ketone, tetramethyl hematoxylone. Tetramethyl hematoxylone readily acetylates to acetyl anhydro tetramethyl hematoxylone, which reduces to α-anhydro tetramethyl hematoxylone. α-Anhydro tetramethyl hematoxylone reacts like a complicated β-naphthol, and accordingly we find that it can be combined with diazotized amines to form azo dyestuffs. A β series of derivatives also exists. β-Anhydro tetramethyl hematoxylone reacts like a complicated α-naphthol and accordingly can be combined with diazotized amines to form azo dyestuffs. Acetyl anhydro tetramethyl hematoxylone nitrates to nitroacetyl anhydro tetramethyl hematoxylone, which reduces to amido acetyl anhydro tetramethyl hematoxylone.

Significant as these derivatives from hematoxylin may be, it is not to them alone I would call attention. To consider them alone would be to miss the other factors that give to logwood extract, to hematine crystals, and to the various forms of natural dyestuffs their unique values for industry. "The new direction in the field of pure science," mentioned by Prof. Ciamician, and "the new chemistry" mentioned by Dr. Little and Prof. Wheeler will undoubtedly explain these factors: at present these remain a mystery and we are able to enumerate only the special results from the applications of natural dyestuffs, and to try by pure science, new chemistry methods, or what you will, to trace our way from the results to the cause, or from the cause to the results.

The results from natural dyestuffs that are of special value to industry may be best illustrated by a consideration of the best known and most prominent of the natural dyestuffs, logwood, as it is called.

The term logwood stands loosely for a variety of products found in trade that are derived from a tree known botanically as *Hematoxylon campechianum*. The extraction of the dyestuff principles from the tree and the subsequent treatment of the liquor of extraction are matters of exact technics, and considerably influence the results obtained in industry. Logwood extract, usually furnished to the trade at a consistency of 51° Tw., is obtained by the concentration under vacuo of the extraction liquors; the coloring principles analyze 85 to 80 per cent

[1] "Ueber das Hematoxylin," *Ber.*, **4** (1871), 329.

[2] "Ein neues Brazilin Derivat," *Ber.*, **20** (1887), 3365.

hematoxylin and 15 to 20 per cent hematine. By oxidation of the logwood extract, the hematoxylin is changed to hematine. The hematine pastes of the trade will run anywhere from 45 to 90 per cent of hematine, the amount of oxidation being determined largely by the purpose for which the hematine is to be used. Logwood extracts and hematine pastes can be brought down to solid or crystal form, and as such are found in the trade as solid extract of logwood, or logwood and hematine crystals. In reality the complexes in logwood extract and hematine pastes are more intricate than the analyses above given.

Logwood enjoys unique distinction in dyeing black on materials and fibers. It dyes wool, silk, cotton, leather, and a great variety of fibers and materials. It is the most generally all-round useful dyestuff for dyeing black. It is also used for the weighting of silk.

The results with logwood on the wool and the silk fibers best illustrate the peculiar excellences that can be secured by the use of this natural dyestuff.

Logwood produces on wool a particularly handsome and fast black. The logwood effects cannot be equaled with artificial substitutes. The underhand solid blueness and the overhand lofty bloom of logwood blacks on wool are proverbial. During the great period of activity in the synthesis of acid and top-chrome blacks, the logwood black was used as a standard of comparison, and the usual words, reiterated almost monotonously as each successive product was placed on the market, were these: "Nearly equal to logwood black in rich blueness and bloom." It has been the despair of the artificial color chemists to secure one synthetic product combining these desirable properties.

In addition to these tinctorial superiorities on wool, logwood possesses other properties that are noteworthy. It is a friend to the colorist under good and adverse conditions alike. Such cannot be said in the same measure of the artificial substitutes for logwood. Logwood dyes uniformly, levels excellently, and penetrates perfectly. It dyes slowly. It may be fed at a boil. The widest blends of stock are evenly colored and penetrated by logwood. Defects in wet and dry finishing are most successfully offset by its use.

Under artificial light the handsome logwood black does not lose its beauty, but, on the contrary, retains its rich, pure tone and, if anything, is intensified in brilliancy and richness. Artificial substitutes for logwood do not stand artificial light as well as logwood; indeed some lose their daylight tone altogether, becoming dull or brown. For evening clothes and for a large variety of suiting and wearing apparel, this superiority alone, other things being equal, establishes a preference for the use of logwood.

If these facts are true, why, asks the intelligent inquirer, has logwood ever been displaced at all on woolen and worsted materials? Among various reasons that may be given there is one above all others that is peculiarly cogent to modern business temperament. Compared with top-chrome blacks and acid blacks, the dyeing with logwood takes more time. Cries efficiency, we must at all hazards have the utmost of production; quality is sacrificed to quantity. A brilliant young colorist has remarked, "If logwood could be dyed to give the same production as top-chrome blacks, there would not be a pound of top-chrome black used in the country."

While this prophecy is extreme, it contains a kernel of truth, and points to an objective for research. Top-chrome blacks would undoubtedly be used in dyeing because of certain inherent excellences, even if logwood blacks could be colored by one-dip processes with equal rapidity.

Nor is the suggestion to color logwood blacks by one-dip processes an idle fancy. Already various investigators have obtained noteworthy results, though the processes have not been tried out over a long period of time in industry.

The production factor on silk, strange as it may seem, is in favor of logwood. Prior to the discovery of the value of logwood for the weighting and dyeing of silk, processes in vogue were most tedious. A little over a decade ago Dr. Heermann[1] discovered that these processes could be greatly shortened and improved by the use of logwood. Logwood seems to have a biological relationship to the silk fiber. The silk fiber will absorb 200 per cent of its own weight of logwood. The volume of the silk in the process is considerably enlarged, and the durability of the silk and its resistance to wear and tear are improved. This important discovery has been utilized in the past years on a large scale by the silk dyers of the world, and has created a veritable revolution in the silk industry.

The various synthetic top-chrome and acid blacks possess no such biological relationship to the silk fiber, and accordingly are utterly incapable of producing these special results so highly prized by silk people.

An erroneous impression has prevailed in chemical and trade circles that logwood blacks are not fast: in particular are not fast to light. Logwood blacks properly dyed are of excellent fastness to light, fulling, boiling in water, and the principal mill and service requirements considered in the choice of a fast dyestuff. Toward strong acids as hydrochloric and sulfuric acids, and toward chlorine, logwood blacks are not fast. This prevents their use on cotton where subsequent cross-dyeing with strong acids or subsequent bleaching is required, but has no effect on their use to color a vast array of materials and fibers for numerous other purposes in the arts.

The elaboration of the use of logwood in the dyeing of leather, the dyeing and printing of cotton, and the dyeing of hair, wood, and various other fibers and materials would push our paper beyond prescribed limits. So, too, with the exposition of special results obtained by the use of the other natural dyestuffs.

The unique properties that distinguish logwood for black dyeing find their parallel for yellow dyeing in fustic, osage orange, and quercitron. Catechu or cutch produces on cotton a rich reddish brown of extraordinary fastness.

It is of interest to note in passing that the yellow natural dyestuffs and cutch are being most extensively used in the dyeing of the olive drab shade on various of the woolen and cotton fabrics for the Army; and that these results, when properly dyed, stand the prescribed tests of the Quartermaster's Department satisfactorily.

We have now briefly reviewed certain fundamental facts relating to natural dyestuffs. A careful consideration of these facts will show that the study of natural dyestuffs will contribute materially to our fund of exact knowledge and consequently to the further development of industry. Such study will call for the utmost of energy and resourcefulness from the devotees of pure science and of scientific dyeing. It is not too much to hazard the prediction that if we will thoroughly investigate these remarkable organic compounds and complexes, formed within the chemical laboratory of nature, we shall witness the dawning of a new era in pure and applied chemistry.

THE MANUFACTURE, USE, AND NEWER DEVELOPMENTS OF THE NATURAL DYESTUFFS

By C. R. Delaney, of J. S. Young and Company, Hanover, Pa.

It is a cause for particular gratification to a representative of the actual manufacturers of dyewood extracts to be asked to address such a body as this in reference to products of which one hears little in comparison with the newer artificial colors, but which, nevertheless, have been and still are of inestimable value to the various trades for which dyestuff production is the key industry. The dyewood extract manufacturers have been so exceedingly busy for the past four years for one reason and their

[1] "The Use of Logwood in the Dyeing and Weighting of Silk," *Mitt. Materialprufungsamt*, 4 (1909), 228.

natural reluctance during the past fifty years to talk about their own work for another, it seems that no one has felt that he had the time to do more than roughly outline the volume and importance of the natural dyewoods, while in direct opposition to this stand, the artificial color makers, obviously taking a page out of the book of the German manufacturers, whose products they are imitating, have been conducting a very violent advertising propaganda, all of which we, of course, have recognized, but having been familiar with the German products of both natures, namely, anilines and advertising, the dyewood makers have simply exhibited a more or less mild curiosity when they saw the German products transferred from German sources to American ones.

We all appreciate in our work that there are very necessary uses for the artificial colors, but unlike the unthinking, we know that there is a very large use for our own. In fact, a chemical analogy will indicate what might be called our state of mind. We all appreciate the value of saccharine, the synthetic product; we appreciate what the chemist has done in producing this material so much more powerful than sugar, which, for certain purposes, it can replace, but we have yet to hear that anybody used saccharine with his buckwheat cakes, preferring the product of Nature's own chemist, the bee. It is the same with a great many dyers who all appreciate the strength, the ease of use, and other salient points about the artificial colors, yet, as in the case of saccharine, there seems to be something wanting, and recently I read a statement made by one of the most celebrated artificial color chemists in which he said that all artificial blacks were judged according to their ability to compare with logwood.

It is obvious to all chemists that the explosives industry and the artificial dyestuff industry are concomitant, but do you not sometimes lose sight of the fact that the tanning industry and natural dyestuff production carry the same analogy? At forty-eight hours' notice any one of our dyewood extract plants can be converted into the manufacture of tanning extracts, and while, of course, the enormous profits of the explosives business, due to its hazards, have certain attractions, nevertheless, there has been a proverb since the time of the early Egyptians that "there is nothing like leather." And while on this subject, it might be well to say that to this date there has been found no substitute for natural dyestuffs for the penetration of leather in dyeing it black.

The prize that all of us have been striving for has been the use of our products by the United States Government, and I rather doubt that any of the artificial color people have anywhere near the total proportion of output in Government contracts that the natural dyestuff makers enjoy. A recent questionnaire sent out to every one of the customers of our company between the period of January 1 and June 30, 1918, discloses so far that 72 per cent of their production of Flavine was used for Army business, also the following percentages of their other products: quercitron bark extract, 33 per cent; logwood extract, 80 per cent; domestic sumac extract, 42 per cent; and divi divi extract, 50 per cent. These percentages would be much higher were it not for the fact that another end of the industry, namely, the wall paper trade, which has always used the natural colors owing to their cheapness and greater efficiency for their work, does not come under the heading of war necessities and, therefore, we have been compelled to deduct the very considerable quantity they consumed from the totals.

In addition to our own country, Canada, France, England, Russia, Italy, Australia, India, and Japan are using larger quantities of our products than they ever did, at least, as far as our own exports show. It is unfortunate and thoroughly representative of the conservatism, to give it the mildest name, characterizing the dyewood extract manufacturers that they have never partaken of the benefits of any propaganda that would bring to the attention of the consumers of dyestuffs the advantage of the natural products over the artificial, and as a result, it seems as though the manufacturer of natural dyes has been lost sight of by a very large number of those people who in reality could actually use the natural dyewood extracts for the colors that they wish to produce instead of the foreign dyestuffs and their imitations upon which they have learned to depend.

It is hardly necessary to inform you that the oriental rugs of several hundred years ago still retain their beauty and brilliancy of color to the present day, and if anyone cares to investigate the clothing of three or four hundred years ago they would find that at the courts of France, in particular, there were colors of vegetable origin used in silks and satins that would rival the most gorgeous shades of the present day. The oriental rug will dispose permanently of the argument as to whether natural colors are fast. Of course, if any extraordinary and ridiculous tests are made, such as boiling in caustic or spotting with acid, generally the natural dyestuffs, unless specially prepared, will be found wanting; but for our part, we always have thought that until clothes were boiled in acid in order to clean them it was hardly necessary to employ such tests as indices of the quality of the dye. If they will stand the exposure to the air and rain and sun and will not run or bleed into surrounding fibers, we believe that they have fulfilled their destiny, and it has always been the aim of the natural dyestuff maker to produce, shall we say, honey rather than saccharine.

Possibly you may have seen in various trade journals a rather surprising statement to the effect that prior to the war 60 per cent of all the concentrated yellow dyestuff that we manufacture under the registered trade-mark name of Flavine was exported to two very large artificial dyestuff manufacturers in Germany and Switzerland. In fact, had it not been for the business that we enjoyed through them it is probable that the manufacture of Flavine would have been discontinued, owing to the fact that we did not appeal directly in the United States to the textile industry as it was something that no manufacturer then could do—compete with the German manufacturers—and retain his self-respect at the same time. However, our foreign business was enough to keep that section of our plants operating and this would indicate that some of the dyes manufactured in this country are of value to those who formerly, we were in the habit of thinking, were the leading authorities. As far as the manufacture of dyewood extracts is concerned, it is exceedingly simple, and yet there are one or two things that have to be thought of and taken into account at the same time. Our coal-tar friends have a number of exceedingly complex reactions to look after and they produce materials with unforgivable names. They, of course, know everything about what they are doing, but we in our business are different. We try to produce the same kind of material to-day that was produced fifty years ago and have a hard job keeping it precisely identical, and this is where we need and use the best chemists that we can secure, in spite of the fact that when we get all through our material is known as extract and not, for instance, as monosulfonodioxyanthraquinone.

To cite a homely illustration of the dyewood extract maker's art, the brewing of a pot of tea will be appropriate. The English chemists at least know that "tea boiled is tea spoiled," and that in the making an infusion process is used for not less than two minutes nor more than seven, and that the water should be between 208° and 212° F. in order to secure the best results, allowing it to cool down slowly. It is also found that tea is made better in earthenware vessels, which are heat retainers, than in metallic ones, even though the metallic ones may be of such composition that they will not easily combine with the tannin present in the leaf. This is extract making on a small scale. We do not confine ourselves to a narrow temperature, but extractions of the necessary raw materials are made, according

to experience which has stretched over many years, at temperatures between 140° and 300° F.; all kinds of pressures are used from below the amosphere to 150 lbs. to the sq. in.; intermittent and continuous infusion and percolation are alike used, depending upon the product to be produced, and you may be interested in knowing that a difference of 10° in the extraction temperature of certain materials will cause a profound difference in the quality and also in the yield or amount of extract produced. An extract plant at best has always been an expensive proposition, and where the barks, leaves, and fruits used are of seasonal gathering, the manufacturer is compelled to maintain an enormous stock of raw material. In our own plants we have not less than 25,000 tons of bark on hand to-day, none of which can be used until later on this year, and there will be no more to be had until the summer of 1919, which in turn cannot be used again until after October. We, therefore, have to carry stocks to last as long as fourteen months, which makes the amount of capital invested in these industries very great indeed.

The woods are cut in one of two manners, either by a large revolving disc with knives placed upon the edge and to which the logs are fed by a power feed, or else by means of the better known wood hog, which is an exceedingly heavy piece of machinery revolving at very high speed, and to which the wood is generally fed by gravity. Instead of the cutting part of this apparatus being placed on the outside of a flat disc or wheel, it is similar to a spool or V-shaped wheel, on the inside of the V being the chipping knives, which are generally staggered. While this apparatus will cut wood more quickly than the disc, it does not chip it as well; at least, this is the opinion of a number of authorities, although I must say that the authorities consulted all use the disc chipper. Some idea of the magnitude of the discs may be had when you understand that one of these discs operating in the United States weighs 35 tons. After the wood is chipped it is generally run through disintegrators such as the Williams or Jeffries mills. You probably are familiar with both of these; but for those who may not be, these mills are simply crushing apparatus containing several score of loose heavy hammers, entirely free excepting at one end, near the center of the mill and swinging from a common central disc. The edge of these hammers moves at a speed of approximately $1^1/_2$ mi. per min. and with about 250 h. p. behind them; any material that gets into their grasp is generally disintegrated or else the mill gives way. There have been times when through carelessness or oversight a steel wedge used for splitting the larger logs or a railroad spike, in the case of car bark, has gone through the mill and been hammered around inside of the cages until the edges are worn off sufficiently for it to be thrown out white hot on the floor or into the elevators which convey it to the rooms wherein the ground material is generally held before extraction. This oftentimes is the cause of the greatly dreaded dust explosions which have wrecked several extract plants. After the material has been properly prepared—and in passing it might be stated that the size and cut of the preparation has a tremendous bearing upon the time of extraction which again has bearing upon the quality produced—it is conveyed by the necessary automatic machinery to either autoclaves or wooden extractors. The autoclaves are either of steel or of steel lined with tile, copper, or bronze. We generally use the copper ones, bronze fitted. These autoclaves take a charge of from one to three tons, according to the size, and are fitted with lines for water, liquor, live and exhaust steam, compressed air and vacuum, so that they can be used for any type of extract that it is desired to produce. The open extractors are generally made of wood and hold from 6 to 12 tons at a charge, but owing to the difficulty of controlling the oxidation, always present when liquids containing tannin are exposed in thin solution to the atmosphere, these large tubs have been superseded in the modern works by autoclaves, although for certain purposes they are still largely used. After the material is exhausted by the necessary solvents, the head liquors are concentrated generally *in vacuo* although occasionally they are partly evaporated *in plenum*. There are, of course, variants of this as, for instance, in the making of powdered extract, sometimes the thin liquors are concentrated *in vacuo* and then finished in the open and *vice versa*, depending altogether upon the material which is to be produced. There is a multiplicity of apparatus for the finishing of these extracts and it seems to me that the principal difference between them is that one costs more than the other.

The uses of these extracts are various. Silk, wool, cotton, leather, paper, all draw upon the natural dyewood extract maker, but I believe that their best use is for wool, silk, leather, and wall paper lake. They seem to be particularly fitted by nature for these purposes and generally nature knows what she is doing. There never has been any really satisfactory substitute for the black which is produced on leather by logwood, and the very best black silks and broadcloths are always dyed with this particular product; and as to wall paper, even in Germany the wall paper manufacturers used to prefer quercitron to the color lakes that were made by the artificial color makers in Germany. It may be that our product sold over there so well because the artificial color makers did not use the same brand of persuasive art upon their own people that they did upon our dyers here before the war.

There has always been one very great advantage that the artificial colors possessed over the natural colors and that is their ease of application. With anilines an operator took a certain amount of material that he wished to dye and placed it in a vessel containing the diluted dyestuff with a little salt or sulfuric acid, turned on the steam, and in an hour the whole operation was finished. With the natural dyestuffs it was different. First of all, the goods had to be soaked in some material that had an affinity for the dyestuff, the so-called mordant, and after this they were placed in the dyestuff and turned around or worked, as the expression is, until the requisite color developed. This required two operations, first the mordanting and then the dyeing, and twice the time; and although our business in the United States was increasing before the war until in the early part of 1914, we made and sold more dyewood extracts than we ever have done for any similar period since 1869. Nevertheless, we could not get over this seemingly insurmountable obstacle to the general employment of our production until the fall of 1917.

It has been taken for granted by the dyewood extract chemist that the following conditions obtain: first, that alizarine is artificial madder; that natural madder is a dyewood extract or, if you prefer it, a vegetable product. If alizarine can be made so that it will no longer be a mordant color, it is obvious that the vegetable product madder can also be made so as no longer to be a mordant color, and if the madder plant stands as a generic type of all of the dyewoods, then by treatments similar to that which the artificial colors receive it might be possible to produce dyewood extracts that would no longer require mordanting in a separate bath in order to fasten on to the fiber.

On November 22, 1917, our company took out patents upon single-bath dyewood extracts made from vegetable dyewoods and here are some dyed swatches of wool and here one of mixed wool and cotton dyed simply by taking a certain quantity of the dyestuff, dissolving it in water, placing the fiber to be dyed in the bath, and treating it exactly similar to the artificial dyestuff. This has removed the one point of superiority possessed by so many of the artificial colors and we believe now that the natural dyewood industry will develop along its just and proper lines. Too long have we been content with producing exactly what we produced before and too long also have we been content to let some interested party say that ours was indeed a veritable dying industry in the sense that it was partly moribund and that

there was no hope for us. To-day when we are operating at what we consider normal capacity for the looms and dye houses in this country, there are required not less than 150,000 tons of logwood and 50,000 tons of quercitron bark to produce the dyes that are being used for the dyeing of black, blue and yellow, and in proportion to the number of looms engaged in 1918 and those engaged on similar production in 1914, there is actually a little less proportionate use of dyewood extracts than there was in 1914, owing to the difficulty of securing supplies from foreign ports due to the shipping situation, and this has compelled some of the dyers to cut down the quantity of logwood and quercitron extract that they are using and substitute some of the artificial colors instead.

Just one thing more. In the various medical journals there have been some statements appearing recently covering the use of Flavine in gunshot wounds. This has appeared in *Chemical Abstracts*, *American Medicine*, and *The Lancet*, and inasmuch as my company is the only manufacturer of Flavine, which is a trade-marked, registered name for the concentrated yellow dyestuff made by us from the inner bark of the black oak, I have done all in my power to bring to the attention of those interested that Flavine has no therapeutic action whatsoever. The material wrongfully called Flavine is one of the acridine derivatives used for dyeing yellow, made, I believe, by the Bayer Company, and with their usual disregard for any hampering conventions, they have seen fit to take the name of the best yellow dyestuff they know, namely Flavine, and label their infernal acridine derivative with it. I take this opportunity of drawing attention to this newer use of a natural dyestuff, namely, the labeling of an artificial color with a name that does not belong to it.

PHOTOGRAPHIC SENSITIZING DYES: THEIR SYNTHESIS AND ABSORPTION SPECTRA

By Louis E. Wise and Elliot Q. Adams
Bureau of Chemistry, Washington, D. C.

The light sensitiveness of the silver bromide emulsion is at a maximum at the extreme violet end of the visible spectrum, and falls practically to zero in the green. The emulsion, however, may be rendered sensitive to the longer wave lengths by the use of dyes which stain silver halide. Plates with such emulsions are known as panchromatic or orthochromatic plates.

For this purpose certain of the azo dyes, of the rosanilines, and of the phthaleins have been used, but all of these, with the exception of erythrosine, have been superseded by dyes derived from alkylated quinolines.

TYPES OF DYES USED

The quinolinium dyes used for photosensitization fall into four main groups differing in methods of synthesis, in absorption spectra, and in their sensitizing action.

(*a*) The isocyanines are formed by the condensation of α-methylated quinolinium alkyl halides (quinaldine derivatives) with themselves or with quinolinium halides. They sensitize chiefly in the green and yellow.

(*b*) The cyanines are formed by the condensation of γ-methylated quinolinium alkyl halides (lepidine derivatives) with quinolinium alkyl halides. They show marked sensitization in the yellow, orange and red.

(*c*) The "pinacyanoles" are formed by the condensation with formaldehyde of two molecules of quinolinium alkyl halide, at least one of which must be α-methylated. They, too, sensitize in the yellow, orange and red and have largely displaced the cyanines.

(*d*) The "dicyanines" are formed from α,γ-dimethylquinolinium alkyl halides. They sensitize in the red and infra-red.

All of these condensations take place in alkaline solution.

SYNTHETIC WORK

I—INTERMEDIATES

BASES—(*a*) Quinoline and Bz-substituted quinolines are prepared by the Skraup synthesis from aniline (or other primary amine), sulfuric acid, glycerin, and a suitable oxidizing agent, preferably arsenic oxide.

(*b*) Quinaldine and Bz-substituted quinaldines were synthesized by condensing paraldehyde with the hydrochloride of aniline (or other primary amine), with or without an oxidizing agent.

(*c*) Lepidine was formed by reduction (by dry distillation with zinc dust) of lepidone, which had been made by condensing aniline with acetoacetic ester.

(*d*) α,γ-dimethyl quinoline and Bz-substituted derivatives were synthesized by treating with hydrochloric acid gas, a mixture of acetone and paraldehyde, and then condensing with the hydrochloride of aniline (or other primary amine).

In general, the yields are unsatisfactory.

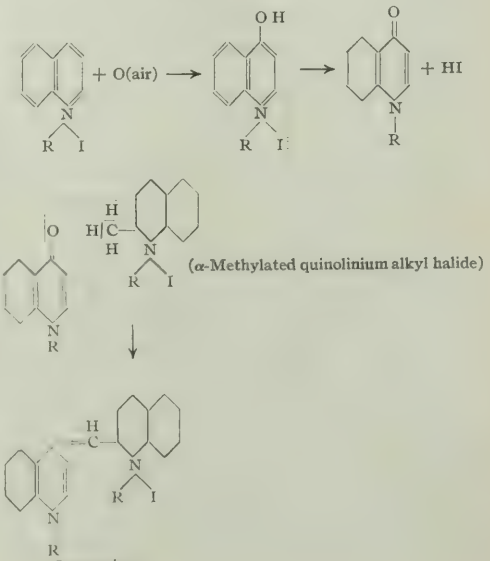
QUATERNARY HALIDES—The quaternary iodides were formed by the addition of methyl (or ethyl) iodide to the base, with or without a solvent. In general, the best yields were obtained without solvent and with the reagents in equimolecular proportions.

These substances are crystalline solids of a more or less pronounced yellow color. They are readily purified by crystallization from alcohol, and their iodine content is easily determined since they yield all their iodine as iodide ion in aqueous solution.

The quaternary iodides may be quantitatively converted into the corresponding chloride or bromide by treating their aqueous solutions with freshly precipitated silver chloride or bromide.

II—DYES

(*a*) The method of synthesis has already been given. In the case of the isocyanines the course of the reaction is probably as indicated:



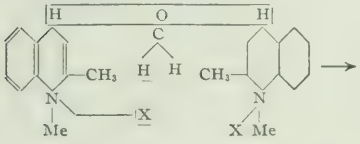
The pairs of intermediates used in the preparation of our isocyanines are listed in Table I as Nos. 1, 2, 3, 4, 5.

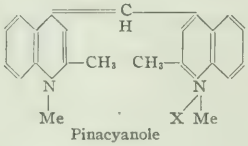
TABLE I

No.	Pair	W.L.	Ext.	W.L.	Ext.	Ratio
	Isocyanines					
1	Quinaldine MeI + Quinoline MeI	558	51	...	...	..
2	Toluquinaldine MeI + Toluquinoline MeI	562	171	...	...	..
3	Toluquinaldine MeI + Quinoline MeI	558	180	...	...	..
4	Toluquinaldine MeI + Quinoline EtI	560	182	...	...	..
5	Quinaldine MeI + Toluquinoline MeI	558	186	...	...	..
	Pinacyanoles					
6	Quinaldine MeI	605	198	563	111	0.56
7	Toluquinaldine MeI	611	290	568	135	0.55
8	Quinaldine MeI + Quinoline MeI	605	330	562	152	0.46
9	Quinaldine MeI + Toluquinoline MeI	606	218	562	102	0.47
10	Toluquinaldine MeI + Quinoline MeI	611	374	568	162	0.43
11	Toluquinaldine MeI + Toluquinoline MeI	611	288	568	138	0.48
12	Quinaldine EtI + Quinoline EtI	Not examined				
	Dicyanines					
13	2,4-Dimethyl Quinoline MeI	653	175	606	92	0.53
14	2,4-Dimethyl Quinoline EtI	656	44	607	36	0.82
15	2,4,6-Trimethyl Quinoline MeI	Not examined				

(*b*) We have prepared only very small quantities of the cyanines. The mechanism of the reaction is undoubtedly similar to that of the isocyanines.

(*c*) The course of the reaction to form the pinacyanoles has not been established but is very probably





Pinacyanole

We have used the pairs of intermediates numbered 6, 7, 8, 9, 10, 11 and 12 in Table I in the preparation of pinacyanoles.

(*d*) The reaction for the formation of the dicyanines is decidedly obscure.

We have made dicyanines from the intermediates numbered 13, 14 and 15 in Table I. All these products have proved to be decidedly impure.

Determination of the iodine content of dyes of the isocyanine and pinacyanole types has indicated in both cases that the nitrogen-iodine ratio is 2 : 1.

ABSORPTION SPECTRA

The spectrophotometric measurements were made with a König, Martens, and Grünbaum spectrophotometer. The dyes were studied in 95 per cent alcohol solution, in a cell 1 cm. thick against a similar cell containing solvent alone. The concentrations of solutions used were 0.02 g. per liter, 0.01 g. per liter, or 0.005 g. per liter, according to the maximum absorbing power of the substance.

The results are given in Table I in terms of the specific extinction coefficient of the dye, that is, the number of liters of solution in which 1 g. of the dye should be dissolved to give a solution, a 1 cm. layer of which would reduce exactly tenfold the intensity of a beam of light of the wave length in question.

Table I gives the intensity and location of the absorption maxima for a number of dyes synthesized. The dyes of the same type show very similar spectra, as can be seen from the table.

THE COLOR LABORATORY OF THE BUREAU OF CHEMISTRY

A BRIEF STATEMENT OF ITS OBJECTS AND PROBLEMS

By H. D. Gibbs, Chemist in Charge, Color Laboratory,
Bureau of Chemistry, Washington, D. C.

It is not my intention this morning to report on any finished work, but merely to give you a sort of airplane view of some of the problems that we have in hand.

About two years ago it was decided to organize the color work of the Bureau of Chemistry. This work originated with the investigation of the dyes employed for coloring food products, and had been carried on in various laboratories of the Bureau for about ten years. It included the identification, analysis, and physiological investigations, and the entire object was the solution of problems arising from and necessitated by the enforcement of the Food and Drugs Act.

The organization of the work to take up problems dealing with the manufacture and utilization of colors is a logical step and a natural extension of the usefulness of the organization. The plan provided for laboratory investigation of colors, both natural and artificial, and the substances entering into their composition, by chemical and physical methods, and the reproduction of laboratory processes on a technical scale. The study of the behavior of substances in large masses necessitated the installation of manufacturing appliances. To accomplish this a rather unique building is in course of erection and equipment on the property of the Department of Agriculture on the Potomac River directly opposite Washington.

This building is 150 ft. by 70 ft., and contains nine chemical and physical laboratories, a library, machine shop, boiler room, engine room, a technical floor 150 ft. by 40 ft., storage rooms, locker rooms and showers.

The equipment will include two 100-h. p. boilers, a 10-ton overhead crane, a 5-ton ice machine, storage battery equipment, all varieties of electric current from a power line of 6,600 volts down, nitrators, sulfonators, fusion kettles, evaporators, autoclaves, dryers, stills, centrifugal machines, and many other large pieces of apparatus in addition to a complete laboratory equipment of chemical and physical apparatus. A railroad siding terminates in the building. Each apparatus is equipped with its own electric motor, where necessary to make a complete unit permitting moving to any desired position as a whole, just as we move the apparatus on a laboratory table. The larger part of the apparatus will be removed from the technical floor when not in actual operation.

The entire equipment is not ready as yet, for the reason that the building is only about one-half completed and war emergency work occupies the completed portion. Adjacent to the main building is a smaller structure for use in our studies on chlorination and other noxious gases that might damage machinery in the larger building.

LABORATORY STUDIES

The laboratory studies naturally have predominated over the plant studies to the present time, for the reason that the laboratory studies naturally come first, and that our own plant has not been completely available for the large scale investigations, except in the case of the chlorination reactions. However, several large-scale operations have been attempted.

The laboratory studies have been progressing along a variety of lines ever since the establishment of the organization. The aim has been to study the development of processes that would be able to withstand competition, and this goal is best reached by the study of conditions underlying yields and costs. We have not been interested in "war babies" that were not directly concerned with the winning of the war. Many problems of the latter nature have been taken up, and if any apology is to be

made for the results to date I must plead that about 80 per cent of the staff is now engaged on war problems, and 80 per cent of our problems are now direct war problems, and were assigned for the reason that almost all are directly in line with our previous experience.

So far the laboratory studies may be divided into five classes: (1) Processes, (2) Dye Intermediates, (3) Dyes, (4) Medicinals, (5) Analytical.

I will take these up in their order and endeavor to give a brief outline of the different kinds of experimental work that have been undertaken by the staff.

1. PROCESSES—Chlorination, sulfonation, oxidation, sublimation. All of these investigations have been for the most part vapor-phase problems.

Chlorination—Studies of a variety of compounds by means of light catalysts have been carried on. Early in our chlorination studies we found that it was impossible to interpret the results because the known analytical methods were deficient. Analytical methods for handling chlorinated toluenes have been completed, and will be published in the next issue of the *Journal of the American Chemical Society*. A technical unit for this chlorination study has been installed.

Sulfonation—These studies have involved the sulfonation of naphthalene, benzene, toluene, and some other compounds in the vapor phase by a continuous process. The analytical methods for handling the variety of derivatives of naphthalene have been completed and an article describing the sulfonation and the analysis of products is practically ready for publication. This work led to a study of methods for making H-acid, and we hope to develop results of interest on this compound.

Oxidation—Oxidation of a variety of compounds by means of catalysts have been carried on in the vapor phase. The most important development of this work is an advanced study of the manufacture of phthalic anhydride.

Sublimation—Sublimation studies have included the purification of a variety of compounds, including phthalic anhydride and a number of hydrocarbons. These studies have required the construction of the vapor pressure curves of a large number of compounds and it is hoped that these will be ready for publication shortly.

2. INTERMEDIATES—An enumeration of the dye intermediates under investigation is as follows:

Phthalic anhydride, methods of manufacture and uses.

H-acid.

A large number of sulfonic acid derivatives of naphthalene, benzene, toluene, and cymene.

The chlorine compounds of toluene and cymene and the study of a number of the quinolines.

3. DYES—*Malachite green*. A study of the Doebener process for the manufacture of malachite green led to studies on the production of benzotrichloride, and these have been included in the chlorination problems. The sulfonephthaleins, cymene dyes, dyes for sensitizing the gelatin emulsions of silver halides, and a number of dyes useful for biological purposes have been investigated.

The manufacture of a large number of compounds from cymene was made possible when the satisfactory methods for nitrating cymene were developed. A number of cymene dyes, homologues of aniline, and various aniline derivatives have been made, showing the possibility of producing as many compounds from cymene as are made from aniline.

The biological dyes have included the development of a number useful in determining the hydrogen-ion concentrations and in blood investigations. The latter are required in considerable quantity by the Surgeon General.

The sensitizing dyes are of great value in photography and are especially useful in aeronautic observation.

4. MEDICINALS—A study of the manufacture of arsphenamine and a study of the patent literature on the subject have been made, and it is hoped that the results will be ready for publication in the near future.

5. ANALYTICAL—The prosecution of many of the investigations has been dependent upon the development of analytical methods for handling the products. Analytical papers on chlorinated toluenes, oil-soluble colors for use in foods, and analysis of anthracene have been published, and other papers are in preparation. The publications that have so far appeared are as follows:

Para Cymene. I—Nitration. By C. E. ANDREWS, THIS JOURNAL, 10 (1918), 453.

The Use of Thymolsulfophthalein as an Indicator in Acidimetric Titrations. By A. B. CLARK AND H. A. LUBS, *J. Am. Chem. Soc.*, 40 (1918), 1443.

The Benzaldehyde Sulfite Compound as a Standard in the Quantitative Separation and Estimation of Benzaldehyde and Benzoic Acid. By G. A. GEIGER, *J. Am. Chem. Soc.*, 40 (1918), 1453.

Crystallography. Note on the Fundamental Polyhedron of the Diamond Lattice. By E. Q. ADAMS, *J. of Wash. Acad. of Sci.*, 8 (1918).

Detection of Added Color in Butter or Oleomargarine. By H. A. LUBS, THIS JOURNAL, 10 (1918), 436.

The Quantitative Estimation of Anthraquinone. By H. F. LEWIS, THIS JOURNAL, 10 (1918), 425.

A Method for the Rapid Analysis of Mixtures of Chlorinated Toluene. By H. A. LUBS AND A. B. CLARK, *J. Am. Chem. Soc.*, 40 (1918), 1449.

Plant Operations—The development of a process for the manufacture of phthalic anhydride has been studied on a plant scale. The work is carried on in coöperation with manufacturers, in accordance with the announcement of the Secretary of Agriculture published in June 1917. The experimental work is still in progress.

The chlorination of toluene on a large scale is being conducted in the technical plant of the Color Laboratory.

Plant investigations for the manufacture of various alcohols and acetone are in progress.

6. PATENTS—The results of laboratory research are patented by the inventors and dedicated to the people by the Department of Agriculture. About twelve patents have been granted and a large number of applications are pending.

The prosecution of a number of phases of this work has been due to Messrs. J. A. Ambler, R. C. Young, G. S. Bohart, and L. E. Wise, in addition to those who have already been listed as publishing articles from this laboratory.

PROBLEMS IN TESTING DYES AND INTERMEDIATES

By E. W. PIERCE, of the U. S. Conditioning and Testing Company

The purpose of this paper is not to disclose any new developments along the lines of dye testing, but rather to make a plea for general coöperation in order to raise the subject to the level it should occupy, now that we have the initiative.

Having been in the most intimate contact with dye testing from an American point of view, for a period of over 20 years, I feel that whatever criticisms I may make are at the same time retroactive.

It cannot be denied that all the present methods of testing dyestuffs are empiric and subject to a wide limit of error. For commercial purposes no great objection is made if this error is plus or minus 2.5 per cent, that is, regarding tinctorial power only. No attempt has been made so far in the valuation of dyes which would take into account the presence or absence of small quantities of by-products or impurities that might be less than 1 per cent and yet cause a marked loss in value of the commercial dye. Thus some recent productions of Rhodamine B were made almost valueless by the presence of a very small quantity of an impurity which caused the shade to be flat and useless for dyeing pinks. A chemical analysis of such a product

might show it to be 99 per cent pure, well within the commercial allowance, but it is still much inferior to a lot that would analyze 90 per cent Rhodamine and 10 per cent dextrine and capable of dyeing a bright shade.

According to the ultimate uses of the dyes, tests are made in a manner that aims to duplicate, on a small scale, the actual application of the color. Dyeings on wool, cotton, and silk, the most common, are followed by paper pulp, lakes, leather, sugar, starch, etc. Colorimetric methods are more recent, but have many limitations.

If it were always possible to obtain identical conditions in the comparative dye test, the only source of error would be that of the individual's ability to read results accurately. However, the dye test has shown that many influences, apparently insignificant, are capable of causing misleading results.

The water used in dyeing is a well-known factor, differences of over 10 per cent being noted between filtered river water and distilled water. Dyes that are equal when tested by one observer may show a difference when tested by another on account of this condition. The presence of foreign material such as salt, Glauber salt, dextrine, or soluble starch may influence greatly the result of tests by two different laboratories. The salts generally act as precipitants and cause both superficial dyeing and lake formation in the dye bath, while the presence of the organic adulterants is like that of a protective colloid and results in slower dyeing, a less exhausted bath, and a greater penetration of the fiber. When the dye bath is finally exhausted, the appearance of the skein in both cases may be satisfactory to the naked eye, but the microscope will show that the one with the dye on the surface of the fiber has a false advantage.

The fibers themselves are not of a nature that would recommend them for exact scientific work. A wool fiber invariably dyes a very full and often bronzy shade near the tip, then becomes lighter toward the root, while the root end is often left practically unstained. The carding and spinning processes so mix the fibers that the naked eye does not notice these defects in a skein or piece of cloth, but they exist and the final result is modified accordingly. When the dye bath contains materials that influence the evenness of the individual fiber the dyeing as a whole shows the effect. These materials may be either actual impurities or placed there intentionally.

Silks are not uniform but are classed as hard- and soft-natured and accordingly dye superficially or uniformly.

Mordanted skeins may be the source of many differences between different observers. The tannin-antimony mordant on cotton is at times a true colloidal adsorption between cellulose and antimony tannate and at others a mechanical adhesion of the antimony compound on the surface of the fiber. The acidity of the dye bath removes and again deposits the final combination with the dye so that the most rigid maintenance of uniform conditions is necessary to obtain concordant results.

Lately a test of hematines by the method of non-oxidizing mordants was required in a hurry, and as no mordanted skeins were on hand they were prepared as usual and the dyeings followed at once. As the results were not satisfactory the test was repeated on the following day with mordanted skeins from the same lot. The second test showed almost double the amount of color of the first series, and the conclusion has been forced upon us that a chrome mordant on wool improves by ageing for 12 hours before use. Failure to observe this condition might result in discrepancies hard to explain.

The most satisfactory test of dyestuff strength is by the colorimeter, but such methods are only dependable when the two solutions are identical in composition and shade. Any variation in acidity, alkalinity, or tone of the color detract from accuracy. It is particularly noticeable now that the productions of different factories vary just enough to interfere with the use of the colorimeter, although it will be found most valuable in controlling the output of any plant.

A few words may be said on the subject of intermediates. It is vitally necessary that some authoritative body specify tests for the proper valuation of the common intermediates. The literature on the subjects is insufficient. Take the case of paraphenylene diamine. We can determine ash, nitrogen, melting and boiling point, solubility, and so on, but these are not a true indication of its suitability for dyestuff manufacture. The presence of isomeric bodies is the greatest fault and none of the ordinary tests are quantitative. It cannot be hoped that we will ever have a system of quantitative methods for aromatic compounds but some of the gaps may be filled. At times it is possible to convert an intermediate into a distinctive coloring matter and make a colorimetric comparison with a sample of the C. P. product and so far this has been the best method at hand.

Isolated cases like paranitraniline have given special methods, such as titration in boiling solution with sodium nitrate, using safranine as an indicator, but whenever there is a tendency to develop a strong color this method is valueless.

If we are now to make America the center of the dye industry it is incumbent upon us to provide the analyst with methods and so facilitate the commercial development along proper lines of control.

ON THE QUANTITATIVE ANALYSIS OF DYESTUFFS

By Alfred H. Halland, of National Aniline and Chemical Company

The large majority of commercial dyestuffs contains besides the dyestuff proper a certain amount of moisture and a great variety of inert ingredients such as common salt, sulfate of soda, carbonate of soda, etc. While a certain amount of these bodies frequently are added in the process known as "Standardization," it is well known that it is practically impossible to isolate water-soluble dyestuffs without a minimum amount of salt, sulfate, and, to a lesser degree, sodium carbonate.

By the quantitative examination of a dyestuff I understand the determination of these various ingredients as well as of the coloring matter proper.

Before going into details I venture to state as my personal opinion that this line of work is being neglected in most dyestuff factories. When a manufacturing chemist delivers a quantity of dye to be "Standardized" he is too often satisfied if said quantity yields a fair amount of "Type." Am I much mistaken when I say that the chemist in many cases does not know what this "Type" really consists of? A quantitative analysis of each of his "Types" would show the chemist just what degree of perfection his manufacturing process has reached. It would either give him the satisfaction of knowing that his process was good or be an incentive to him to improve it. In the case of a great many complex dyestuffs, for example, certain polyazo dyestuffs, the actual yield of dyestuff from given quantities of intermediates is really quite poor. A quantitative analysis of the finished dyestuff, as well as of the intermediate azo bodies, should be instructive and should be carried out in all cases of bad yields. It would obviously only be necessary to do this work once for each individual "Type" as all future lots could be compared to the "Type" by the usual dyeing tests.

The quantitative determination of sulfur present as sulfonic acid groups, or of the degree of saturation of these with soda or potash, or of halogen, if such be present in the molecule, would form a valuable addition to the knowledge gained by a purely qualitative analysis of dyestuffs such as the chemist is occasionally called upon to make.

I now would like to review the methods which we have used in Buffalo with a fair degree of success. While I do not claim any scientific perfection or absolute accuracy for them, they have not been found seriously wanting.

DETERMINATION OF MOISTURE

Certain water-insoluble dyestuffs such as oil-soluble azo dyes, lake colors, bromo acid, etc., contain none, or very little moisture.

The great mass of water-soluble dyestuffs contain moisture, partly loosely bound, and partly, and that I believe is the general rule, in the form of water of crystallization. It is interesting to observe the great tenacity with which even great quantities of water are retained by certain dyestuffs. This explains why the ordinary practice of drying organic compounds in a desiccator over sulfuric acid gives altogether too low figures for moisture when applied to dyestuffs. A sample of Wool Red 40 E lost in desiccator during 3 days 2 per cent in weight, while the same sample on drying to constant weight in an air oven at 125° C. showed a loss of 12 per cent. This could be illustrated by a great many examples. For purposes of determining the moisture content it generally suffices to place the dyestuff in an air oven held at 125° C., until constant weight is observed. The temperature of 125° C., or even higher, is generally tolerated by a dyestuff without any evidence of decomposition. It has been recommended to place the dyestuff for moisture determination in a tube through which a current of hydrogen or carbon dioxide is conducted while the tube is maintained at a constant temperature by being surrounded by vapors of a suitable liquid, for example, boiling toluol. These precautions are as a rule quite unnecessary except when dealing with easily oxidized dyestuffs.

DETERMINATION OF SODIUM CHLORIDE

When the dyestuff does not contain any halogen in the molecule or when it is not a hydrochloride, as in the case of basic colors, the salt determination is a simple matter. The general procedure is to mix the dyestuff intimately with from 5 to 10 times its weight of C.P. anhydrous sodium carbonate and heat this mixture in an iron crucible gradually to a dull red heat turning the mass over occasionally with a steel spatula until complete charring or partial combustion has taken place. The crucible content is, after cooling, mixed intimately with pure potassium nitrate in the proper ratio to insure an easy flux and the mass placed in the crucible again, where it is cautiously heated until complete oxidation and fusion have taken place. The crucible content is then taken up with water, filtered, acidulated with nitric acid, and the sodium chloride determined in the usual manner with silver nitrate.

When halogen is present in the molecule it must be determined separately and the sodium chloride calculated by difference. In the case of basic dyes like Methylene Blue or Safranine, I believe a direct titration of the dyestuff by means of a standard solution of an acid dyestuff, for example, Naphthol Yellow according to Knecht or by titanous chloride according to Knecht and Hibbert would be advisable. The titanous chloride titration is altogether very satisfactory for a great many simple dyestuffs, but fails in the case of more complex azo dyes.

DETERMINATION OF SULFATE OF SODA

This is not as simple as the salt determination and calls for greater ingenuity. Sometimes a direct precipitation in the acidulated solution of the dyestuff gives a fairly pure barium sulfate. As, however, a great many dyestuffs form hard soluble barium salts, the precipitated barium sulfate is often more or less colored. This can be corrected by washing the precipitate with warm ammonium carbonate whereby the color lake is decomposed into the ammonium salt of the dye which passes through the filter and barium carbonate which can be removed by dilute acid.

When the direct precipitation with barium chloride fails, it sometimes is a good plan to precipitate the dyestuff from its aqueous solution as thoroughly as possible with salt and determine the sulfate in the filtrate with eventual after-treatment with ammonium carbonate.

In some cases when the dyestuff cannot be "salted out," advantage can be taken of the fact that acid and basic dyestuff mutually precipitate one another. If, for example, the problem is to determine the amount of sulfate in Patent Blue or Acid Green a solution of a suitable basic color free from sulfates can be added to the solution of the acid color until a drop of the mixture placed on filter paper shows excess of the basic color. The condensation product is then filtered off and the barium sulfate precipitated in the filtrate. As a suitable basic color I prefer Chrysoidine, because it can be easily prepared free from sulfates.

By these various methods a determination of the sulfate of soda present in the dyestuff can be secured without a very high degree of accuracy.

DETERMINATION OF SULFUR AND SODIUM OR POTASSIUM

When the sulfate has been determined it is often of interest to determine the total sulfur present, including that residing in sulfonic acid groups. The fusion of $^1/_2$ g. or less of the dyestuff with soda and niter is generally more satisfactory than the classical heating in a sealed tube with nitric acid according to Carius.

The amount of sodium or potassium present in a dyestuff is easily found by moistening a small quantity of the sample in a porcelain or platinum dish, driving the sulfuric acid off by heating the crucible, and repeating this process until a perfectly white ash remains. This is then heated to a dull red heat and weighed as sodium sulfate.

After the chemist has made the series of quantitative determinations mentioned it should be possible by piecing them together to form a correct picture of the true composition of the dyestuff before him.

CHEMICAL MARKETS OF SOUTH AMERICA

By O. P. Hopkins, Washington, D. C.

CHEMICAL TRADE OF CHILE, PERU, AND BOLIVIA

Received August 27, 1918

The prosperity of Chile, Peru, and Bolivia depends primarily upon the output of minerals, and in this respect the group differs radically from Argentina, Brazil, and Uruguay, which were examined in connection with the trade in chemicals in the September number of This Journal. Sodium nitrate, copper, and tin are supplied by this group in enormous quantities and the value of these materials to the war industries of the belligerent countries is so great that the exporting countries have for the past two years been enjoying a prosperity that has transformed their whole economic life.

These countries are not, however, heavy importers of industrial chemicals. The market at present is confined largely to such articles as perfumery, medicines, paper, soap, and glass, and American manufacturers have succeeded in increasing their sales of these lines as the result of the shutting off of European supplies. The opportunity of the future lies in maintaining the advantage thus gained and developing the trade still further.

As in the previous review, there is a table showing the imports of each country, compiled from the original Spanish statistics, and more detailed tables showing the trade with the United States, based upon statistics published by the United States Bureau of Foreign and Domestic Commerce.

CHILE

The nitrate beds are the chief source of Chile's prosperity, affording the country one of the most valuable natural monopolies in the world. Copper has also come into its own again as a result of war demands and is exported in great quantities. Agriculture and stockraising are second in importance only to mining, and in recent years manufacturing has been developed rapidly, thanks to plentiful supplies of iron, coal, and timber, efficient labor, and ample water power. It is safe to assume that Chile will consume increasingly great quantities of industrial chemicals, although it is at present difficult to estimate what proportion will be imported. American goods in general are highly esteemed, but have not been pushed so energetically as have the goods from certain other countries.

Over $3,000,000 worth of chemicals, pharmaceutical products, and perfumery was imported in 1913, and of that total Germany furnished more than a third, or more than twice the amount supplied by the United States. Germany also had an advantage in dyes, paints, and inks, and maintained a striking superiority in paper and paper products. The United States supplied the bulk of the mineral oils.

The statistics in the following table are based upon official Chilean figures for the calendar years 1913 and 1915, the last normal and latest available war years, and serve principally to show the extent of the market before the war and the manner in which it was divided among the principal competing countries. The year 1915 shows a falling off all around from the normal year, as the country had not recovered from the depression and dislocation of trade that followed the outbreak of hostilities. Since that time the great demand for Chile's minerals has brought in an era of prosperity that has never been equaled in the history of the country.

CHILEAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1913	1915
CHEMICALS, PHARMACEUTICAL PRODUCTS, PERFUMERY		
Chemicals	$1,015,861	$ 623,200
Pharmaceutical products	1,688,444	810,782
Perfumery	336,740	125,093
TOTAL	3,041,045	1,559,075
Germany	1,044,837	132,292
United States	492,270	627,347
PAINTS, DYES, INKS	763,412	264,009
Germany	326,980	33,508
United Kingdom	285,500	135,630
United States	85,687	77,978
EXPLOSIVES	922,954	563,841
Germany	180,482	14,471
United Kingdom	346,010	148,282
United States	235,932	390,682
VARNISHES	171,301	81,182
United Kingdom	62,017	47,190
United States	52,700	25,357
INDUSTRIAL OILS	1,079,310	523,830
Germany	166,195	31,463
United Kingdom	439,305	122,616
United States	456,088	358,988
CRUDE PETROLEUM	4,405,727	3,712,768
United States	3,500,395	2,640,056
NAPHTHA PETROLEUM, GASOLINE, KEROSENE, PARAFFIN, FOR INDUSTRIAL PURPOSES	1,078,253	633,288
United States	1,061,825	620,592
PARAFFIN WAX	588,687	612,873
Germany	302,887	8,354
United States	143,643	560,329
SHEET AND PLATE GLASS	272,880	72,782
Belgium	151,386	6,347
United States	1,030	42,555
PAPER, CARDBOARD, AND MANUFACTURES OF	3,581,027	1,905,781
Germany	1,959,087	241,419
United States	463,573	413,164

The extent to which the present prosperity of the country has reacted upon the purchases of chemicals and allied products from the United States can be readily traced in the next table, in which gratifying gains are indicated for almost every item. The sales of American chemicals, drugs, and perfumery in the fiscal year 1917 easily surpass the German total previous to the war. Over $1,000,000 worth of business is noted for the "All other" group alone, and it is regrettable that further details are not available as to the articles included in that classification. The substantial gain in the imports of American dyes is an interesting and encouraging feature, as is the gain in receipts of American paper. Certainly it should be possible to retain much of this trade when the war is over.

Details of the imports from the United States are shown in the following table, which is based upon official American statistics for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN CHILE

ARTICLES	1914	1917
Aluminum and manufactures	$ 1,938	$ 17,197
Asphaltum and manufactures	50,347	30,090
Babbitt metal	11,231	61,936
Blacking, shoe paste, etc.	18,506	51,145
Celluloid and manufactures	117	8,285
Cement, hydraulic	35,807	112,397
Chemicals, drugs, dyes, etc.:		
Acids:		
Sulfuric	48,277	37,827
All other	3,415	71,869
Baking powder	10,663	25,676
Bark extract for tanning	251	21,963
Calcium carbide	72,289	78,296
Copper sulfate	1,385	38,828
Dyes and dyestuffs	893	116,646
Medicines, patent and proprietary	200,918	365,041
Petroleum jelly, etc.	840	20,320
Roots, herbs, barks	77	22,014
Soda salts and preparations	.....	211,691
All other	68,365	1,038,531
Clay, fire	58	9,340
Explosives:		
Cartridges, loaded	45,220	74,861
Dynamite	107,087	968,765
Gunpowder	5,270	10,266
All other	15,134	1,192,023
Glass and glassware	40,224	290,753
Glucose	14,808	18,182
Grease		
Lubricating	78,326	121,209
Soap stocks, and other	1,882	36,184
India-rubber manufactures	139,256	714,571
Ink	12,408	39,781
Leather, patent	56,305	313,639
Metal polish	2,028	4,136
Naval stores	68,897	164,848
Oilcloth and linoleum:		
For floors	1,117	17,322
All other	9,855	37,438
Oils:		
Animal	2,872	6,291
Mineral:		
Crude	118,500	67,224
Gas and fuel	1,365,661	2,826,963
Illuminating	1,028,155	399,860
Lubricating, etc.	418,279	561,225
Gasoline	166,724	97,955
Other light	12,412	462,703
Vegetable:		
Cottonseed	436,672	257,948
Linseed	2,598	31,197
Other fixed	11,982	148,343
Volatile	217	14,386
Paints, pigments, etc.:		
Dry colors	64	27,982
Ready mixed paints	26,829	55,912
Varnishes	10,712	23,520
White lead	725	14,108
Zinc oxide	.....	5,632
All other (including crayons)	22,763	102,737
Paper and manufactures	233,603	1,188,139
Paraffin and wax	92,098	577,644
Paste	203	3,599
Perfumery, cosmetics, etc.	25,437	51,844
Photographic goods:		
Motion picture films	5,268	13,904
Other sensitized goods	18,213	46,902
Plumbago and manufactures	2,297	27,295
Quicksilver	.....	409
Soap:		
Toilet	91,330	127,790
All other	16,290	27,560
Sugar, refined	687	9,618
Wax, manufactures of	1,145	6,687

Chile sent to the United States about $45,000,000 worth of sodium nitrate and an equal amount of copper in 1917, and it would be a difficult matter to overestimate the vital importance of these two materials to the cause of the Allies. The $4,000,000 worth of iodine was another valuable contribution, as was the $2,000,000 worth of tungsten ore. The shipments of tin ore and bismuth are to be credited to Bolivia, however, as they merely pass through Chile. The importance of Chile as a reservoir of war materials is made clear in the following table, which is based upon American statistics for the fiscal years 1914 and 1917:

CHILEAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Antimony ore	$ 8	$ 461,462
Bismuth	.....	11,627
Bones, hoofs, horns	.....	13,040
Chemicals, drugs, dyes, etc.:		
Argols	.....	108,160
Iodine, crude or resublimed	433,293	4,380,818
Potash:		
Nitrate	.....	77,720
Salts of	.....	18,751
Soda, nitrate	17,808,763	44,231,240
All other	.....	51,279
Copper:		
Ore	1,974,429	4,840,321
Concentrates	.....	40,764
Matte and regulus	2,004,898	2,645,973
Unrefined, black, etc	.....	35,779,947
Refined, in bars, etc	2,145,748	2,301,685
Glue and glue size	607	67,810
Hide cuttings, raw	.....	3,841
India rubber, unmanufactured	.....	392,624
Iron ore	7,829	50,145
Lead ore	91,994	178,503
Paper and products	.....	7,640
Platinum	.....	62,981
Tanning materials: Quebracho wood	.....	37,445
Tin:		
Ore	.....	2,708,373
Bars, etc	.....	24,401
Tungsten-bearing ore	.....	2,013,411
Wax:		
Beeswax	36,975	157,212
Vegetable	.....	8,063
Zinc, pigs	.....	485

PERU

Mining and agriculture are the chief industries of Peru. The mineral resources are varied and extensive, including copper, gold, silver, lead, quicksilver, coal, bismuth, vanadium, tungsten, nickel, iron, sulfur, antimony, petroleum, salt, zinc, borax, cobalt, gypsum, asbestos, ocher, kaolin, molybdenite, manganese, magnesia, mica, peat, and various marbles. Copper is extensively worked at present, with American capital heavily interested, but the silver output is also important, as it has been since the sixteenth century. Few of the other minerals are produced in anything like important quantities, so that it can be safely said that even today the mineral industry is only in its infancy.

Considering the proportion of the country that is either mountainous or desert, agriculture is surprisingly well developed, the principal products being sugar cane, cotton, coca, rice, and grapes. The total value of the crops of the country can be placed somewhere between 40 and 50 million dollars.

The manufacturing industries are not well developed, although the output of the sugar mills is now considerable and the domestic supplies of cotton and wool have led to the development of a prosperous textile industry.

Industrial chemicals are not required in large quantities, but there is a steady demand for many of the finer chemicals. In 1913 the imports of chemicals, drugs, medicines, and pharmaceutical supplies amounted to slightly more than $1,000,000, which was divided fairly evenly among American, German, French, and English manufacturers, the Americans leading with $291,000. In 1916 the imports were nearly $1,500,000, of which American manufacturers furnished very nearly $1,000,000 worth. American goods have always been in good demand in Peru, a circumstance that is usually explained as being a natural consequence of extensive investments of American capital in the mining industries of the country.

As will be seen in the following table, which is a compilation from official Peruvian statistics, none of the articles usually classed as chemicals is imported to the extent of $500,000 annually; in fact, patent medicines are the only item exceeding $300,000 in value. It will be noticed, however, that the American share of the imports has been substantially increased as a result of war conditions and there is no convincing reason why this business should not be retained and expanded when normal conditions are restored.

Of the classes of goods that can be considered as allied chemical products, "colors, paints, varnishes, oils, and gums" were imported in 1916 to the extent of more than $2,000,000, the United States having almost a monopoly of the trade. Mineral oils are the most important item in this group. Explosives and paper are both important, American manufacturers now dominating the market.

The table is based on statistics for the calendar years 1913 and 1916, the last normal year and the latest available war year. These figures should be used only as a general guide in estimating the extent of the markets and the relative share of the principal competing countries in the trade.

PERUVIAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1913	1916
CHEMICALS, DRUGS, ETC.		
Acids:		
Sulfuric	$ 5,161	$ 60,103
United Kingdom	307	20
United States	2,209	60,083
Tartaric	10,673	13,962
Germany	5,261	.....
United States	31	6,942
Disinfectants, prepared	24,536	35,715
Germany	3,205	.....
United States	18,205	35,355
Glycerin	6,029	7,135
United Kingdom	2,468	260
United States	64	6,255
Medicines, proprietary	348,950	327,343
France	108,037	34,763
United States	162,078	236,749
Methyl alcohol	21,180	4,547
Germany	21,180	.....
United Kingdom	.....	4,544
Quinine	131,437	90,747
France	49,790	8,972
United States	2,229	34,008
Soda ash	20,295	28,477
United Kingdom	17,378	13,071
United States	1,165	15,263
Soda, bicarbonate of	12,080	50,566
United Kingdom	6,159	2,551
United States	5,084	24,839
Soda, caustic	36,608	67,629
United Kingdom	25,980	8,319
United States	9,266	59,247
Sulfur	19,434	49,070
Italy	12,635	10,740
United States	292	29,855
COLORS, PAINTS, VARNISHES, OILS, AND GUMS	1,772,828	2,198,913
Germany	420,371	820
United Kingdom	301,602	277,591
United States	894,878	1,770,555

PERUVIAN IMPORTS, ETC. (*Concluded*)

ARTICLES	1913	1916
EXPLOSIVES	$ 516,851	$ 938,582
United States	201,221	886,390
Dynamite, etc	325,512	755,816
United States	160,317	755,816
PAPER, CARDBOARD AND OFFICE SUPPLIES		
Total imports	914,862	1,312,900
France	54,044	74,980
Germany	403,723	10,000
United Kingdom	104,637	127,823
United States	234,000	787,851
Newsprint paper	189,386	307,641
Germany	128,355	900
Norway		5,621
Sweden		4,881
United States	56,894	286,869
Book and lithographic paper	78,897	120,490
Germany	33,734	749
United Kingdom	15,964	23,590
United States	10,618	90,268
SHEET AND PLATE GLASS	28,781	53,889
Belgium	24,956	
United Kingdom	1,158	4,542
United States	199	47,025

The character of chemicals and allied products sold in Peruvian markets by American manufacturers can be determined more accurately from the following table, which is based upon official American statistics for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN PERU

ARTICLES	1914	1917
Aluminum and manufactures	$ 276	$ 17,605
Babbitt metal	4,949	13,500
Blacking, shoe paste, etc	4,526	19,896
Candles	275	3,329
Celluloid and manufactures	121	8,434
Cement, hydraulic	109,902	125,367
Chemicals, drugs, dyes, etc.:		
Acids:		
Sulfuric	4,679	21,274
All other	103	31,729
Baking powder	1,420	3,604
Calcium carbide	22,787	19,364
Copper sulfate	....	4,523
Dyes and dyestuffs	2,635	94,775
Medicines, patent and proprietary	197,320	245,373
Petroleum jelly, etc	245	7,497
Roots, herbs, barks	....	5,317
Soda salts and preparations	....	80,892
All other	81,132	377,924
Chewing gum	143	5,475
Explosives:		
Cartridges, loaded	17,508	47,577
Dynamite	56,284	219,771
Gunpowder	....	45,925
All other	26,221	382,487
Flavoring extracts and fruit juices	34	7,738
Glass and glassware	18,986	156,485
Glue	468	3,347
Grease:		
Lubricating	24,351	17,912
Soap stock and other	3,372	9,773
India rubber manufactures	44,155	156,593
Ink	3,614	23,427
Leather, patent	17,963	100,962
Lime	....	3,183
Naval stores:		
Rosin	22,795	34,257
Tar, turpentine, pitch	495	4,807
Turpentine, spirits	17,966	32,923
Oilcloth and linoleum	1,726	17,535
Oils:		
Animal	136	2,417
Mineral		
Gas and fuel	....	89,563
Illuminating	73,357	13,427
Lubricating, etc	67,939	144,283
All other	262,121	565
Vegetable		
Cottonseed	458	8,042
Linseed	948	26,318
Other fixed	2,006	28,753
Volatile	283	3,176
Paints, pigments, etc		
Dry colors	5,511	11,670
Ready-mixed paints	12,355	19,384
Zinc, oxide	....	2,096
All other (including crayons)	2,189	53,060
Paper and manufactures	80,745	681,111
Paraffin and paraffin wax	22,745	255,178
Perfumery, cosmetics, etc	44,791	108,710
Photographic goods:		
Exposed motion-picture films	....	7,773
Other sensitized goods	12,324	19,082
Plumbago and manufactures	477	16,822
Soap:		
Toilet	6,868	85,555
All other	15,069	13,408
Stearin, vegetable	....	4,752
Sugar and molasses	12	100,489
Wax and manufactures	855	5,458

Copper is easily the most important of the materials now shipped to the United States by Peru, as the next table shows, the exports having been greatly stimulated by the war. Other important items are cane sugar, mineral oil, tungsten ore, and India rubber. The tin originates in Bolivia. The following table is compiled from American statistics for the fiscal years 1914 and 1917:

PERUVIAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Antimony ore	$	$ 5,378
Chemicals, drugs, dyes, etc		
Colors or dyes	.....	6,456
Glycerin, crude	.....	2,930
Soda, cyanide	.....	2,190
Copper:		
Ore	751,582	833,085
Concentrates	.....	60,778
Matte, regulus, etc	866,211	306,939
Unrefined, in bars, etc	6,597,499	20,684,121
India rubber, etc.:		
Balata	....	4,400
Gutta-percha	.....	1,275
India rubber	427,092	1,227,776
Lead	.....	44,717
Oils:		
Crude mineral	506,535	261,039
Refined mineral:		
Benzine, gasoline, naphtha	867,020	1,395,453
All other	.....	146,514
Sugar, cane	181,519	3,576,707
Tin:		
Ore	.....	18,115
Bars, etc	.....	6,688
Tungsten bearing ore	....	1,073,001
Wax, Beeswax	.....	5,411
Zinc	.....	2,720

BOLIVIA

Bolivia's wealth lies in mineral deposits, and it is estimated that more than $2,000,000,000 worth of metals have been taken from the country since the coming of the Spaniards in the sixteenth century. Gold and silver were formerly recovered in immense quantities, but of the total mineral production of $27,000,000 in 1912, over $23,000,000 was tin. The silver output the same year was something more than a million and a half, while the gold production was practically nil. Nearly $1,000,000 worth of bismuth was recovered, which represents a large part of the world's production. As a source of tin Bolivia is now second to the Malay peninsula. The immense forests have not been exploited nor has agriculture been developed, although there are unlimited possibilities in that direction. Aside from the reduction of tin ore there is very little activity that can be classed as manufacturing.

Naturally there is little demand for chemicals or chemical products, but such imports as were recorded by the Government for 1913 and 1915 are shown in the following table. There seems to be little possibility of developing a trade in these lines in the near future.

BOLIVIAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1913	1915
CHEMICAL PRODUCTS	$ 49,830	$ 5,273
Germany	19,356	232
United States	4,876	3,295
PREPARED MEDICINES	162,704	88,075
Germany	52,982	4,391
United States	27,816	19,340
PERFUMERY AND COSMETICS	58,295	12,735
Germany	17,291	390
United States	13,922	2,164
SOAPS	109,687	95,133
United Kingdom	55,373	61,737
United States	4,814	5,844
PAINTS, DYES, VARNISHES	127,619	20,870
Germany	61,811	2,847
United States	6,272	2,668
EXPLOSIVES	446,316	312,090
Germany	362,705	329
United States	5,145	143,130

BOLIVIAN IMPORTS, ETC. (*Concluded*)

ARTICLES	1913	1915
MINERAL OILS AND THEIR DERIVATIVES	$ 86,403	$234,630
Germany	20,533	7,288
United States	21,116	118,683
VEGETABLE OILS, EDIBLE	14,124	17,870
Italy	4,536	6,590
United States	521	4,048
OILS, OTHER	47,232	8,456
Germany	14,823	48
United States	11,146	6,254
SHEET AND PLATE GLASS	46,664	18,337
Germany	21,078	121
United States	5,129	9,437
GLASSWARE	103,845	21,518
Germany	53,500	3,232
United States	6,576	6,261
PAPER AND CARDBOARD (EXCEPT WALL PAPER)	167,391	91,012
Germany	70,353	6,598
United States	15,742	28,790
MANUFACTURE OF PAPER (EXCEPT BOOKS)	31,914	14,138
Germany	15,562	1,629
United States	414	1,516

How the war has affected what little trade American manufacturers have with Bolivia can be ascertained from the following table, which is compiled from American statistics for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN BOLIVIA

ARTICLES	1914	1917
Blacking, shoe paste, etc.	$ 1,136	$ 4,642
Candles	...	3,841
Cement, hydraulic	...	1,781
Chemicals, drugs, dyes, etc.:		
Acids	119	4,423
Calcium carbide	573	364
Medicines, patent and proprietary	23,792	13,208
Soda salts and preparations	...	9,561
All other	4,600	29,334
Explosives:		
Cartridges, loaded	6,622	23,768
Dynamite	...	72,044
Gunpowder	...	12,556
All other	26	42,217

AMERICAN PRODUCTS SOLD IN BOLIVIA (*Concluded*)

ARTICLES	1914	1917
Glass and glassware	$ 7,895	$19,469
Grease, lubricating	1,933	5,464
India-rubber manufactures	...	31,618
Leather, patent	1,475	5,024
Oils:		
Refined mineral:		
Gasoline, etc.	1,998	4,494
Illuminating	16,647	22,199
Lubricating, etc.	20,583	36,026
Naphthas, etc.	1,998	59,797
Vegetable:		
Cottonseed	22	6,123
Linseed	233	2,353
All other	187	6,862
Paints, pigments, etc.:		
Ready-mixed paints	2,647	1,236
White lead	...	23,688
All other	1,619	7,095
Paper and manufactures	83,227	66,405
Paraffin, etc.	720	85,045
Perfumeries, cosmetics, etc.	1,830	3,685
Soap:		
Toilet	7,050	15,914
Other	330	5,781
Sugar, refined	6	817

The statistics supplied by our own Government do not show many imports from Bolivia, as shipments are made from the Pacific and Atlantic ports of neighboring countries and consequently credited to them. Of the nearly $3,000,000 worth of tin ore imported into the United States during the fiscal year 1917, practically all was credited to Chile in our statistics. Such imports jumped to $10,000,000 in 1918. Imports of bismuth were valued at $196,000 in 1917, of which $32,000 worth is credited to Argentina, Chile, and Uruguay, and is obviously of Bolivian origin. The preliminary statistics for the fiscal year 1918 do not show imports of bismuth.

ORIGINAL PAPERS

VALUATION OF RAW SUGARS[1]

By W. D. HORNE

In the sugar trade it has long been customary to buy and sell raw sugars on their polarization, adopting usually a basis of 96° for centrifugal sugars and 89° for muscovado and molasses sugars. For every degree above the basis a certain additional increase is paid, while for each degree below the basis a double deduction is made.

This system, while based on practical considerations and having much to recommend it, is still far from satisfactory, because it does not take sufficient account of the many influences on refining of sugars introduced by their endless variations.

Efforts have therefore been made in recent years to attempt a rough standardization of raw sugars on the part of some of the advanced manufacturers. Such methods consist of grading the sugars according to the size of grain, hardness of grain, cleanliness of solution, odor, and reaction, as well as polarization and moisture, with perhaps some other determinations.

Admirable as these efforts are, they still fall far short of what is desired, for they are based on assumptions which frequently are not borne out in practice and entirely overlook many important variations in raw sugars which radically affect their value for refining purposes.

It is the object of this paper to direct attention to the practical considerations involved in valuation of raw sugars for refining purposes and to suggest some amplifications of the tests applied, with the hope that it may lead to a full discussion of the subject and in the belief that closer attention to the points involved must inevitably lead to greater efficiency of manufacture with a consequent decrease of wasteful operation in both manufacture and refining.

The refining value of a raw sugar depends upon its content of sucrose and the availability of that sucrose, as modified by the nature and quantity of the impurities. The nature of the impurities will determine the ease of their separation from the sucrose during refining.

Refining consists principally of (1) affination or washing the residual mother liquor of the raw sugar massecuite from the solid grain of the sugar; (2) defecation and filtration, to remove insoluble substances and some soluble impurities from the solution of the washed sugar or from the dilute washings; (3) decolorization by boneblack or other means; (4) crystallization and separation of pure sugar from the other constituents.

The response of any raw sugars to tests for the first three of these operations can be determined readily

[1] Read before the Division of Industrial Chemists and Chemical Engineers, 56th Meeting of the American Chemical Society, September 10 to 13, 1918.

by operations herein described, giving a far closer grading of the sugar in its refining value than by the data at present supplied.

The proposed tests are novel only in some details and in their immediate application to a precise valuation of raw sugars on a strictly mathematical and therefore scientific basis.

The object of washing the raw sugar is to remove the film of low-testing molasses from the surface of the grains. A 96° polarizing sugar is usually crystallized from a solution having a purity of something less than 80, and the separation of the sucrose in crystals leaves a mother liquor of between 60 and 70 purity. Purging the massecuite in centrifugals removes, it is true, a large part of this syrup, but unless the sugar crystals are sprayed with water or a sugar solution in the centrifugal machine, an appreciable amount of this mother liquor remains adherent to the crystals.

As the object of refining is to separate the impurities from the sugar as promptly and thoroughly as possible, the first operation of refining consists of washing this residual mother liquor from the faces of the sugar crystals, and the condition of the crystals is a factor of great importance in this purification. An even grain of large size is the easiest to cleanse. Small crystals present relatively more surface than larger ones, carrying more syrup, requiring larger amounts of wash water, and present greater resistance to the purging of the sugar. They also dissolve more freely in the wash water or sugar solutions used for mixing and washing, thus decreasing the yield of washed sugar and increasing the amount of washings. This carries relatively pure sugar off into impure washings and increases the labor of its recovery. Small grained sugars are slow to purge and are a detriment to rapid work.

Clustered grain is another objectionable feature as these conglomerates hold a certain amount of low mother liquor which refuses to wash out.

The purity of the grain itself is of fundamental importance for if that is not of high test, no amount of washing will yield a washed sugar of the desired quality.

All raw centrifugal sugars should be boiled from clean solutions of sufficient purity to insure a nucleus of the purest type, ranging over 99 in test. This can best be done by starting grain on concentrated juice, building up later if need be with syrups or mother liquors from other sugars.

If a second or third sugar is used as seed grain the resulting crystals will contain more impurity and can never be washed up to the highest purity.

One of the best attempts at regulating the production of raw sugar so as to meet reasonable requirements of refiners, has been made by the Cuban-American Sugar Company. Their tests include size of grain, taking a diameter of a little less than a millimeter as standard; hardness of grain, as observed when rolled between the thumb and finger; odor, divided into normal, musty, fruity, and sour; cleanliness, as indicated by the milligrams of insoluble matter per 100 g., or by the turbidity of 5 g. dissolved in 25 cc. of water, as well as polarization and moisture.

The hardness of grain is at best a questionable factor. Its solubility is what counts, and the smaller it is the more it dissolves. The refiner wants to know what yield will be had of washed sugar in washing any particular sample and how pure the washed sugar will be. The more directly and accurately these facts can be determined, the more useful the information will be.

In working out this question the matter of first importance was to adopt the proper liquid for washing the raw sugar. Water is not suitable as it dissolves too much of the grain. A pure sugar solution has the objection of tending to obscure the difference between high and low sugars through adding to each approximately the same absolute amount instead of the same relative amount of pure sugar. What I have found to be more satisfactory is a saturated solution of the raw sugar itself. This has the advantage of dissolving none of the grain and removing practically all of the mother liquor from the crystals, and finally of altering to a minimum degree the purity of the washed sugar. The only other method would be to use an alcohol washing method or its equivalent, or to use a syrup or molasses obtained by working back and washing several times, both of which are too slow. The low molasses also becomes too viscous to use to advantage.

The method used is to mix 100 g. of the raw sugar with 45 cc. of water, shake 10 min. to saturate, let settle, and decant 92 cc. of the resulting solution upon 200 g. of the raw sugar. This is well mixed into a magma and purged in a small laboratory centrifugal.

In the experiments here referred to, a 5-in. cyclone centrifugal has been used, with which about $^1/_2$ min. is needed to get up full speed. Two minutes' steady running after this is all that is needed, making about 9 revolutions of the handle shaft each 10 seconds.

The sugar is thus made comparatively dry, and the yield of washed sugar is found by weighing the basket with the purged sugar in it.

The sugar is then removed, dried 2 hrs. at 98° C. in a water-jacketed air bath, and polarized. A good centrifugal sugar, not mixed with seconds, will polarize about 99.4, which, of course, is the purity of the washed crystals, and the ordinary centrifugal sugars, such as constitute the greater part of the present-day supply, will have a purity of at least 99°. This is in exact accord with refinery practice, showing that the method above described gives as pure a washed sugar as that obtained under working conditions, where clear water is used in the final washing in the centrifugals.

Washing an ordinary 96° centrifugal sugar yields washings of 75° to 80° purity, or thereabouts, and it is highly desirable that all of the impurities possible should be separated from the grain and forced into the syrup, for these two are handled separately and each additional pound of impurities that hangs back in the washed sugar necessitates just so much extra work for its final elimination. A pound of impuri-

ties will lose about 0.4 of its mass in the boneblack, and carry with its remainder about 0.4 lb. of sugar into residual syrup, having a purity of about 40°. In washings of 80° purity only about $2^1/_2$ boilings or crystallizations are necessary to effect this separation, whereas in washed sugar of 98° purity 6 or 7 boilings and crystallizations with all the correlated operations will be necessary to eliminate the impurities. In a washed sugar of 98° purity, therefore, as compared with one of 99° purity taken as standard, there will be 1 per cent of the mass which will have to be boiled, etc., four extra times. It follows that each 1 per cent of impurities above the normal 1 per cent left in the washed sugar costs the refiner 1 per cent × 4 × the cost of boiling, etc., × price per lb. of raw sugar above the basic price of raw sugar, and should be valued accordingly. Conversely, a sugar washing up to 99.5° purity under standard conditions is 0.5 per cent × 4 × boiling cost × price per lb. of raw sugar less expensive to refine than the normal and should be valued in accordance.

The second point to be taken into account is the amount of defecation required and the speed of filtration. These two items are rather closely related, as no raw sugar solutions will filter clear unless defecating material be added to flocculate the fine suspended impurities into masses sufficiently large to be caught in the meshes of the filter cloth or other medium employed. Raw sugars require differing amounts of defecant and consume widely varying lengths of time for filtration.

It has always been customary to neutralize any acidity with lime added in a thin cream. Formerly the flocculation required was obtained by adding blood from slaughter houses to the solution before heating to the coagulating point of serum, then raising the temperature and causing a strong flocculation.

Later, phosphoric acid and acid phosphate of lime came into vogue and these, neutralized with lime, proved very satisfactory when using filtering bags. But the rapid work done in the beet sugar industry in filtering carbonate of lime in filter presses could not be followed in sugar refining on phosphate of lime because this precipitate is soft and chokes up the cloths when subjected to the high pressure necessarily used in the filter press.

Now, in the past few years, a suitable defecant for use in filtering sugar solutions through filter presses has been found in the great deposits of infusorial earth at Lompoc, Cal. One vein of this deposit, after special processes of treatment, is now being largely used, under the name of Filtercel, by nearly all the refiners of the country. But despite the most careful treatment in defecation, some raw sugars will filter very slowly, delaying the operations of a refinery sometimes in an exaggerated and very costly manner. Such sugars are commonly called gummy, and frequently indeed they give an excessive amount of precipitate when treated, in solution, with an excess of alcohol and a little acetic acid. These sugars are in fact very common and their objectionable quality is quite evidently due to the improper defecation of raw cane juice, a matter that is capable of nearly complete correction, and that at almost no added expense. Some raw sugars, on the other hand, filter very slowly, although containing no excessive gummy matter, probably from high sulfates, from clay, and other causes.

In order to determine the relative filterability of a raw sugar, it has been found best to use a 45 per cent solution defecated with the minimum amount of acid calcium phosphate and made slightly alkaline with a standard sucrate of lime. Into 18.1 cc. of this solution, representing 10 g. of raw sugar, introduce 0.2 cc. of a solution of acid calcium phosphate made up to contain 1 per cent P_2O_5. This will represent 0.02 per cent P_2O_5 on the dry sugar. Then add saccharate of lime standardized against the P_2O_5 solution so as to balance it volume for volume when using phenolphthalein, until the solution is just faintly alkaline to litmus. This is heated to boiling in a test tube and allowed to settle while inclined at 45°. Other tubes are rapidly prepared in succession, using 0.03 per cent P_2O_5, 0.04 per cent, and so on, noting the minimum amount which gives a clear supernatant liquor.

After thus determining the minimum amount of defecant that will give a clear solution by this preliminary trial, one adds the indicated amount of acid phosphate and lime to 100 cc. of the 45° Brix sugar solution, heats gradually to 190° F., lets stand half a minute off the hot surface, and pours slowly in a small stream upon the top of the triple thickness of a 6-in. bag filter cloth folded like a filter paper in a 3-in. perforated brass cone, with about 625 holes per sq. in., setting loosely by means of attached lugs, in a vulcanite funnel with no stem. In about $^3/_4$ minute, when the transfer is complete, the cloth is closely covered with a watch glass. The time is observed which is required for the filtration of 70 cc. If the cloth is of the right structure this filtrate will appear clear.

Excessive amounts of defecant retard rather then aid filtration.

In the refinery the column of liquor constantly rises in the bags, while in this test the column, after the short period of introduction, constantly sinks, so that conditions are quite different, and while they cannot be directly compared, there is found to be this relation—that the slower the solution is to filter in the refinery the longer the time required for 70 cc. to pass through the small filter cloth. In sugar solutions that filter freely this test portion will run through in 5 min. or less. In medium sugars from 5 to 10 min. will be taken, while poor sugars require 10 to 15 min., and bad samples take from 15 to 20 min., or even longer.

As a very slow filtering sugar may easily increase the time of filtration in the refinery to 120 per cent of the normal, it follows that time lost may be approximated by adding 7 per cent to the normal time for each additional 5 min. in the experimental filtration test. The percentage of excess time multiplied by the price of a pound of raw sugar multiplied by the cost of normal filtration will give approximately the correction to be deducted from the basic price

to arrive at the refining value of a slow filtering sugar.

The third item to be taken into account as affecting the value of a raw sugar is its readiness to yield up its color on filtration through boneblack or on subjection to any other decolorizing process. After all, refining sugar is principally decolorizing it, and any system of standardization or valuation of raws which ignores this important feature is lacking in one of the essential details.

Sugars may be of a wide range of shades and from many causes, as the variety of cane, burnt cane, caramelization during manufacture, over-liming, working back molasses and second or third product sugars, contamination by iron salts, and so on. Some of these coloring matters are more easily absorbed than others and their absorption by different agents varies widely. For instance, the natural color of cane juice is only slightly absorbed by boneblack, while Norit absorbs it quite freely; and this latter agent takes up 95 parts of color due to the action of lime on invert sugar as easily as it absorbs 23 parts of color due to caramel.

These and other considerations render an empirical test desirable, based on general common practice. Such a determination of the decolorability of a raw sugar by boneblack, for instance, may be arrived at by dissolving 10 g. of raw sugar in 30 cc. of water, adding 0.25 g. of Filtercel and 2 g. of the best boneblack ground finer than 60 mesh, bringing all gently to a boil, and filtering through paper. A similar test, made as the first is, but without boneblack, affords the basis of comparison. After reading the colors of the filtrates either against a tintometer standard or by comparing the depths of columns to give equal colors, one may readily calculate the amount of color absorbed by the boneblack.

It will be found that a fair average sugar will yield about 75 per cent of its color in this test, and any greater amount yielded means a proportional economy in char work required, while a smaller absorption designates a larger amount of char work that will be required. One can easily calculate the amount to be added to or deducted from the basic price of a sugar to arrive at its value in respect to filterability. Thus a sugar giving up only 60 per cent of color instead of 75 per cent should have $^{15}/_{60}$ of the normal char filtering expense deducted from the basic price to recompense for the extra expense that will be entailed in its char filtration.

Other factors might be taken into account, as the amount of ash in the raw sugar, but as under present conditions it is of less importance how much melassigenic ash there is than how much time and labor will have to be expended in refining the sugar, these factors may, for the present, be disregarded.

The extra refining expenses enumerated in the above examples are very small, it is true, and would occur in relatively few cases, but with upward of $600,000 worth of raw sugar entering the port of New York alone, daily, even small decimals add up to large aggregates and are certainly worth taking into account.

Just now there is so ready a market for all raw sugar that competition in its sale is slight, but when the present stress is over and Europe resumes her large production there will be a great surplus, with corresponding competition to sell. Then the purchaser will pick and choose what suits him best, and it is the part of caution for the raw-sugar maker to consider what class of sugars will be most desired and to manage his manufacture accordingly. It is in the hope of assisting in this very particular discrimination that these suggestions are presented.

YONKERS, NEW YORK

ON THE PREPARATION OF AN ACTIVE DECOLORIZING CARBON FROM KELP[1]

By F. W. Zerban and E. C. Freeland

Dr. J. W. Turrentine, in charge of the United States Experimental Kelp Potash Plant at Summerland, California, has for several years been engaged in working out methods for the commercial utilization of the giant kelps of the Pacific Coast. During the course of his investigations it occurred to him that the char obtained in the manufacturing process used might perhaps be converted into a decolorizing carbon. It appears, however, that this question was not taken up actively, until one of the authors of this article conceived the same idea, while engaged in a study on carbons that might be used in the cane sugar industry. At his request, Dr. Turrentine sent him some dried kelp to experiment with. In the first test the kelp, after thorough drying and grinding, was carbonized in an iron retort provided with an outlet for gases, until no more fumes were given off. The char was then transferred to a closed iron receptacle and heated for 2 hrs. to a bright red heat. It was then cooled, boiled out with hydrochloric acid, washed with water, and dried. Upon examination it was found that the resulting carbon reduced the color of a molasses test solution to about one-third of that obtained by using an equal quantity of our standard carbon, Norit. A sample of kelp char, also received from Dr. Turrentine, when treated in a similar manner as the dried kelp, produced only a very poor carbon. We therefore decided to investigate this matter more thoroughly, and at our request Dr. Turrentine very kindly furnished us an ample supply of raw material for our further experiments, and we wish to express to him our thanks for this courtesy, as well as for the great interest he has taken in the progress of our work. The material received consisted of three different samples. The first, A, was kelp (*Macrocystis pyrifera*) dried in a rotary kiln; the second, B, was "incinerated" kelp, prepared as described below; and the third, C, was a sample made by subjecting kelp to destructive distillation. The last sample was kindly sent to us through Dr. Spencer, who was investigating the destructive distillation of kelp at the Forest Products Laboratory, Madison, Wisconsin. None of the three samples had been leached with water.

[1] Presented before the Division of Industrial Chemists and Chemical Engineers at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

Upon investigation it was found that there are three factors which have an important effect on the properties of the final product sought. First of these is the particular point in the process at which the soluble salts and other ash constituents are removed. The second is the method by which the material is carbonized. We used two different ways with Sample A. In one experiment it was charred in an open iron saucepan over a gas ring burner, until fumes ceased to come off and the material was thoroughly carbonized. In other tests the process was conducted in a half gallon, heavy iron retort with a descending iron condensing tube about $1/2$ in. in diameter and 3 ft. long. This was heated over a gas ring burner. Sample B, which was a char, had been prepared by feeding dried kelp into a revolving "incinerator," setting it on fire, and after it had been heated sufficiently, cooling it rapidly by quenching. Sample C was only partly carbonized, having undergone destructive distillation at a temperature not exceeding 314° C.

The third factor is the temperature to which the char, obtained by carbonization, is heated in a closed receptacle. We effected this final heating in an iron cylinder made from a nipple of 2-in. pipe, closed at both ends by screwed-on iron caps. This cylinder was placed in a muffle furnace commonly used for making ash determinations in sugar products, and which produces a maximum heat of about 800° to 900° C.

The three factors mentioned will be taken up in detail in this paper. The decolorizing effect on sugar products of the various carbons made was determined by the following method: 5 g. of the carbon under examination are added to 200 cc. of a 3 per cent solution of a stock sample of low-grade molasses. The solution is brought just to the boiling point and at once filtered through a folded filter. The decolorized solution is then compared colorimetrically with one obtained under the same conditions, but using 5 g. of Norit instead of the carbon. The color of the solution obtained by means of Norit is used as a standard and is called "1." Carbons more effective than Norit will give figures below "1" and those less effective figures above "1". The reciprocals of the figures give a direct measure of the effectiveness of the carbon as compared with Norit.

EFFECT OF LEACHING

A part of each sample, A, B, and C, was boiled out several times with water, thoroughly drained, and again dried. Parallel experiments were then made with both leached and unleached material. The following table gives the tests and their results:

Treatment	Color of Solution Decolorized with Carbon from: Leached before heating	Not leached before heating
A, charred in retort, heated to bright red heat in closed iron cylinder, boiled out with water	5.00	2.86
A, charred, heated to bright red heat, boiled out with acid, then water	2.78	1.25
B, heated to bright red heat, boiled out with water	2.56	1.37
B, heated to bright red heat, boiled out with acid, then water	1.47	0.34
C, heated to bright red heat, boiled out with water	3.57	3.33
C, heated to bright red heat, boiled out with acid, then water	1.85	1.37

The table shows that the better carbon is always obtained from the unleached material, and, in fact, the only carbon that is better than Norit, and considerably so, was prepared from material that was not treated with any solvent until after it had been brought to red heat. We may conclude from this that if our object is to make an active carbon, none of the mineral matter must be removed before heating the material to red heat.

EFFECT OF METHOD OF CARBONIZATION

The way in which the kelp is carbonized is almost of as great importance as the question of leaching. The different methods of charring have already been described above. It is very difficult to carbonize the kelp in the iron retort always under the same conditions on account of varying gas pressure and because the condensing tube often gets more or less clogged with tarry products, thus preventing the free escape of the fumes. The effect of these factors which were not under control is strikingly shown in the figures below.

Treatment	Color
A, carbonized in an open saucepan, then heated to bright red heat in closed cylinder, boiled out with acid, then water	0.28
A, carbonized in iron retort, then heated to bright red heat, boiled out with acid, then water	0.31
Same, other experiment	0.50
Same, other experiment	0.75
Same, other experiment	1.25
B, heated to bright red heat, boiled out with acid, then water	0.34
C, heated to bright red heat, boiled out with acid, then water	1.37
C, first completely carbonized in open saucepan, heated to bright red heat, boiled out with acid, then water	1.70

These experiments show that the best results are obtained when the raw material is carbonized quickly at a comparatively high temperature and in such a way that the fumes can freely escape. Carbonization alone, however, is not sufficient to make an active decolorizing carbon, as is shown by the fact that Sample B itself, without first being heated to red heat, produced a color of 3.70 when extracted with water, and of 1.56 when extracted with acid and then washed with water. Sample C gave 3.85 and 1.72, respectively.

EFFECT OF TEMPERATURE TO WHICH THE MATERIAL IS HEATED AFTER CARBONIZATION

Three series of experiments were made to test this question, two (1 to 4 and 5 to 8) with char obtained by carbonizing Sample A in the iron retort at low temperature, and another with Sample B as received (9 to 11).

No.	Treatment	Color
1	A, carbonized in iron retort, heated to full red heat, boiled out with water	2.86
2	A, carbonized, heated to medium red heat, boiled out with water	3.23
3	A, carbonized, heated to low red heat, boiled out with water	3.57
4	A, carbonized, heated to barely red heat, boiled out with water	4.17
5	A, carbonized, heated to full red heat, boiled out with acid, then water	1.25
6	A, carbonized, heated to medium red heat, boiled out with acid, then water	1.52
7	A, carbonized, heated to low red heat, boiled out with acid, then water	1.47
8	A, carbonized, heated to barely red heat, boiled out with acid, then water	1.72
9	B, heated to full red heat, boiled out with acid, then water 0.34 and 0.30, average	0.32
10	B, heated to medium red heat, boiled out with acid, then water	0.62
11	B, heated to low red heat, boiled out with acid, then with water	1.43

We find that within the temperatures at which tests were made the best carbon is obtained by heating to the highest temperature, full red heat. It is possible and even probable that still better carbons might be prepared by heating to even higher temperatures, but this would hardly be of practical interest. One experiment was made in which a quantity of B was heated in a clay crucible in a Fletcher furnace, but observation showed that the temperature was not any higher than we could obtain with the iron cylinder in the muffle furnace. The resulting carbon, after washing with acid and water, produced a color of 0.36, which is very close to the 0.32 shown in the above table for the muffle heated carbon.

Another experiment was carried out in order to see whether a good carbon could not be made in one operation. The iron cylinder described above was filled with dried kelp, and one of the caps was only screwed on loosely, so that the fumes might escape, without giving the air free access to the char. After heating to full red heat the carbon was boiled out with acid, and washed with water. It produced a color of 0.75, and was therefore much less effective than the carbon produced in two operations.

We have also found that it is not necessary to extract the carbon directly with hydrochloric acid. The water-soluble salts can first be removed with this solvent, and the greater part of the remaining ash is then dissolved with hydrochloric acid, after which the acid is again washed out with water.

Summarizing briefly, our tests have shown that a carbon which has a much greater decolorizing power than Norit can be prepared in the laboratory by quickly carbonizing dried Pacific Coast kelp in such a way that the fumes can freely escape. After they cease to come off, the char is transferred to a closed iron receptacle and heated for 2 hrs. or so to red heat. Instead of charring dried kelp, "incinerated" kelp may be used directly. The carbon is then boiled out either with dilute hydrochloric acid, or first with water and then acid. This is again washed out with water, and the carbon dried. It remains to be seen whether the process can be worked successfully and economically on a large scale, and whether the price to be gotten for the finished product will warrant its manufacture. The most logical place to work out the first problem is the United States Experimental Kelp Potash Plant in California, and we hope that the Bureau of Soils may be willing and able to take up this project.

The great decolorizing power of the kelp carbon is probably due to two factors. We had found before that active decolorizing carbons can be prepared from cellulose materials by first impregnating them with either infusible substances like lime, alumina, silica, or else with such substances as chlorides, etc., which are volatile at the temperature at which the carbon is made. In all these cases the carbon must be heated to red heat to get good results, and the impregnating substances must then be removed with proper solvents. In the particular case of potassium chloride as impregnating substance the carbon obtained was rather poor, and the potassium chloride content of the kelp alone would not explain the decolorizing power of the kelp carbon. There is also too little infusible ash to account for it. However, a distinguishing feature of kelp is its high nitrogen content, and it seems reasonable to suppose that this is largely responsible for the great effect of kelp carbon. The great decolorizing power of carbons made from highly nitrogenous materials, like blood charcoal, or the carbon made from the residues of the manufacture of ferrocyanide and from similar materials has long been well known. We noticed that in every case where we obtained a good carbon from kelp, prussian blue was formed when the carbon coming from the muffle was extracted with hydrochloric acid. It imparted to the wash waters a deep blue color, being dissolved in colloidal form. The rôle played by the nitrogen is not known definitely, but the effect of its presence is quite plain.

SUMMARY

It is shown in this paper that under proper conditions a decolorizing carbon much more effective than Norit can be prepared from Pacific Coast kelp. The factors affecting the decolorizing power of the carbon are discussed, and a method for making the most effective carbon is described.

LOUISIANA SUGAR EXPERIMENT STATION
NEW ORLEANS, LOUISIANA

THE ROLE OF OXIDASES AND OF IRON IN THE COLOR CHANGES OF SUGAR CANE JUICE[1]

By F. W. ZERBAN

If the methods now being used in the manufacture of white sugar directly from the cane are to be placed on a strictly scientific basis, it will be necessary to gain a more accurate knowledge of the coloring matters which have to be removed or the formation of which has to be avoided. A great deal of work has already been done in this direction, but much more still remains to be done. Any such investigation must first take into consideration the coloring matter found in the cane itself and in the raw juice obtained from it by applying pressure or diffusion.

Previous investigators have found that the cane contains chlorophyll, saccharetin, and, in the case of dark-colored canes, also anthocyanin. Neither the chlorophyll nor the saccharetin dissolve in the juice upon milling, but pass into it mechanically with the finely divided bagasse. They therefore do not affect the color of the juice itself, except in the form of solid suspended particles, and do not make their presence felt until the juice is treated with lime, an excess of which causes the saccharetin to turn yellow. Anthocyanin, however, is quite soluble in the raw juice, and this is the reason why dark-colored canes give a darker juice than light-colored ones.

But all these facts do not explain the dark color of raw juice from light-colored canes. C. A. Browne[2]

[1] Presented before the Division of Agricultural and Food Chemistry at the 56th Meeting of the American Chemical Society, Cleveland, September 10 to 13, 1918.

[2] *Louisiana Bulletin*, **75**, 249; **91**, 17.

states that the darkening of raw cane juice is due to the effect of an oxidizing enzyme, closely related to oenoxydase, upon certain polyphenols present in the juice. This enzyme was found to act upon hydroquinone, but not on tyrosin. Browne concluded from this that tyrosinase was absent in cane juice. However, he found a peroxidase in some cases.

Previously, Raciborski[1] had discovered two oxidizing enzymes in cane, but did not investigate their connection with the darkening of cane juices. He found in the growing parts of the cane an oxidase (a laccase) which turned tincture of guaiac blue in the absence of hydrogen peroxide. It was very unstable, soon losing its oxidizing action upon standing, and being destroyed rapidly by heating above 60°. But besides this laccase he detected in all parts of the cane, young or old, an enzyme giving a dark blue coloration with tincture of guaiac to which hydrogen peroxide had been added. This enzyme was therefore what we now term a peroxidase. It was found to be very stable, and resistant to temperatures of 90° to 95°. He called this substance leptomin. Further tests showed it to be present in all the higher plants investigated, and Raciborski drew from this the conclusion that his leptomin performed an important function in the life of all higher plants, being comparable to the hemoglobin of the animal kingdom.

Prinsen-Geerligs found in 1905[2] that the gray color of certain sugars is associated with the presence in them of small quantities of iron, and he suggested that the iron was in the form of a saccharate. In 1913 Shilstone[3] again called attention to the fact that the iron, of which practically all modern sugar machinery is made, was responsible for the dark color of certain sugars, and I. F. Morse[3] made a similar suggestion. Shilstone also recognized the fact that the iron must be in the form of extremely dark-colored compounds, because otherwise the very great effect of mere traces of iron could not be explained. He suggested that the iron was combined with "organic acids." It remained for Schneller[4] to show what particular class of organic iron compounds could cause the grayish tint of sugars and the abnormally dark color of other sugar products. Schneller based his explanation on the discovery by Szymanski[5] and by Browne[6] of "tannins" in cane, *i. e.*, of aromatic compounds giving the well-known color reaction with ferric salts, and which need not necessarily be true tannins in the chemical sense of the word, but may be any of the numerous polyphenols or phenolcarbonic acids. As a further support of his explanation, Schneller called attention to the researches of Gonnermann[7] and of Grafe[8] on the darkening of beet juices. Both of these authors had concluded from their investigations that the dark color of beet juices is caused by the action of tyrosinase on pyrocatechin in the presence of ferrous salts. According to Gonnermann, the pyrocatechin which both he and Grafe found in beet juices is not present as such in the beet itself, but is formed, as soon as the juice is extracted, by the action of tyrosinase on the tyrosin of the beet.

In view of these facts Schneller's explanation seemed so plausible that it was decided to test it further, and to see whether the dark color of cane juices could be experimentally explained on the basis of Schneller's hypothesis. It was decided to make the necessary tests with material as free as possible from the natural coloring matters of the cane which we have enumerated above. For this reason we used young cane shoots from which the leaves were entirely removed, and which therefore contained practically no chlorophyll. Neither could they contain any anthocyanin, and the presence of any saccharetin could not make itself felt to any extent, because it does not dissolve in the natural juice. The young shoots have the further advantage that they are rich in "tannin," and that the color reactions would therefore be more pronounced.

We first undertook the identification of the oxidizing enzymes of the cane, and a study of the effects of iron salts. The nature of the "tannins" will form the subject of a later paper.

A young cane shoot was ground to pulp with a little water in a porcelain mortar, and we were surprised to find that the color of the solution obtained was entirely unlike that of a mill juice. It was dark brown, instead of the characteristic muddy green color of mill juice. This at once suggested that the iron of the mill had something to do with the color of the mill juice. In a second test we added a crystal of ferrous sulfate, the size of a pin-head, to the water in which the cane was macerated, and we at once obtained a dark green juice, exactly of the same tint as mill juice, only more pronounced. It might be objected here that the cane itself contains iron. This is perfectly true, but it is well known that the iron is in organic combination and not in ionized form.

We would conclude from these tests that the brown color obtained in the first instance is due to the action of oxidases on the polyphenols, while in the second case the ferrous salt reacts with both the oxidase and the polyphenols yet unattacked. The result will be the green color due to the reaction of ferric salts with certain polyphenols which will entirely mask the brown color of the oxidation products of polyphenols. In order to study this question further, the following experiments were made:

Six flasks were prepared, with equal quantities of water in each.

Test 1—A cane shoot was cut up into fine chips, and they were dropped directly into the water. The mixture was then allowed to stand, with frequent stirring. The juice gradually turned dark brown.

Test 2—Same as Test 1, but water was first heated to boiling and was kept boiling while the cane slices were dropped in. This juice remained colorless for days.

Test 3—Same as Test 1, except that 15 mg. of iron in the form of ferrous sulfate were dissolved in the water, before the cane was added. The juice rapidly turned a muddy green to a greenish black.

[1] *Archief v. d. Java-Suikerind.*, No. 8, **1906.**
[2] *Louisiana Planter*, **49**, 402.
[3] *Modern Sugar Planter*, No. 6, **43.**
[4] *Louisiana Bulletin*, **157.**
[5] *Ber. der Vers.-Stat. für Zuckerrohr in West Java*, **2**, 13.
[6] *Louisiana Bulletin*, **91**, 9.
[7] *Z. Ver. D. Zuckerind.*, **57**, 1068.
[8] *Oesterr.-Ung. Z. Zuckerind.*, **37**, 55.

Test 4—Same as Test 1, except that 15 mg. of iron in the form of ferric chloride were dissolved in the water before adding the cane. Similar result as in Test 3.

Test 5—Same as Test 2, except that after short boiling the flask was rapidly cooled in running water. Then 15 mg. of iron as ferrous sulfate were added. The juice remained colorless for some time, but gradually became green, as the ferrous iron was oxidized.

Test 6—Same as Test 5, but substituting ferric chloride for the ferrous sulfate. Juice at once became dark green after addition of the ferric chloride solution.

The results clearly show that the color of a raw juice depends on several factors, *viz.*, the presence or absence of oxidizing enzymes, the presence or absence of iron salts, and the form in which any iron salts are present. The result of Test 1 is due to the effect of the oxidizing enzymes on the polyphenols of the cane.

		Material Not Extracted With Alcohol			Material Extracted With Alcohol		
No.	Test Reagent	No addition A	Acid B	Alkaline C	No addition D	Acid E	Alkaline F
1	Water	Dark, muddy brown	Brownish yellow	Dark, muddy brown	Very slight darkening	No change	Very slight darkening
2	Pyrocatechin, 1 per cent soln.	Quickly turns golden yellow, darkens to medium brown	Quickly lemon-yellow, darkens to brownish yellow	Quickly turns pinkish yellow, darkens to dark brown	Darkens very quickly through yellow	Same as D, but less quickly	Same as D, but more quickly
3	Resorcinol, 1 per cent soln.	No change	No change	No change	No change	No change	No change
4	Hydroquinone, 1 per cent soln.	Purple, darkens to brown	Light purple, much lighter than A	Turns purple rapidly, darkens to purplish brown	Purple, darkens to brown	Same as D, but less quickly	Same as D, but more quickly
5	Pyrogallol, 1 per cent soln.	Golden yellow, darkens to brownish yellow	Golden yellow, lighter than A	Turns yellow rapidly and soon darkens to brown	Like A	Like B	Like C
6	Phloroglucinol, 1 per cent soln.	No change	No change	No change	No change	No change	No change
7	Guaiacol, 1 per cent soln.	Purplish pink	Light pink	Purple	Turns purple quickly	Lighter than D	Darker than D
8	Paracresol, 1 per cent soln.	Brownish yellow	Reddish brown	Brownish yellow	Pinkish yellow	No darkening, turns milky	Yellowish red
9	Paracresol, 0.1 per cent soln. plus crystal of glycocoll	Reddish brown	Brownish yellow	Dark reddish brown	Orange-red	No darkening	Red, next morning blue, with copper-colored reflex
10	Tincture of guaiac	Blue			Blue		
11	Tannin, 1 per cent soln.	Light yellow	Very light yellow	Yellow	No change	No change	No change
12	Tyrosin, 1 per cent soln.	Dark, muddy brown	Brownish yellow	Greenish black	Muddy gray	No change	Muddy gray

In Test 2 the enzymes are destroyed by boiling, and since there were no iron ions present, the juice did not change at all. Test 3 is a duplicate of the one already described and discussed above. In Test 4 there is no need for the oxidase to act upon the iron salt because it is already in the ferric form. The color of a juice extracted in the presence of iron salts will depend on the quantity of these salts. When this is infinitesimally small the brown color of the oxidation products of the polyphenols will overbalance the green color of the polyphenol-iron compounds. As the iron gradually increases we get mixtures of green and brown, and finally the green will become the dominating color. This is reached with only very small quantities of iron. In Test 5 the enzymes are eliminated by boiling. The juice therefore contains only unoxidized polyphenols, as in Test 2. They give no reaction with ferrous salts, but as the oxygen of the air gradually oxidizes the iron to the trivalent form, the color of the phenol-iron compound appears. In Test 6 this happens at once after the ferric salt is added.

Now we can readily understand why cane juice that has not come in contact with iron turns brown (Test 1), and why juice obtained by the mill in the sugar factory turns green (Test 3). We have found, when passing young cane shoots through a clean laboratory mill, that the first part of the juice is brown, but soon the particles of fiber in direct contact with the iron of the mill form enough organic ferrous salt so that they rapidly turn greenish black, and all of the juice that passes later assumes a green color.

Having ascertained the exact rôle played by the iron, the next step was to identify the oxidizing enzymes present in the young shoots. Previous work along this line has already been mentioned. Browne's results showing the absence of tyrosinase seemed surprising in view of the fact that the writer found tyrosin in cane.[1] However, for this very reason tyrosinase could not readily be identified by the addition of tyrosin to the juice. It was therefore necessary to look for tyrosinase with the aid of other reactions. Besides, not much reliance can be placed on any identification of enzymes made on the basis of tests with cane juice, or even with solutions obtained by dropping cane slices directly into the test solutions, because the polyphenols present in the cane are also acted upon by the enzymes, and the reactions are thus liable to be obscured. A more reliable method consists in dropping thin slices of the material into strong alcohol contained in a mortar and macerating them with a pestle. The alcohol precipitates the enzymes, while the polyphenols go into solution. The alcohol is then filtered off rapidly, the residual pulp dried quickly between filter paper, and the remaining pulp may now be used for carrying out the tests with the various polyphenol solutions.

Several series of experiments were made, both by dropping thin slices of cane shoots directly into the water solutions of the various reagents, and also by using the alcohol-extracted pulp in the same way. In every case parallel tests were made in solutions slightly acidified with acetic acid, and in others made slightly alkaline with sodium bicarbonate. In every experiment a drop of toluene was added to the test solution. The preceding table gives the results of these experiments.

The results show that the tests in which the material was not extracted with alcohol in some cases gave characteristic reactions, while in others they were more affected by the polyphenols naturally present in the cane than by the test reagents used. This is especially marked in the tests with paracresol. Nos. 8

[1] Original Communication, *8th Int. Congr. App. Chem.*, **8**, 103.

and 9. Here the water solutions gave in every case colorations similar to those obtained in the absence of the phenols used as reagents, and the tint was only slightly influenced by the latter. But the alcohol-extracted pulp gave in these cases, very characteristic reactions which clearly show that the cane shoots contain not only a laccase (8E, 9E), but also tyrosinase (8D, 8F, 9D, and especially 9F, which is such a characteristic reaction that it cannot be mistaken). The presence of a laccase is further shown by the tests with hydroquinone, pyrogallol, guaiacol, and tincture of guaiac. The effect on pyrocatechin may be due to both laccase and tyrosinase, as pyrocatechin seems to be acted upon by both of these enzymes. The reaction obtained with tyrosin itself was not very characteristic, for reasons already explained above, and also on account of the well-known interference with this reaction by other substances, particularly amido acids, which often have either an inhibitory effect on tyrosinase, or may entirely change the color produced.

Tests for oxidases with potassium iodide-starch solution also gave positive results with both extracted and unextracted pulp. This reaction is not due to nitrites, because boiled juices do not give it, nor is it obtained in the presence of $N/2$ sulfuric acid.

The activity of both laccase and tyrosinase diminishes very rapidly, as was already pointed out by Browne and by Raciborski. But the peroxidase reaction with tincture of guaiac and hydrogen peroxide could be obtained in juices that had been kept for weeks, preserved with toluene. In the light of Bach and Chodat's theory of oxidases this may be due to the fact that the organic peroxide part of the oxidase is quickly used up when acting upon the polyphenols also contained in the cane itself, but that the peroxidase part of the oxidase is much more stable.

Since the amount of tyrosin found in the cane by the writer was extremely small, it would appear that the dark brown color of cane juices in the absence of iron is due largely to the effect of the laccase upon the polyphenols of the cane, and only in small part to that of the tyrosinase upon tyrosin. The reaction is therefore greatly different from that taking place in beet juices.

The question as to the nature of the polyphenols has so far not been taken up. Schneller suggested pyrocatechin from analogy with the beet and from the green iron reaction. During the past grinding season several pounds of eyes which are rich in polyphenols were cut off from sugar canes, and dropped directly into alcohol. Cane tops also were sliced and treated in the same way. But in spite of these precautions the materials, which were kept in the laboratory, after several months' standing, had darkened so much that it was found impossible to isolate any polyphenols from them in a pure state. So far we have been unable to find any pyrocatechin in these solutions, although the positive result of Wolff's test[1] would point to the possibility that pyrocatechin or some related substance is present in the sugar cane. We intend to approach this problem by a different method and hope positively to identify any polyphenols or phenolcarbonic acids.

SUMMARY

The presence in young cane shoots of a laccase, of tyrosinase, and of peroxidase has been established. It is shown that the dark brown color of cane juices obtained in the absence of iron is due to the action of the laccase upon the polyphenols present in the cane, and to a small extent, to that of the tyrosinase upon the tyrosin of the cane. The dark green color of cane juices from the factory mill is due to the interaction of the laccase, the polyphenols of the cane, and of the ferrous salts formed by the action of the organic acids of the cane upon the iron of the mill. The ferrous salts are rapidly oxidized by the oxidases of the cane to the ferric state, and these give the characteristic dark-colored compounds with the polyphenols of the cane.

LOUISIANA SUGAR EXPERIMENT STATION
NEW ORLEANS, LOUISIANA

LABORATORY AND PLANT

METHODS OF ANALYSIS USED IN THE COAL-TAR INDUSTRY. II—DISTILLED TARS AND PITCHES

By J. M. Weiss

Received August 20, 1918

In Paper I of this series[1] the author presented the testing methods of The Barrett Company for crude tar together with introductory matter to which we would refer the reader of this paper. All references to previous tests noted in this paper refer to the preceding paper.[1]

DISTILLED TAR TESTS

TEST C2—WATER. Identical with B2.

TEST C3—SPECIFIC GRAVITY (PYCNOMETER). Identical with B5.

TEST C4—SPECIFIC GRAVITY (PLATINUM PLAN). Identical with B6.

TEST C5—INSOLUBLE IN BENZOL. Identical with B7.

TEST C6—VISCOSITY. Identical with B10.

TEST C7—CONSISTENCY (SCHUTTE)

APPARATUS—Schutte penetrometer (see Fig. IV).[2] Stop watch.

METHOD—The collar shall be filled by placing it upon a flat tin roofing disk which has been coated with a thin film of vaseline and pouring an excess of material into the collar. After cooling and contraction the excess material shall be cut off level with the upper edge of the plug by means of a heated knife blade. The collar shall be then immersed in water of the required temperature and left at that temperature for 15 min. The collar with roofing disk attached shall be screwed into the tube while the tube

[1] THIS JOURNAL, **10** (1918), 732.

[1] *Ann. inst. Pasteur*, **31**, 92.

[2] Figures are numbered consecutively in this series of articles

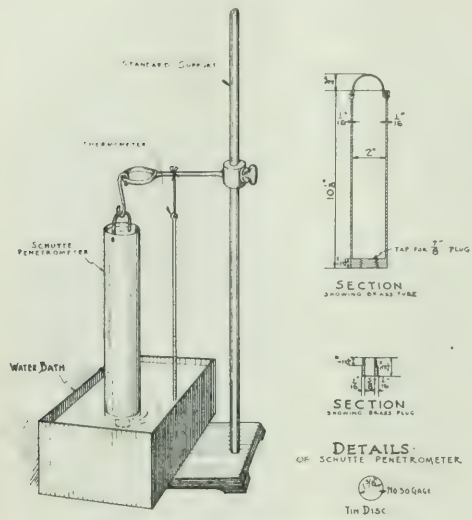


FIG. IV—ASSEMBLY OF SCHUTTE PENETROMETER

is in position. The water bath shall just cover the shoulder of the tube. The tube shall be filled with water of the required temperature and the roofing disk removed by slipping it sideways. The time (measured by a stop watch) from the slipping off of the disk to the sudden drop of the water in the tube, shall be noted and reported in seconds.

PRECAUTIONS—Take extreme care to keep the water bath within 0.5° F. of the required temperature. See that the thermometer used for taking this temperature is of tested accuracy. Note that the thread on the collar is so cut that it screws into the tube to an exact depth of 1/4 in. Plug the small holes at the top of the tube around the handle with wax or pitch to prevent leakage of water during the test.

ACCURACY—± 5 per cent.

NOTES—As the bitumen is displaced from the plug there is a very slight and gradual fall of water in the tube. The end-point is, however, a sharp and sudden drop and is unmistakable.

If no temperature for the test is specified, the temperature (in even 10° F., *i. e.*, 40°, 50°, 60°, etc.), at which the test gives results nearest to 100 seconds, should be selected.

TEST C8—CONSISTENCY (FLOAT)[1]

APPARATUS—Float tester (see Fig. V). Brass plate, 5 × 8 cm. Stop watch.

METHOD—The brass collar shall be placed with the small end down on the brass plate which should be previously amalgamated with mercury by rubbing it first with a dilute solution of a mercury salt and then with metallic mercury. Sufficient of the material to be tested shall then be melted in a suitable container, care being taken to prevent loss by volatilization or formation of air bubbles. The material shall then be poured into the collar in a thin stream until slightly more than level with the top. The surplus shall be removed, after cooling to room temperature, by means of a steel spatula, the blade of which has been slightly heated. The collar with plate attached shall then be placed in water at 5° C. and allowed to remain at that temperature for at least 15 minutes. A suitable water bath shall be filled 3/4 full of water, placed over a burner and brought to the temperature at which it is desired to make the test. This temperature shall not be allowed to vary during the test more than 0.5° C. from the required point. The brass plate shall be removed from the collar and the latter with contents shall be screwed into the aluminum float, which shall then be immediately floated on the carefully regulated warm bath. As the plug of bituminous material becomes warm and fluid, it is gradually forced upward and out of the collar until the entrance of water causes the collar to sink. Unless otherwise specified, the time in seconds (noted by a stop watch) from placing the float in water to the *time the water breaks through the material* shall be reported as the consistency of the material.

PRECAUTIONS—No test should be recorded if water finds its way into the float through the thread of the plug. This can be avoided by thoroughly coating the thread with grease or vaseline.

NOTES—In certain specifications it is required to take the time from placing the float in water until the float sinks. This may make a difference of 5 to 10 seconds in the result. Tests are ordinarily made at 50° C. At 100° C. the test is not at all sensitive for distilled tars.

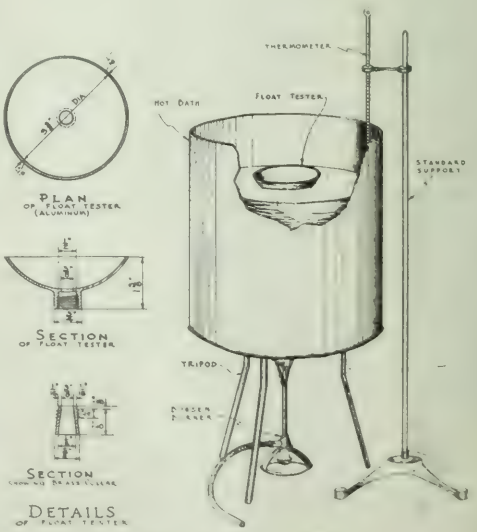


FIG. V—ASSEMBLY OF FLOAT TESTER

[1] Adapted from Bulletin 314, Office of Public Roads.

TEST C9—DISTILLATION[1]

APPARATUS—See Fig. VI.

Flask: The distillation flask shall be a 250 cc. Engler distilling flask, having the following dimensions:

Diameter of bulb	8.0 cm.
Length of neck	15.0 cm.
Diameter of neck	1.7 cm.
Surface of material to lower side of tubulature	11.0 cm.
Length of tubulature	15.0 cm.
Diameter of tubulature	0.9 cm.
Angle of tubulature	75°

A variation of 3 per cent from the above measurements shall be considered allowable.

Thermometer: The thermometer shall conform to the following requirements:

The thermometer shall be made of thermometric glass of a quality equivalent to suitable grades of Jena or Corning. It shall be thoroughly annealed. It shall be filled above the mercury with inert gas which will not act chemically on or contaminate the mercury. The pressure of the gas shall be sufficient to prevent separation of the mercury column at all temperatures of the scale. There shall be a reservoir above the final graduation large enough so that the pressure will not become excessive at the highest temperature. The thermometer shall be finished at the top with a small glass ring or button suitable for attaching a tag. Each thermometer shall have for identification the maker's name, a serial number, and the letters "A. S. T. M. Distillation."

The thermometer shall be graduated from 0° to 400° C. at intervals of 1° C. Every fifth graduation shall be longer than the intermediate ones, and every tenth graduation beginning at zero shall be numbered. The graduation marks and numbers shall be clear-cut and distinct.

The thermometer shall conform to the following dimensions:

Total length, maximum, 385 mm.
Diameter of stem, 7 mm.; permissible variation, 0.5 mm.
Diameter of bulb, minimum, 5 mm.; and shall not exceed diameter of stem.
Length of bulb, 12.5 mm.; permissible variation, 2.5 mm.
Distance, 0° to bottom of bulb, 30 mm.; permissible variation, 5 mm.
Distance, 0° to 400°, 295 mm.; permissible variation, 10 mm.

The accuracy of the thermometer when delivered to the purchaser shall be such that when tested at full immersion the maximum error from 0° to 200° C. shall not exceed 0.5°; from 200° to 300° C., it shall not exceed 1° C.; from 300° to 375° C., it shall not exceed 1.5° C.

The sensitiveness of the thermometer shall be such that when cooled to a temperature of 74° below the boiling point of water at the barometric pressure at the time of test and plunged into free flow of steam, the meniscus shall pass the point 10° below the boiling point of water in not more than 6 seconds.

Condenser: The condenser tube shall have the following dimensions:

Adapter	70 mm.
Length of straight tube	185 mm.
Width of tube	12–15 mm.
Width of adapter end of tube	20–25 mm.

[1] See "Standard Method for Distillation of Bituminous Materials Suitable for Road Treatment," A. S. T. M. D-20-16, published in 1916, A. S. T. M. Standards, pages 540, *et seq.*

Stands: Two iron stands shall be provided, one with a universal clamp for holding the condenser, and one with a light grip arm with a cork-lined clamp for holding the flask.

Burner and Shield: A Bunsen burner shall be provided, with a tin shield 20 cm. long by 9 cm. in diameter. The shield shall have a small hole for observing the flame.

Cylinders: The cylinders used in collecting the distillate shall have a capacity of 25 cc. and shall be graduated in 0.1 cc.

METHOD—The apparatus shall be set up as shown in Fig. VI, the thermometer being placed so that the top of the bulb is opposite the middle of the tubulature. All connections shall be tight.

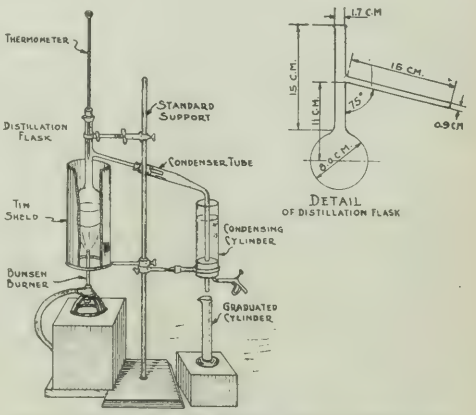


FIG. VI—ASSEMBLY FOR DISTILLATION TEST OF DISTILLED TARS
A. S. T. M. D-20-16

If the presence of water is suspected or known, the material shall be dehydrated before the test is made (see B3).

One hundred cubic centimeters (see note) of the dehydrated material to be tested shall be placed in a tared flask and weighed. After adjusting the thermometer, shield, condenser, etc., the distillation is commenced, the rate being so regulated that 1 cc. passes over every minute. The receiver is changed as the mercury column just passes the fractionating point.

The following fractions should be reported:

Start of distillation to 110° C.
110° to 170° C.
170° to 235° C.
235° to 270° C.
270° to 300° C.
Residue

To determine the amount of residue, the flask is weighed again when distillation is complete. During the distillation the condenser tube shall be warmed when necessary to prevent the deposition of any sublimate. The percentages of fractions shall be reported both by weight and by volume.

NOTE—It is usually impractical to accurately measure 100 cc. of the materials used for distillation. Therefore, the weight corresponding to 100 cc. should

be calculated from the predetermined specific gravity and this amount weighed into the flask. For example, if the specific gravity is 1.189, the operator should weigh out 118.9 g. for the test.

PITCH TESTS

TEST D2—SPECIFIC GRAVITY (PLATINUM PAN)

This is identical with B6 with the special note that care must be taken to prevent the formation of air bubbles on the pitch when immersed in water.

TEST D3—SPECIFIC GRAVITY (PYCNOMETER)

This is identical with B_5 with the same modifying note as given under D_2.

TEST D4—SPECIFIC GRAVITY (SUSPENDED CUBE)

APPARATUS—Chemical balance.

Wooden bridge: Usually supplied with balances. This consists of a small wooden beaker support which holds a beaker over the balance pan and at the same time allows the pan to oscillate freely without contact with the bridge at any point.

METHOD—A lump of pitch shall be suspended from the hook above the left-hand pan of the balance by means of a fine waxed silk thread in such a manner that the cube is about one inch above the pan and its weight noted. The bridge shall be applied with a beaker of freshly-boiled distilled water at a temperature of about 13° C. (55° F.). The lump of pitch (still suspended from the hook) shall be immersed in the water, the temperature allowed to rise to 15.5° C. (60° F.), and the weight in water noted. The weight of the pitch in air divided by its loss of weight in water gives the specific gravity.

PRECAUTIONS—When weights are taken see that the balance pan swings freely and does not touch the bridge or beaker. See that the pitch cube is free from air bubbles.

TEST D5—INSOLUBLE IN BENZOL (FREE CARBON)

All matter as to apparatus, method, precautions, and accuracy given under B7 (except as noted below) apply to this test on this material.

SPECIAL NOTE—If the pitch is hard enough, grinding the material taken for test will be advantageous in aiding the subsequent solution. It is well to examine the carbon residue for foreign matter, such as wood slivers, pieces of bagging, etc. If such foreign matter is present, the test should be rejected. The requirement (as given under B7) to pass the material hot through a 30-mesh sieve does not apply to these materials.

TEST D6—WATER MELTING POINT

APPARATUS—See Fig. VII.

Pitch mould. Hook made of No. 12 B. and S. gauge copper wire (diam. 0.0808 in.). Beaker, 600 cc., Griffin's low form.

Thermometer: The thermometer shall conform to the following specifications:

Total length	370 to 400 mm.
Diameter	6.5 to 7.5 mm.
Bulb length	Not over 14 mm.
Bulb diameter	4.5 to 5.5 mm.

The scale shall start not less than 75 mm. above the bottom of the bulb and extend over a distance of 240 to 270 mm. The graduations shall be from 0° to 80° C. in 1/2° C. and shall be clear cut and distinct.

The thermometer shall be correct to 0.25° C. as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the Bureau of Standards.

The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and so annealed as not to change its readings under conditions of use.

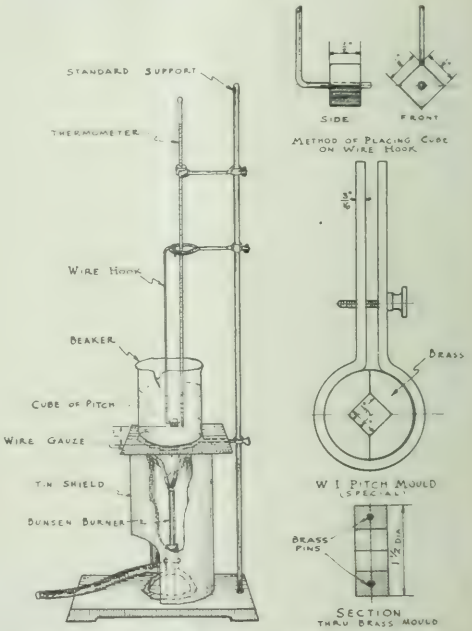


FIG. VII—ASSEMBLY OF TEST FOR WATER MELTING POINT

METHOD—(*a*) *Pitches having melting points between 43° C. and 77° C. (110° to 170° F.).* A clean shaped half-inch cube of pitch shall be formed in the mould and placed on the hook of wire (see Fig. VII for detail of method of placing the cube on the wire). The apparatus shall be assembled as shown in Fig. VII, placing 400 cc. of freshly-boiled distilled water at 15.5° C. in the beaker.

The thermometer shall be placed so that the bottom of the bulb is level with the bottom of the cube of pitch and shall be immediately contiguous to, but not touching, the cube.

The pitch cube shall be suspended so that its bottom is one inch above the bottom of the beaker and allowed to remain in the water at 15.5° C. for 15 min. before starting the test. Heat shall then be applied in such a manner that the temperature of the

water is raised 5° C. (9° F.) each minute. The temperature recorded by the thermometer at the instant the pitch touches the bottom of the beaker shall be reported as the melting point.

(*b*) *Pitches having melting points below 43° C. (110° F.).* These shall be tested exactly as under *a*, except that the water at the start shall be 4° C. (40° F.) and the cube shall be allowed to remain 5 min. at this temperature before starting to apply the heat.

PRECAUTIONS—The use of boiled distilled water is essential, as otherwise air bubbles may form on the cube and retard its sinking. The rate of rise must be uniform and not averaged over the period of the test. All tests where the rise is not uniform shall be rejected. A variation of not more than ±0.5° C. for any minute period after the first three is the maximum allowable.

ACCURACY—±1° F.

NOTES—Pitches of the *a* range of consistency can ordinarily be molded at room temperature, but, if necessary, cold or hot water can be used to harden or soften them. Pitches of the *b* range can be conveniently formed in water of about 4° C. (40° F.).

A sheet of paper placed on the bottom of the 600 cc. beaker and conveniently weighted will prevent the pitch from sticking to the beaker when it drops off, thereby saving considerable time and trouble in cleaning.

This method shall not be used on pitches above 77° C. (170° F.), water melting point. Such pitches shall be tested as under D7.

TEST D7—AIR MELTING POINT

APPARATUS—Melting point oven (see Fig. VIII).

Tripod: The oven shall be mounted on a suitable tripod of such size that it supports the outer edge only of the oven, leaving the bottom exposed directly to the heat of the burner.

Burner: A Tyrell burner of type A. H. T. 22884, E. & A. 1462 shall be used for heating. It shall be provided with a suitable chimney (A. H. T. 22984, E. & A. 1590).

Hooks: Made of No. 12 B. and S. gauge copper wire (diam. 0.0808 in.).

Copper Cup: This shall be of about 50 cc. capacity, in size $1^1/_2$ in. deep. by $1^1/_2$ in. diameter. It shall be provided with a wooden handle (see Fig. VIII).

Thermometer: This shall conform to the following specifications:

Total length	380 to 385 mm.
Diameter of stem	6.5 to 7.5 mm.
Bulb length	Not over 14 mm.
Bulb diameter	4.5 to 5.5 mm.

The graduations of the scale shall be from 30° to 160° C. in $^1/_2$° C. and shall be clear cut and distinct. The 30° mark shall be at least 75 mm. above the bottom of the bulb. The length between the 30° mark and the 160° mark shall be between 230 mm. and 275 mm.

The thermometer shall be correct to 0.25° C. as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the Bureau of Standards.

The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and so annealed as not to change its readings under conditions of use. It is desirable not to have a supplementary bulb above the main bulb, but if this is done, such supplementary bulb must not be separated from the main bulb by a distance of more than 2 mm.

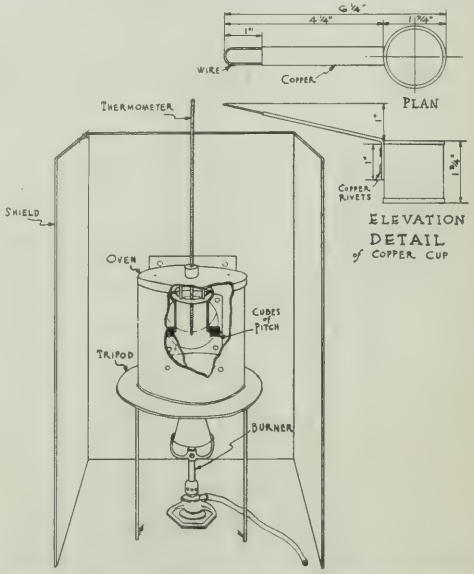


FIG. VIII—ASSEMBLY OF AIR MELTING-POINT TEST (FOR PITCHES)

METHOD—The copper cup (see Fig. VIII) shall be half filled with pitch and carefully heated until melted. The cube shall then be formed by pouring into the mould and allowing to cool. The cube shall be suspended in the oven on a hook of proper length so that its center rests on a level with an imaginary line running through the centers of the observation windows. The bottom of the thermometer bulb shall be level with the bottom of the cube of pitch. The temperature of the oven is raised exactly 5° C. (90 F.) each minute and the temperature recorded by the thermometer at the instant the pitch drops to the bottom of the oven shall be taken as the melting point.

PRECAUTIONS—Care shall be taken to avoid noticeable evolution of vapors in the heating and melting of the pitch. If necessary an oil bath may be used. The apparatus should be set up in a place free from drafts and if necessary protected by means of a shield set apart from the apparatus. The oven itself must not be lagged.

The rate of rise must be uniform and not averaged over the period of the test. Any tests where the rise is not uniform shall be rejected.

A variation (after the first 3 min. of the test) of ±1° C. is the maximum allowable. Not over two cubes shall be run in the oven at the same time,

and these shall not be pitches with melting points more than 5° C. (9° F.) apart. The cubes shall be close to but not touching the thermometer and equidistant from it.

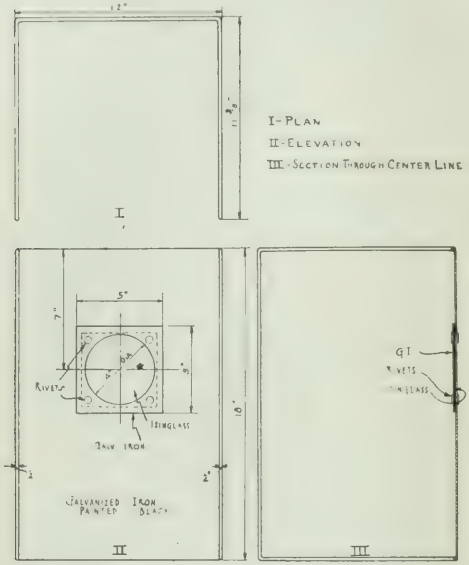


Fig. IX—Detail of Shield for Air Melting-Point Test

NOTES—This method shall be used only on pitches melting above 77° C. (170° F.). To make results by this method comparable with result obtained in water, 6.5° C. (12° F.) may be added to the observed melting point, but the results of melting-point tests *must* always be reported in terms of the method by which the test is made.

In a laboratory free from drafts a shield is not necessary. If one is needed, a convenient type which can be easily constructed is shown in Fig. IX.

TEST D10—EVAPORATION

APPARATUS—Copper drying oven, 8 in. × 8 in. × 10 in., A. H. T. 41500, E. & A. 3030. The oven shall be completely covered inside and out with $^1/_8$ in. asbestos board, excepting the outer bottom surface. The door of the oven shall also be covered inside and out with the same thickness of asbestos. The shelf of the oven shall be 2.5 in. above the bottom of the oven.

Evaporating dishes: These shall be made of pure nickel. They shall be 2 in. inside diameter at the bottom and $^9/_{16}$ in. high, tapering at the top to a diameter of $2^1/_8$ in. (see Fig. X). They shall be provided with a suitable handle of the same material.

Thermometer: This shall be graduated from 0° to 300° C. in 1° C. and of such a length that when placed in position the 100° C. mark will be within 10° C. above the cork. This requires a total length of 300 to 350 mm. with the 100° mark about 140 cm. from the bottom of the bulb. The thermometer before use shall be checked at full immersion against a thermometer calibrated at full immersion by the Bureau of Standards, and the readings used thereby corrected.

Burner: The oven shall be heated by a Tyrell burner (A. H. T. 22884, E. & A. 1462), provided with a chimney of the type A. H. T. 22984, E. & A. 1590.

Assembly of apparatus: Shown in Fig. X. Each dish shall be placed on a round $^1/_4$-in. asbestos pad of approximately the same diameter as the dish. The bulb of the thermometer shall rest in a pan of suitable high-flash oil, on a similar asbestos pad. The pan in which the thermometer bulb is inserted shall be higher than the others and need not be made of nickel. The height shall be such that the thermometer bulb is completely immersed in the oil. Not more than 4 pans, including the one with the thermometer, shall be run in the oven at one time. The pans shall be arranged symmetrically with respect to the center of the shelf of the oven.

METHOD—Approximately 10 g. of pitch shall be weighed into a dish, placed in the oven, held at 163° C. (325° F.) ±2° C. for 7 hrs., removed, allowed to cool in a desiccator, and the loss of weight noted.

PRECAUTIONS—The oven should be set up in a place free from drafts and should be regulated to temperature before the dishes are inserted.

NOTE—Where the laboratory has a reasonably uniform gas pressure, it is advisable to have a burner of the A. H. T. 22860 type permanently connected by iron pipe under the oven and provided with a shut-off cock. The regulation of the burner can then be left in the same adjustment between tests, thereby obviating all but minor adjustments during the test.

TEST D11—SLIDE

APPARATUS—Water-jacketed oven (of type A. H. T.

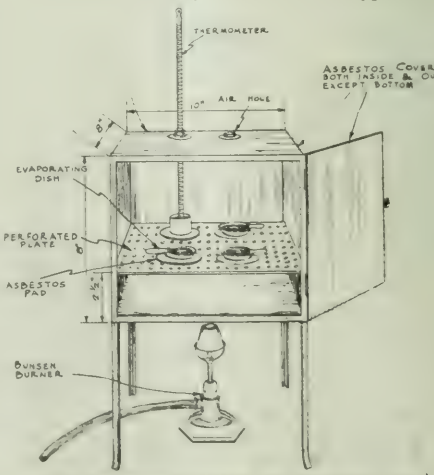


Fig. X—Assembly of Drying and Evaporating Oven

41508, E. & A. 4876), size 10 in. × 12 in. Slide plate (see Fig. XI). Pitch mould (see Fig. IV).

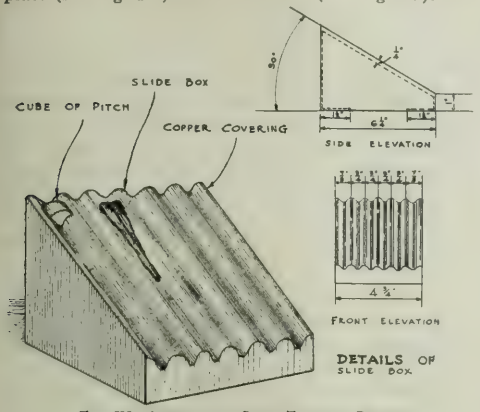


FIG. XI—ASSEMBLY OF SLIDE TEST FOR PITCHES

METHOD—A half-inch cube of pitch such as used for the melting-point test shall be placed at the top of one of the depressions in the corrugated plate, warmed slightly, and pressed down so as to present a rounded top, care being taken to keep the lower edge intact. A mark shall be made on the adjoining ridge parallel to the lower edge of the cube, which shall then be placed in the oven and held at 40° C. for 7 hrs. The temperature shall be measured by a thermometer whose bulb is 1 in. above the center of the upper surface of the slide plate, and whose scale is such that the effective range may be observed outside of the oven. After the 7-hr. period has elapsed, the plate shall be removed from the oven and a second mark made from the ridge parallel to the furthest point the pitch has reached. The linear distance between the two marks shall be reported as the slide.

NOTE—Very soft pitches which may run beyond the end of the slide must be observed from time to time and the time interval at which they reach the end of the slide noted.

THE BARRETT COMPANY
17 BATTERY PLACE, NEW YORK CITY

A CONVENIENT ELECTRIC HEATER FOR USE IN THE ANALYTICAL DISTILLATION OF GASOLINE[1]

By E. W. DEAN

Received May 14, 1918

INTRODUCTION

A recent technical paper[2] of the Bureau of Mines recommends and describes a method for the analytical distillation of gasoline. The discussion published deals only with such details as are essential to the accuracy and uniformity of the method and for the sake of simplicity omits matters which concern only ease and convenience in manipulation.

One of the important requirements of the method is that the distillation be conducted at a fixed and uniform rate. To fulfil this requirement it is necessary to employ a source of heat that can be accurately regulated and that is not subject to uncontrollable fluctuation. The procedure commonly employed in petroleum-testing laboratories involves the use of a gas burner equipped with gas and air regulating devices and protected from air currents by an enclosing screen or shield. In the laboratories of the Bureau there has been employed instead a special electric heater which has proven so advantageous that a description is now being offered for general information.

DISADVANTAGES OF GAS AND ALCOHOL BURNERS

Testing laboratories generally use a source of heat for gasoline distillation, either gas or alcohol burners. The former are generally preferred, although there is now on the market at least one type of special large alcohol lamp[1] that the Bureau knows to be satisfactory.

The chief disadvantage of all flame heaters is the difficulty in keeping them under proper control. Both accurate regulation and freedom from fluctuation are difficult to attain. Moreover, ordinary gas burners are not designed for the particular requirements of gasoline distillation and though more satisfactory types[2] are undoubtedly used by many laboratories they are at best less satisfactory than electric heaters. In addition to difficulties in regulating and shielding, there are considerable losses of heat to the surrounding air and to parts of the apparatus that should not be heated externally. This escape of heat may prove a source of discomfort to the operator and is liable to introduce minor possibilities of variation in the results of an analysis. Finally the use of flame heaters for the distillation of volatile inflammable liquids introduces an element of danger

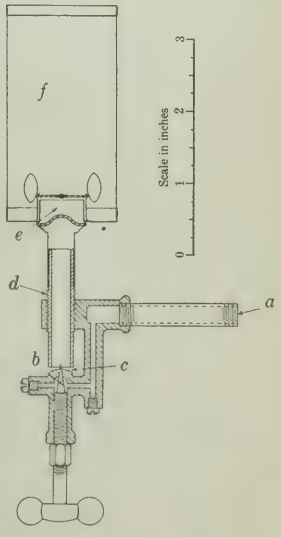


FIG. I

Special gas burner designed and employed for gasoline distillation by the Atlantic Refining Company. Burner is composed of a special bronze casting equipped with sensitive needle valve and a screw adjustment for the regulation of the air-gas mixture. The various features appear as follows: a = gas inlet; b = gas regulating valve; c = air inlet. d = screw adjustment controlling air supply; e = gauze cap to prevent flame "striking back"; f = mica chimney for protection of flame against drafts

[1] Published by permission of the Director of the U. S. Bureau of Mines.

[2] E. W. Dean, "Motor Gasoline, Properties, Laboratory Methods of Testing, and Practical Specifications," Bureau of Mines, *Technical Paper* No 166 (1917), 27 pp. See also Am. Soc. Test. Mat. *Year Book* 1915, pp. 568-569; Part I, Committee Reports, 16 (1916), 518-521.

[1] Made by the C. J. Tagliabue Manufacturing Co., Brooklyn, N. Y.

[2] The most satisfactory gas burner with which the Bureau is familiar is a type in the Philadelphia laboratory of the Atlantic Refining Company. Through the kindness of Chief Chemist F. C. Robinson, of this company, drawings and specifications for this burner in its present state of development have been obtained and are shown in Fig. I of this paper

which, though slight when the operator is skilful and careful, is nevertheless a marked disadvantage.

ADVANTAGES AND DISADVANTAGES OF ELECTRIC HEATERS

The chief advantages of electric heaters have been indicated indirectly through mention of the disadvantages of flame heaters. The two vital elements of superiority are better regulation and freedom from uncontrollable fluctuation. In addition a well-designed electric heater delivers heat almost exclusively to the liquid that is being distilled, thereby increasing the comfort of the operator and avoiding possibilities of error due to transfer of heat to the thermometer bulb through any other medium than the condensing gasoline vapor. Finally, the danger of breakage of flasks, and of fire, either in case of breakage or through ignition of uncondensed gasoline vapor, is reduced to a minimum.

The chief disadvantages of electric heaters are relatively high cost and difficulty in obtaining equipment of satisfactory type. Heaters such as are used by the Bureau are not at present obtainable in the market, but it is believed that manufacturers will supply them if a demand exists. They can be made readily by the user by following the description given in the present paper though this involves some little mechanical work and possible difficulty in procuring nickel-chromium wire, which is at present sold under a licensing system. The cost of electric heaters is moreover bound to be several times that of gas or alcohol burners and there is also an up-keep cost to be taken into account as the resistance elements are subject to gradual deterioration. The convenience and efficiency of electric heaters is, however, believed to more than compensate for these disadvantages.

GENERAL PRINCIPLES INVOLVED IN THE BUREAU OF MINES HEATER

The type of heater designed by the Bureau of Mines involves no elements of novelty and is simply the result of applying well-recognized principles of electric furnace construction to the requirements of the present type of work. The fact that only a small portion of the surface of the distilling flask can be heated (a circle $1^1/_4$ in. in diameter), renders it necessary to use a heater which is actually a small furnace. Owing to the fact that heat is transmitted through an air space instead of by actual contact with the glass the resistance element operates at a relatively high temperature. It has not been found, however, that the limits of durability of either the wire or the insulating materials have been exceeded.

The gasoline distillation heater is actually a small electric furnace with a heating element in the form of an inverted cone. The resistance material is ordinary nickel-chromium alloy wire. Electrical insulation is effected by a supporting cone of alundum. Thermal insulation is obtained by jacketing the heating element with kieselguhr composition, enclosed in a tight metal box with a cover of hard asbestos board.[1]

[1] Transite sold by the H. W. Johns-Manville Co

CONSTRUCTION OF HEATERS

The heaters used by the Bureau have been constructed in its own laboratories and it is realized that they probably lack much of mechanical perfection. They have, however, been perfectly satisfactory in use and as the interest of the Bureau has been in service rendered rather than in details and methods of construction, no experiments along the line of mechanical improvement have been attempted since the first heaters of the present type were put in use. The following description is offered simply as a record of experience and not with the idea that it represents either the only or the best way of accomplishing the desired purpose.

HEATING ELEMENT

MATERIALS—Heaters have been made with two common grades of nickel-chromium resistance wire,[1] each of which has been found satisfactory. It has not yet been determined whether the longer life or higher grades of the same type of material (such as Chromel A or Nichrome II) would be sufficient to warrant the greater cost. Alundum cement[2] has proven entirely satisfactory as electrical insulating material.

SHAPE AND SIZE OF THE HEATING ELEMENT—The first heating elements made proved satisfactory in the matter of shape and size and no experiments were made to ascertain if some other design might be better. The conical form was adopted principally because it suited the method of hand manufacture. Dimensions of the cone appear in the following paragraph.

METHOD OF CONSTRUCTION—Heating elements are built on a conical wooden core (see Fig. II), consisting of two parts, the cone proper and a removable base, which when in position acts as a supporting flange for the alundum cement. The cone is $2^3/_8$ in. high and $1^3/_4$ in. in diameter at the base. The flange projects about $^3/_8$ of an inch. A number of small holes are drilled in the cone, the arrangement being such that they fall on a spiral line making six turns of even pitch. Wire brads are set in these holes to hold the resistance wire in position while the alundum cement is being applied.

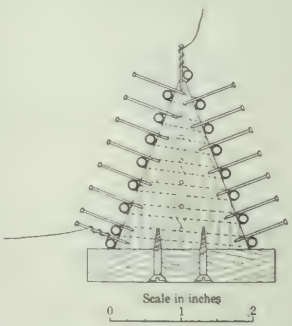


FIG. II

Showing the conical wooden form used in making heating elements. The helix of resistance wire is shown held in place by brads inserted in small holes in the wood.

The resistance wire is wound on a mandrel of about $^1/_8$ in. diameter, and the helix thus obtained stretched

[1] Nichrome, sold by the Driver-Harris Co., Harrison, N. J.; Chromel C, sold by the Hoskins Co., Detroit, Mich

[2] Manufactured by the Norton Co., Worcester, Mass.

to a length of about 26 in. It is then placed on the cone, where it is held in position by the brads. The ends of the wire are made fast by twisting them securely around brads at the apex and the base of the cone. The arrangement is shown in Fig. II.

Experience has indicated that heating elements may be satisfactorily constructed, using sizes and quantities of wire indicated by the following tabulation:

Voltage of Current	B. and S. gauge of wire	Feet of wire to be used	Resistance in Ohms (approximate)	Amperes carried
110	24	20	30	3.6
220	27	40	120	1.8

The full-load capacity of heaters for either voltage is about 400 watts. It is of course understood that these figures are only roughly approximate and that they make no attempt to take account of the minor variations introduced by the use of wire of slightly different composition and by decrease in wattage at higher temperatures.

After attaching the wire to the well-greased mold a thick paste, made by mixing alundum cement with water, is applied. The layer should be about $^3/_8$ in. thick and the cement should be well worked in between the turns of the helix. It is not, however, necessary to get it between the individual turns of wire as these are sufficiently insulated by the coating of oxide that forms on the wire. The alundum is allowed to dry and harden for at least a day at ordinary atmospheric conditions. Rapid drying occasionally results in the development of cracks, which may also be caused by the use of alundum paste containing too much water. After this drying the heating element is removed from the wooden core. This is accomplished by pulling out the wire brads, removing the base of the mold, and then screwing it on again after inserting a gasket which bears on the alundum mass. At this stage the latter is deficient in mechanical strength and must be handled with care. It is next smoothed up with a thin paste of cement and dried for several hours at a temperature of 100° to 150° C. Finally it is fired in a muffle furnace at a temperature of 700° to 900° C., or, lacking the use of a satisfactory furnace, it may be cautiously brought to a red heat by connecting it with a properly regulated electrical current. It is then hard and of a strength about equivalent to that of ordinary stoneware.

SUPPORTING CASE—The Bureau has used as supporting cases stout brass boxes with tops of hard asbestos (Transite) board. The dimensions and general construction of the box and assembled heater are shown in Fig. III.

INSULATING MATERIALS—The insulating material preferred by the Bureau of Mines is a kieselguhr composition sold in the form of bricks.[1] The bricks are shaped roughly to the desired inside and outside form, the interstices being filled with brick dust. Shredded asbestos, plain kieselguhr, or magnesia might, if desired, be used instead.

ASSEMBLING OF HEATER—The heating element is attached to the Transite top of the box, as shown in

[1] Nonpareil bricks, made by the Armstrong Cork Co., Pittsburgh, Pa.

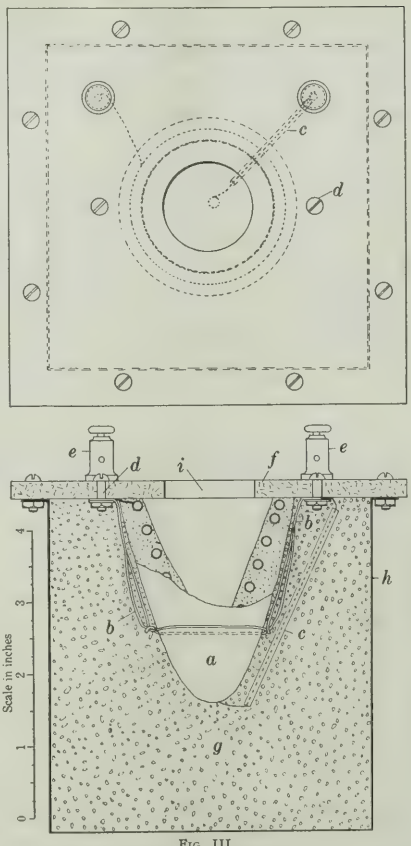


FIG. III

Plan and section of the complete heater showing: a=heating element; b=wire attaching heating element to the cover of the insulating case; c=silica or porcelain tube insulating the electrical lead coming from the apex of the cone; d=screws to which the supporting wire b is attached; e=binding posts connecting with the heating element; f=transite top of the supporting case; g=kieselguhr composition used for heat insulation; h=metal enclosing box; i=opening through which heat is delivered to the distilling flask.

Fig. III. The cover is fastened to the metal box with small "stove nuts" screwed through the asbestos and the projecting metal flange.

REGULATING RHEOSTATS

In the Bureau the heaters have been used connected in series with regulating rheostats of the slide wire type. It has not been found satisfactory to secure regulation by the procedure of turning the current intermittently on and off. Satisfactory results have been obtained by the use of rheostats that permitted reduction of the heat delivered to about a third of the full-load maximum. Rheostats having the following minimum ratings have been found satisfactory: For 110-volt current, 25 ohms resistance and 3.6 amperes carrying capacity; for 220-volt current, 100 ohms resistance and 1.8 amperes carrying capacity.

The rheostats used by the Bureau have cost between $9 and $10 apiece, but it is possible that cheaper equipment capable of giving adequate service may be obtainable in the market. Water rheostats might be employed, and were at one time in service in the Bureau. They are, however, of the nature of a makeshift.

DETAILS OF OPERATION

The type of heater described is designed for the distillation of gasoline and should not be employed for high-boiling liquids. The surface from which heat is delivered is too small for such petroleum products as kerosene, and for this type of work it would be desirable to construct a heating element with larger radiating surface.

Heating elements are of course subject to deterioration in the course of time but the Bureau does not know what their actual life is. As yet none of the heaters have burned out while being used with gasoline, although as indicated above rapid deterioration occurred when kerosene was distilled. Probably, also, rapid deterioration will ensue if a heater is left for a considerable period of time at full current consumption without any liquid to distil. It is, however, desirable to warm heaters up before beginning a distillation, as they come to heat only after 10 or 15 min., and time can be saved with the first distillation of a series if the electric current is turned on before the other preliminary operations of making a distillation are begun. The current should not be left on between distillations of a series.

SUMMARY

The general requirements for methods of heating in the analytical distillation of gasoline have been discussed briefly. The inherent disadvantages of flame heaters have been indicated and a convenient electric heater used in the Petroleum Laboratories of the Bureau of Mines has been described in detail.

CHEMICAL SECTION, PETROLEUM DIVISION
U. S. BUREAU OF MINES, PITTSBURGH

FOURTH NATIONAL EXPOSITION OF CHEMICAL ENGINEERS

The Fourth National Exposition of Chemical Industries, held in the Grand Central Palace, New York City, September 23–28, 1918, has now become a part of the history of the American chemical industry during this remarkable period of expansion. The carrying out of the program as originally planned was made possible through the recognition by the War Department of the direct bearing of the Exposition upon the military program, and the results of Exposition Week have abundantly justified this sympathetic coöperation.

The increased number of exhibitors of chemical products and machinery completely filled the vacant spaces caused by the withdrawal of support by the Railroad Administration of the railways' program for industrial development through chemical surveys.

A striking feature of many exhibits was the evident thought taken to give the lay public a clear understanding of the relations between various lines of manufacture. The recompense for such effort lay in the thoughtful study given to these exhibits by visitors. Several exhibitors displayed attractive booths, though engaged now solely upon war problems, with no opportunity for sales through the usual channels of commerce.

The symposiums on important phases of the industry brought together a mass of well-digested material which constitutes a distinct addition to chemical literature. Once again the daily press has effectively supported the Exposition. Through the reports of the proceedings, as well as through the large attendance, the function of the Exposition in moulding a sympathetic public opinion has been realized.

At a joint meeting of the Managers and the Advisory Committee it was decided to hold the Fifth Exposition at Chicago, in the Coliseum and its Annex, during September 1919 —[EDITOR.]

OPENING ADDRESSES

September 23, 1918

PERMANENT CHEMICAL INDEPENDENCE

By CHARLES H. HERTY
Chairman Advisory Committee of the Chemical Exposition

This annual assemblage of the products of American chemical industry and of the mechanical appliances by which these products are manufactured provides fitting occasion for a stock-taking of past accomplishments and a care-taking for the permanency of those additions to our national wealth whereby economic independence may be assured. To secure this independence it is essential that there should be close coöperation between the chemist and the American people, which can only be brought about when the chemist takes the people into his full confidence regarding the problems whose successful solution is a matter of joint responsibility. By the presentation of these exhibits and by open discussion of the problems confronting the industry, a sympathetic understanding is produced which creates a sound, intelligent public opinion, which is the greatest asset any industry can possess.

The number of exhibitors continues to grow, in keeping with the continued expansion of the industry throughout the nation The only disappointment is the setting aside by the Railroad Administration of the large plans which had been inaugurated by the industrial departments of the several railroads for presenting here a marvelous display of those natural resources of this country which still await the touch of the chemist to rise to their true dignity as invaluable assets. It has been deemed necessary to eliminate during war times this most promising and well-inaugurated line of development. This backward step is a matter of keen regret, taken, strange to say, just at a time when, for economic efficiency, increase rather than curtailment of such development was to be expected, and when the call for the chemist was insistent from all other centers of industrial life. It is sincerely to be hoped that maturer consideration will result in a reversal of this gravely erroneous policy.

MEASURES OF EXPANSION

In taking stock of the chemical industry first thought turns naturally to the matter of available capital. The amount of capital accessions has continued to grow. During the first eight months of 1918, $59,164,000 was added, making the aggregate authorized capital invested in the industry since August 1, 1914, the date of the outbreak of the war, $386,967,000.

These figures do not include, of course, the investments made by the National Government in the great chemical plants whose output is used solely for war purposes. The total production of these plants sets our Government apart as the largest manu-

facturer of chemicals in the world. In the after-war period when the story may be told of the rapidity of construction and of the enormous output of these plants it will add a brilliant chapter to the romance of chemistry. Meanwhile we can rest content in the assurance that the great army which we are now hurrying to Europe will be abundantly supplied.

Perhaps the picture of the growth of the industry can best be gathered from a few figures concerning our export trade, for export statistics indicate production in excess of domestic needs, great as these demands have been during the past year. Four items have been selected, three because of their fundamental character, and one on account of the rapidity of its development.

Exports	1913/1914	1917/1918
Sulfuric acid	12,000,000 lbs.	68,000,000 lbs.
Caustic soda and soda ash	Negligible	334,000,000 lbs.
Benzol	Negligible	25,000,000 lbs.
Dyes, dyestuffs and dyewoods	$357,000	$17,000,000

Doubtless in future years these figures will appear diminutive, but at the present they constitute an inspiring hope for that future.

A fair measure of the increasing participation of the Government in chemical activity is shown in the supplemental appropriation estimates submitted by the War Department to Congress on September 17, 1918. Aside from the great appropriations for explosives, there has been requested for the Chemical Warfare Service, the recently organized division having to do solely with offensive and defensive gas warfare, $198,704,000, a sum greater than was asked for the clothing of the increased army we are now raising. Germany began poison gas warfare; within the next twelve months it will have more than its fill of it.

PUBLIC SUPPORT

The present status of the American chemical industry and its prospects for the future must prove gratifying to all good citizens of this republic, but these prospects can never be fully realized unless the work of the chemist is supported by sound and loyal public opinion, which, in turn, will eventually manifest itself in the form of a thoroughly sympathetic attitude on the part of official representatives of that public opinion.

The stress of war preparations and the great part we feel that we are destined to play in the decision have aroused a wholesome national pride, which should contribute to the development of an atmosphere of good will! America must make good! America can make good! America shall make good! These thoughts fill the minds of our people to-day. The craze for "imported goods" which has so often palsied industrial effort is now being supplanted by pride in domestic achievement. Certainly the label "Made in Germany" no longer exerts its hypnotic influence over the masses of the world. Yet German propaganda is insidious, is ever present, and must constantly be combated if we are to gain that measure of national self-containedness in essential industries which will guard us against a recurrence of the economic tribulations which characterized the period immediately following the blockading of German ports. The chief centers of that disturbance were coal-tar chemicals (dyes and medicinals) and potash; and I beg to ask your serious attention to certain conditions attending the efforts to create these industries in this country.

DYES AND GAS WARFARE

No word is needed concerning the marvelous development of the dye industry. It is here to-day for your inspection. Nor need I dwell upon the close relation of this industry to that of high explosives. That point has already sunk deep into our national consciousness. It was appreciation of this relation perhaps even more than economic need, which brought together producers and consumers in a unique display of unanimity which procured from Congress a protective tariff and anti-dumping legislation guaranteeing life for the young industry.

There was an additional argument for such legislation, however, undreamed of by any of us at that time. We had not entered the war and gave no thought to the efforts which might be required of us in the matter of poison gas production. But when our authorities, following our entrance into the war, determined to meet the Germans with their own weapons and on a scale far greater then they had ever contemplated, it became necessary to make use of every available means for manufacture of toxic material. The great plants planned for Government construction and operation were not sufficient for the program. I am violating no confidence in telling you that at this juncture the Government turned to the young dye industry for plants and trained organizations to augment its poison gas output, and splendidly has the young industry responded. For military reasons I am advised not to mention specific plants or the products manufactured therein, but with official sanction I may say that five dyestuff plants are now participating in the production of this material, while many others are contributing indirectly to the same end. The plants were suited to the needs, staffs and workmen were familiar with this kind of work, and the conversion to the new rôle was thus enabled quickly to be made.

In view of the adaptability of the dyestuff industry to such serious national needs, it is difficult to be patient with many of our mercantile establishments which still insist upon placarding their counters with signs such as "The color of these goods cannot be guaranteed." What a sweet morsel of comfort these placards are to the enemy, in effect an effort to preserve the market for him by our own people, if such they are! Was it ever the practice to guarantee all colors? Certainly not, for even before the war nine-tenths of the dyes used were not fast and did not need to be. Moreover, are our merchants not yet aware of the conditions which led for a time to the uncertainties as to color fastness? Do they not know that in the period of acute shortage of German dyes, before the American industry was started, many German dyes were used for purposes never intended, and so gave bad results, in most cases falsely attributed to American origin, and so when remaining German stocks approached depletion, and the American products began to appear on the markets, these were likewise used in ways never intended, with equally as poor results as in the case of the misuse of the German dyes? With the present adequate domestic production, these matters are correcting themselves. Public sentiment can, and I believe will, make an end of the disloyal placards.

NEEDED LEGISLATION

Assurance of the future of the coal-tar chemical industry lies not only with our people as a whole but even more directly with their representatives in Congress, for it must not be forgotten that legislation stands to-day, as a result of the enactment of the 1916 General Revenue Bill, which is directly in favor of the German industry, at the risk of the very life of the American industry. Every phase of the domestic industry has been studied by the Tariff Commission, and, according to a recent statement of a representative of the Commission, its report to Congress will be published soon after the passage of the Revenue Bill. While nothing is known of the character of this report, I am confident that when the results of this impartial study of the industry are presented to Congress the same unanimous vote will characterize the correction of errors of existing legislation as has just marked the passage by the House of the $8,000,000,000 revenue measure. But the time for action is short, if we achieve the great military victory in 1919 to which all look forward with supreme confidence. No opportunity must be afforded for the practice of industrial infiltration which may sap the very foundations of the coal-tar chemical industry.

In this connection may I suggest the legislative correction of

an error for which we chemists are primarily responsible. In the existing Act intermediates are assessed one-half the duties of finished dyes, which ratio was adopted by Congress upon our recommendation. Experience has shown that this differentiation is a mistake. The difficult stage of production is from the crudes to the intermediates, far more difficult than from the intermediates to the finished dyes. And it is in the field of intermediates that dyestuffs, high explosives, and medicinals meet upon common ground. Furthermore, it is evident that when these industries bear the brunt of foreign attack the enemy will take advantage of questions of definition to avoid the higher duties, or will seek to accomplish the same purpose by shipping the lower-assessed intermediates for assemblage here into finished dyes by simple processes requiring little outlay. Justification of this contention is furnished by the following extract (page 22) from the "Census of Dyes and Coal-Tar Chemicals, 1917" just issued by the Tariff Commission:

"With these exceptions the American dye industry was based entirely on imported intermediates. * * * * This peculiar situation was due primarily to the provisions of the tariff laws of 1897, 1909, and 1913, which have consistently placed a higher duty on dyes than on intermediates. In general, the German industry dominated the field, and the Americans were unable to compete. It happens, however, that in the making of certain dyes the last chemical step of transforming the intermediate into the finished dyes is a comparatively simple and cheap process. As the rate of duty on intermediates was lower than that on the finished dyes, the margin in some instances was sufficient to make it profitable to avoid paying the higher duty on dyes, by importing the intermediates and completing the manufacture of the dyes in the United States."

Knowing therefore where the attack will be made, would it not be the part of wisdom for us to strengthen our forces at this point by legislation which will place all of these products on the same dutiable basis?

COAL-TAR MEDICINALS

Coal-tar dyes have received an abnormal amount of attention from our people and our press. Of equal importance and of far greater meaning to the comfort and well-being of our people are the coal-tar medicinals. In spite of unfavorable legislation our manufacturers have worthily met their responsibilities in this field. Especially is this noted in the recent statements of Government officers that the needs of our Army for these materials have been fully met by our home output. Congress, I am again confident, will correct the unevenness in legislation which hangs as a life-threat over this line of production.

Congressional action, however, will not suffice in itself, for, in the matter of medicinals, we are particularly susceptible to our prejudices. A well-advertised name frequently means more to us than a knowledge of quality. In this connection it has been amazing to note a persistent campaign of newspaper advertising, seeking to convince our people that only tablets of aspirin stamped with the magic word "Bayer" (A German name! In such times as these!) give assurance of genuine acetylsalicylic acid. These tablets are "made on the banks of the Hudson," but in the plant of an enemy-owned corporation now controlled by the Alien Property Custodian. This particular brand of material, no longer patented, sells to-day in large quantities and at a price greatly above that of the same substance manufactured by American firms, whose product has been shown by official tests to be of equal purity. The most remarkable feature of this advertising campaign is that it is being carried on by American directors, appointed by the Alien Property Custodian, and with the American directorship emphasized in the advertising matter, thereby beclouding the main issue of enemy ownership. Zeal in trusteeship is of course commendable, but a campaign of misrepresentation and of exploitation is reprehensible. Good faith does not demand the piling up of undue profits for the benefit of Germany after the war. We do not need such assets for settlement of war claims, for according to recently published figures the value of German property already seized in this country is fifty times that of American property seized in Germany. Away with any such flaunting of false German superiority. The public should rebuke it, and follow the example of pharmacist de Haven, of West Chester, who was recently reported in the press to have burned his large stock of aspirin manufactured by the enemy-owned corporation, and then "telegraphed for a fresh supply from a real American firm!"

INDEPENDENCE IN POTASH SUPPLIES

The blockade of German ports produced a great shortage not only of coal-tar chemicals, but also of potash for fertilizers. In many respects the two situations were closely analogous, the acute shortage, the complete dependence, and the consequent sharp rise in prices. In the case of the coal-tar products the situation was met by a prompt union of forces on the part of producers and consumers, the latter being largely New England mill men who would not shy at the matter of protection of a home industry by tariff. The chief consumers of potash, however, are the cotton planters of our Southern states, and, among these, advocacy of a protective tariff was unthinkable. Producers and consumers therefore failed to get together for the common fight against foreign dependence.

The abundance of raw material is just as favorable for a domestic potash industry as was the case in the coal-tar chemical industry. The brines of Nebraska, now yielding 60 per cent of our present production; Searles Lake in California, estimated to contain from 10 to 20 million tons of potash; the giant kelps of the Pacific Coast, with their remarkable power of selective potash extraction from sea water; the alunite of Utah; precipitated cement dust, with an estimated possibility of 50,000 tons of potash per annum; the dust from blast furnaces, with a possible yield of 200,000 to 300,000 tons per year; the potash-rich silicates, such as the green sands of New Jersey and the Cartersville slates of Georgia—wherever we turn, potash is at hand, in forms, however, too slowly available for plant food, but awaiting the skill of the chemist backed by necessary capital.

In spite of the lack of coöperation during the past three years some progress has been made. The 1000 tons of K_2O produced in 1915 was increased to 9,720 tons in 1916 and to 32,000 tons in 1917. Much fundamental investigation has been carried out, and the promise for the future is hopeful. Success can be predicted if producers and consumers get together, and if public opinion is aroused to the fact that failure to secure national independence in this matter vitally affects the entire nation. The Mining Bill, as modified by Senator Henderson, and now before the Senate, may prove the solution. It may be that protective duties or direct subsidy will be called for, or possibly the relief from war taxation of capital invested in this industry—whatever the cost and whatever the method adopted, Government assistance is needed and may be secured if the demand is nation-wide. Independence in potash can be assured if this country makes up its mind that it will no longer be dependent upon Germany for its supplies, but its mind must be made up quickly. This is one of the most urgent questions, in both its economic and its political aspects, before this country to-day. We cannot afford to neglect it.

THE EXPOSITION IN WAR AND IN PEACE

By F. J. Tone

President American Electrochemical Society

During the past four years we all must agree that the chemical industry of America has passed through the most important period of its history. This has been a war not only between

efficiently organized armies and nations but between efficiently organized industries. Our chemical industry to-day is pitted against the chemical industry of Germany and one has only to study this great Exposition to be convinced that the American chemist is going to measure up to his opportunity. At the beginning of the war our industry was highly organized in special fields but it lacked symmetrical development. It was unbalanced. It lacked self-containedness and coördination. It has taken the war to enable the chemical industry to find itself and it has likewise taken the war to enable this country to discover that it has a great chemical industry and to recognize it as a great national asset; and it must be said that one of the big forces which have worked toward the progress of chemistry and toward public recognition of chemistry in America has been this Exposition. We give all honor to the men whose foresight and energy made this possible.

In this big forward movement of the past four years the electrochemist has played a large part. America has long enjoyed a supremacy in electrochemistry, but in spite of the strong position of the industry before the war no one would have dared to predict the expansion which the war would demand of us. It has called for chlorine, cyanamid, air nitrates, and phosphorus in vast quantities. It has required the ferro-alloy industry, the electrode industry, the abrasive industry to quadruple their outputs.

As a single example, consider briefly the contribution of electrochemistry and electrometallurgy to the aircraft program. The airplane motor has a crank case and pistons of aluminum. Its crank shaft and engine parts subject to the greatest strains are all composed of chrome alloy steel. All of these parts are brought to mechanical perfection and made interchangeable by being finished to a fraction of a thousandth of an inch by means of the modern grinding wheel made from electric furnace abrasives. Calcium carbide and its derivative acetylene are making possible an ample supply of cellulose acetate for airplane dope. When the aviator trains his machine gun on an enemy plane his firing is made effective by tracer bullets of magnesium or phosphorus. When our bombing planes begin to carry the war into Germany it will be with bombs perhaps of ammonium nitrate or picric acid or other high explosives all depending largely in their manufacture on electrochemical reagents. Without the pioneer work of Hall, Acheson, Willson, Bradley and others, the present aircraft program would be impossible of achievement.

Then there is gas warfare, the very basis of which is chlorine. Germany has long been a nation of chemists and when she planned a war of frightfulness it followed as a matter of course that she should seek to make it also a war of chemical frightfulness. Much as we deplore it, therefore, we have been forced to throw our best energies to the solution of the problems of gas warfare. It is interesting to note that chlorine, the product of the electrolytic cell, is the basis of mustard gas, chlorpicrin, phosgene, and almost all of the important war gases. Thus does electrochemistry enter fundamentally into the modern military machine.

It is important for us to remember that while we are working to develop our industry to a point where it will meet the demands of the war, our work is only begun. If this is in a measure a chemists' war, we must work to see that afterwards we have a chemists' peace. After the war will come bigger problems and bigger responsibilities and no one has a bigger opportunity than the chemist to make life better and to serve his fellow-man. We have the problems of the conservation and proper utilization of our resources, the elimination of wastes, the problem of foodstuffs, clothing, and sanitation. All these problems and many others touch the every-day life of the people and are preëminently the problems of the chemist. Fortunately the nation is coming to realize to what an extent it depends in war and in peace on the work of the chemist. By the establishment of the Chemical Warfare Service our place in the military organization has been definitely recognized. We want the same recognition in the councils of the nation after the war. We want the Government to recognize the value of scientific methods in legislation and administration and we will look to this Exposition in future years as one of the forces which will visualize to the rest of the country the rôle of the American chemist.

THE IMPORTANCE OF PRACTICAL CHEMISTRY

By G. W. Thompson

President American Institute of Chemical Engineers

This National Exposition of Chemical Industries, the fourth that has been held, is a growing illustration of the advantage to our industries which chemistry has afforded. The growth of our industries of all kinds has been greatly assisted by chemists. Strictly speaking, all industries are chemical industries, but some industries are more obviously chemical industries than others. This Exposition has, naturally, more to do with the industries which are obviously chemical, but the general proposition that all industries are dependent upon chemical processes should be emphasized, even if in each case the connection is not obvious to the unthinking man.

We learn by adversity. This war has taught us that all industry is more or less chemical in its character. The fact that the assistance of chemistry has been particularly demanded during the last four years has been due to the fact that our most powerful enemy has been perhaps a little wiser than we have been in the past, and we, seeing the extent to which chemistry could be of service to a nation, both in war and in peace, have learned a lesson, although our education in this respect may not be complete. If chemistry has been of great assistance to us during this war, how much more will it be of assistance to us when the war is over and we are again in competition with a great commercial enemy who earlier than us learned the lesson of which I am speaking. The few remarks that I have to make to-day are in the direction of trying to impress upon our people the necessity of learning this lesson more completely, learning it from day to day, learning it with respect to war and with respect to peace.

Every one needs instruction along this line, but I will address myself particularly first to those who control manufacturing operations, second, to the universities and colleges where chemists are taught, and, third, to chemists themselves. Those who control manufacturing operations must learn more fully and completely the need of chemical knowledge for the perfection of industry, the need of chemists in their organization. Our universities and colleges must learn that however valuable pure chemistry may be as an interesting study and for the purpose of training the mind, the most important thing that chemistry does is to be found in its application; that while it is extremely interesting and upbuilding to think in terms of atoms and molecules, it is equally important to think in terms of large quantities of the chemical components that enter into reactions. Chemists must learn more fully and completely the need of applying their knowledge to chemical processes conducted on a large scale.

Permit me to elaborate my appeal for a greater education of these three groups of individuals. Again, let me speak to those who are at the head of concerns that control manufacturing operations. They will, without doubt, agree to the broad academic statement that I have already made, that all manufacturing industries are chemical to a greater or less degree and that for their successful prosecution the chemist is an essential factor. Some manufacturers are more progressive than others in this respect, and they are the ones who have made the greatest success in recent years. This academic statement, however, is to be valued by its application. Manufacturers need chemists and they should do everything in their power to secure a supply of the best chemists possible. The progress of manu-

facturing is dependent upon the development of chemical knowledge, and the manufacturers should give their assistance in every way in their power to the development of chemical knowledge. Manufacturers can do a great deal to help the universities and colleges in developing more efficient methods of instruction. They can do this by calling university and college professors into their councils and developing the practical sides of these professors so that the students in their charge will be developed along lines which will be useful to industry. The teacher in chemistry who is not in touch with practical manufacturing operations cannot properly instruct the student under him and build him up so as to make him capable, on graduation, of entering into the industries and applying his knowledge to their furtherance. Practical business men often distrust college professors. They say that they are theoretical and visionary. This in many cases is due to the fact that the practical business man has a narrow vision. Sometimes it may be true that instructors in chemistry have not a practical turn of mind. Whether this view of practical business men is true or not, the remedy is in their hands, and if they will see their broad duty, they will throw open their plants more freely to instructors in chemistry and make the education of chemists a part of their organized plan. In other words, our colleges and universities must be used by our manufacturers and our manufacturing plants must be opened to use by our universities and colleges.

Now, let me address another word to our educational institutions. They are not entirely free from criticism. It is my opinion that the educational institutions of this country should give honorary degrees to men who have accomplished big things in the industrial world. The practice in many of these institutions is to give degrees only to those who have done original work in what is called pure science, but which work may be of no immediate practical use. It is my opinion that the man who discovers by hard labor things of practical value in the chemical world is deserving of some recognition from our colleges for his contribution to practical science. I believe that our universities and colleges should, all of them, turn more to the practical aspects of education. Many of them think only of its cultural side. Culture is desirable; no one questions this; but culture is not incompatible with an education that suits a man for the practical affairs of life. It is absurd to say that a man, to be successful in the business world, must be a boor, for its corollary is that the man of culture cannot succeed in the business world. Culture with an education that will make the student of practical use is what we want, and the educational institution that thinks only of culture is about as badly off as the educational institution that thinks only of the practical affairs of life. Our educational institutions should keep in touch with manufacturing operations, and instructors in chemistry should keep their feet upon the earth, even if we cannot expect them at all times to keep their heads out of the clouds.

Since this war started it has been a wonderful thing to see how chemists generally have offered themselves to our Government in the hope that they would be able to help in solving the practical problems confronting it. Many instructors of academic chemistry descended from their exalted positions and attempted to handle problems which they by experience have been unfitted to solve. All honor to these men; we do not criticise them, and have only praise to offer for their self-sacrifice. How much better would it have been, however, if these men had been better acquainted with the practical matters with which they became intrusted. They came nobly to our country's assistance. They broke down the barriers with which they were surrounded, and it is a delicious hope that when peace arrives they will not allow these barriers again to be erected.

To chemists generally I address this word. You have the power of influencing the opinion of those who control industries and the opinion of those who control the policy of our educational institutions. I would ask you to insist upon it that the manufacturers of our country and our educational institutions get closer together and that between them there be opened up wide avenues of intercourse. The result will be that each will be modified. Our industries will be influenced by our educational institutions, and our educational institutions will have breathed into them some of the life of the business world.

We all know that this Exposition is to be a success, but success in the best sense of the term involves the power of growth. Success does not consist only in the doing of single definite things, but in the bigger sense means the doing of a series of definite things, each member of the series being of a greater value than that which immediately preceded it. My few remarks are directed to the desire that chemists and chemical industries, and expositions of this kind will have such vitality and growing power that each succeeding achievement will surpass that which preceded it, in a progressive and developing series.

CONFERENCE ON ACIDS AND CHEMICALS

September 24, 1918

DEVELOPMENT IN NITRIC ACID MANUFACTURE IN THE UNITED STATES SINCE 1914

By E. J. Pranke, of the American Cyanamid Company

The production of nitric acid in 1914, according to the Census of Manufactures, was 78,589 tons of nitric acid of average strength and 112,124 tons of mixed acid. According to other data given in the census, these figures represent about 89,000 tons of 100 per cent nitric acid. All of this acid was produced from nitrate of soda, consuming about 160,000 tons of nitrate. The pre-war importation of nitrate of soda amounted to about 560,000 tons per annum; hence the normal consumption for purposes other than the manufacture of nitric acid was about 400,000 tons.

The present rate of importation is about 1,600,000 tons of nitrate per annum. Since very little is going into storage and the total consumption for purposes other than nitric acid manufacture has increased but slightly, if at all, it may be estimated that at least 1,000,000 tons of nitrate per annum are being converted into nitric acid at the present time. This is equivalent to 650,000 tons of 100 per cent nitric acid of which nearly five-sixths is being used for the manufacture of military explosives.

The building of the new nitrate of soda acid plants has offered an excellent opportunity for the introduction of many improvements. The Dutch ovens under the retorts have been displaced by modern fire boxes provided with a proper arch. This change has effected a saving in coal consumption of approximately 25 per cent. The chemical stoneware from the retorts to the condensers and the glass condenser tubes have been displaced by acid-proof, high-silica iron, such as Duriron and Tantiron. The volvic-ware saucers in the towers have also been displaced by acid-proof iron. The chemical ware from the condensers to the absorption towers, and the glass lines for circulation of acid at the sides and top of the towers, however, are retained. The absorption tower capacity has been increased about 40 per cent by the addition of more towers. Spiral rings for tower packing have taken the place of the ordinary form of packing.

Important changes have also been made in operation. The average charge of 5,000 lbs. of nitrate per retort has been increased to about 7,500 lbs. The retorts, instead of being operated in batches, are now operated in rotation. Instead of 3 runs per retort per day the usual practice is now 2 runs per day. Temperatures are also controlled more carefully than in the past.

The result of these improvements is an increase in the amount of nitrogen recovered as acid from an average of about 78–80 per cent to about 92–94 per cent of the nitrogen in the nitrate

of soda. At the same time the labor requirement has been somewhat decreased.

A good beginning also has been made in the recovery of nitrose gases produced in the various nitration operations. In some of the systems that have been devised as much as one-half of the fumes are being recovered. The collection of the gases from the many nitration units, however, is still a serious problem. While the aggregate amount of acid that is being recovered is large, it represents only a small fraction of the acid gases that are being wasted. In the ordinary nitration operation as carried out at present about one-tenth or one-twelfth of the nitric acid is wasted in the wash waters, while on an average about one-eighth is lost as fumes, of which one-half is recovered in plants that are equipped with recovery systems.

Nitric acid by direct combustion of air by the arc process has not had any important development as yet in America. Three small plants, more or less on an experimental scale, have been built in the United States and operated for short periods. The production of these plants thus far has been negligible. The total annual capacity probably does not exceed two or three thousand tons of nitric acid per annum.

Nitric acid by the oxidation of ammonia has received a considerable and important development since the outbreak of the war. In 1914 there were no ammonia oxidation plants in this country. At the present time there are under construction ammonia oxidation plants with a capacity equal to about 225,000 tons of 100 per cent nitric acid per annum.

The first commercial-sized oxidation plant was established in July 1916, at the Ammo-Phos Works of the American Cyanamid Company, at Warners, New Jersey. Six catalyzer units were installed, each with a presumed capacity of 14 lbs. nitric acid per hour. Improvements in the design of the catalyzer and in methods of operation have brought the capacity to over 40 lbs. of nitric acid per hour. The catalyzer used is a single fine platinum gauze with an area of about 2 sq. ft., electrically heated. Over a period of 2 years two of these units have supplied the nitric requirements of the 60,000 ton sulfuric acid chamber plant at this works. The ammonia is taken directly from cyanamid autoclaves producing about 30 tons of ammonia gas per day, used mainly for aqua ammonia manufacture. This plant has served for several months as a training school for the instruction of operatives for the Government cyanamid-nitrates plants. Hence, more extensive records are available than would normally be the case. As an example of the normal operation of the catalyzers on ammonia taken directly from the autoclave mains, the following figures are quoted verbatim from the records for the week July 13 to 19, 1918. Each value is the average of determinations of two chemists working independently, with the exception of those marked (*) which are determinations of one chemist only.

Catalyzer No. 5			Catalyzer No. 6		
Date	Time	Efficiency	Date	Time	Efficiency
July 13	2.35 A.M.	96.2	July 13	5.30 A.M.	90.0
July 13	8.40 A.M.	98.5	July 13	1.10 P.M.	93.0
July 13	5.20 P.M.	93.1	July 13	8.40 P.M.	93.4
July 13	11.50 P.M.	96.0	July 14	2.50 A.M.	93.0
July 14	5.50 A.M.	97.4	July 14	1.00 P.M.	94.2
July 14	5.10 P.M.	94.8	July 14	10.15 P.M.	93.2
July 15	10.35 A.M.	95.0	July 15	8.15 A.M.	95.6
July 15	5.15 P.M.	95.8	July 15	2.30 P.M.	90.7
July 16	1.50 A.M.	95.4	July 15	11.30 P.M.	92.6
July 16	11.20 A.M.	95.4	July 16	8.00 A.M.	90.0
July 17	1.10 A.M.	92.1	July 16	8.25 P.M.	93.0*
July 17	1.00 P.M.	92.3	July 17	9.30 A.M.	90.9
July 18	12.50 A.M.	91.4	July 17	8.20 P.M.	94.0
July 18	10.55 A.M.	92.6	July 18	7.40 A.M.	92.0
July 18	8.00 P.M.	91.9	July 18	5.10 P.M.	91.6*
July 19	9.50 A.M.	93.6	July 19	4.15 A.M.	93.0
Average for week ...		94.5	Average for week		92.5

The cyanamid-nitrates plant at Muscle Shoals, Alabama, will use the electrically heated, single gauze catalyzer. It will produce approximately 90,000 tons of 100 per cent nitric acid per annum. The plant is expected to go into operation about November 1, 1918. The cyanamid-nitrates plant near Cincinnati and the one near Toledo, Ohio, will also use the same process, each producing at one-half the above rate. They are expected to be in operation early next spring.

The Government experimental plant at Sheffield, Alabama, known as Nitrate Plant No. 1, which will make about 15,000 tons of nitric acid per annum, has adopted a non-electrically heated multiple screen, consisting of several layers of platinum gauze, welded together at points, and rolled into the form of a cylinder. The ammonia-air mixture flows outwards through the screen at a rate several times as fast as with the electrically heated single screen. After the oxidation has been started by external application of heat the temperature is self-sustaining from the heat of reaction.

In view of the perfect control obtainable with electrical heating, the cost of the electric energy consumed, amounting to about one-third of one per cent of the present market value of the nitric acid, may be regarded as negligible. As to the single versus the multiple screen the efficiencies cited above as examples of normal operation of electrically heated single screens are believed to represent the highest standards yet attained in the practical operation of ammonia catalyzers.

It is understood that the Semet-Solvay Company has an ammonia oxidation plant at Syracuse, New York, using the multiple screen without electrical heating. This plant is producing several tons of sodium nitrite per day. Information regarding efficiencies is not available.

In addition to the plants above mentioned the Navy Department, about two months ago, decided to build a plant at Indian Head, Maryland, for fixing nitrogen by the modified Haber process used at Plant No. 1. All the ammonia produced will be oxidized to nitric acid, yielding about 30,000 tons per annum.

Considerable work is also being done on the use of catalyzers to hasten the conversion of the nitrose gases obtained from the catalyzers into nitric acid. The object is to reduce the amount of space required for reaction chambers. The experiments along this line show promise of early success.

The nitric acid producing rate in the spring of 1919 will be about 650,000 tons from nitrate of soda and about 225,000 tons by oxidation of ammonia obtained from the air, a total of 875,000 tons of 100 per cent nitric acid. This is about nine times the pre-war normal consumption. In 1914 the industrial explosives industry consumed about 50,000 tons per annum, while all other uses took only about 40,000 tons. The only notable increase in consuming ability since 1914, aside from military explosives, has been in the dye industry. In 1917 it was estimated that 30,000 tons of dyes were produced in America, equal to the total 1914 consumption. The production will probably increase somewhat further, but at most could hardly consume more than 30,000 or 40,000 tons of concentrated nitric acid. With a producing rate of 875,000 tons and a consuming ability in peace times of 125,000 or possibly 150,000 tons, it is evident that over four-fifths of the nitric acid producing capacity will have to be shut down as soon as peace conditions are established.

The successful development of the ammonia oxidation process raises the question whether this may not become the principal source of nitric acid in the future. While a categorical statement cannot be made, some of the major factors may at least be pointed out. The cost of converting nitrate of soda to concentrated nitric acid is just about equal to the cost of converting autoclave ammonia gas to concentrated nitric acid, interest and depreciation included in both cases. Ammonia gas, however, is a cheaper form of nitrogen than is nitrate of soda. It is cheaper by the amount of sulfuric acid required to fix the ammonia gas in the form of sulfate of ammonia, for nitrate of soda and sulfate of ammonia in the past have always sold at about the same price per pound of nitrogen. They will probably

be sold on a competitive basis after the war, or if there is any difference, the ammonium form will probably be the cheaper. The differential between ammonia gas and sulfate of ammonia, then, will make a difference of about 15 to 20 per cent in the cost of the nitric acid, in favor of ammonia oxidation. The fact that the nitrate of soda acid plants are being amortized during the war and are conveniently located for peace-time industrial uses, while new ammonia oxidation plants would have to be built at these same points in order to avoid transporting acid, is relatively not very important, because the interest and depreciation charge saved by amortization of the nitrate of soda acid plants is only about 4 per cent of the normal cost of the acid. The decisive factor will probably be simply the question whether the difference in cost of acid by the two processes is a sufficient incentive to overcome the inertia of human nature against changing existing practices.

POTASH SYMPOSIUM

September 25, 1918

RECOVERY OF POTASH FROM KELP

By C. A. Higgins, of the Hercules Powder Company

The recovery of potash from kelp, and the utilization of kelp ashes, principally as a fertilizer, is an art that has long been practiced. Many centuries before the German Syndicate began to market potash salts from their Stassfurt mines, the crofters around the rocky shores of Scotland and the northern coast of France had burned the drift kelp as a fuel, and scattered the ashes over their land as a fertilizer. The great success which resulted from the use of this kelp ash on the land caused a rapid expansion in the business of kelp harvesting, until about the beginning of the 19th century quite a flourishing industry had already sprung up.

The opening up of the German potash mines, however, about the middle of the 19th century, began to flood the market with potash at a price far below that at which the old kelp burners could produce it, and although the kelp potash industry still struggled along in isolated parts of the coast among the Scottish crofters, and to some extent in Japan, it may be said that the German production killed the kelp industry, which had up to that time attained fairly considerable proportions.

The outbreak of the present war, however, drove potash users to look for new sources of supply, and naturally one of the first to come to their attention was kelp. Previous to the outbreak of the war many writers had drawn attention to the huge perennial beds of kelp which grow practically uninterrupted all along our coastal waters on the Pacific side, from the Mexican line to Alaska, and around the scattered groups of islands which lie close to the California shore. These vast fields of kelp seemed to offer inexhaustible supplies of potash, which according to the preliminary survey made by the Government, bade fair to supply far more than the normal requirements of our country for the indispensable muriate of potash. All that remained was to devise economical means for harvesting these vast beds and drying and reducing the kelp to a suitable condition for transportation and use as a fertilizer. Within a few months, therefore, of the cutting off of the German muriate, various large companies were prospecting the Pacific Coast for suitable sites on which to erect plants for the harvesting and extraction of potash from the Pacific kelp.

The earliest attempts at harvesting were very crude and involved a good deal of manual labor. Men in flat-bottom scows would reap the weed by hand with large sickle knives and burn it in a rather primitive way. The ash was afterwards sold to the big fertilizer companies at a price based upon the potash content, which generally ranged around 15 per cent K_2O. Later, however, modern methods were installed for the harvesting of kelp. Large flat-bottom, steam or gasoline-propelled scows were equipped with a mechanical reaping device and band conveyors which cut the kelp and conveyed it in one operation into the tanks aboard the harvesting vessel, at very much less expense than that involved in the old method of hand cutting. These harvesters, when filled, then proceeded to shore under their own power and discharged their contents into hoppers at the plant, which in turn fed series of mechanical dryers, where the kelp leaves were dried and partly incinerated by passage through revolving drums heated by oil burners. The dried incinerated kelp leaves were next ground and sacked, and were then ready to be shipped to the fertilizer factory. Some attention is paid in the drying process to insure that a minimum of the potash and nitrogen content of the kelp is lost by the destructive distillation effect of the drying equipment. That, briefly, is the method now in use in plants where potash is considered as the only valuable constituent of the kelp. Experience has shown, however, that this process of producing potash and realizing the values of kelp is very expensive, and will exist possibly just so long as the war and the present high price of potash last.

A few figures will show the status of the kelp ash industry in this regard. Using the modern harvesting methods that I have already briefly touched upon, experience shows that it costs around $1.10 to harvest and bring a ton of kelp leaves ashore. Analyses show that the average potash content of the raw kelp as harvested in California coastal waters is about 1.3 per cent K_2O, which means that it costs about $85.00 to bring in the green kelp equivalent to 2000 lbs. 100 per cent K_2O. To this, of course, must be added the cost of drying these kelp leaves, which contain about 90 per cent of moisture, and by reason of their gelatinous and cellular structure present quite a problem in desiccation. All indications seem to point very clearly to the fact, therefore, that any industry which looks to the production of potash from kelp on a permanent peace-time basis must reduce its costs very considerably, or produce valuable by-products in the same process which in turn will effect a reduction in the cost of the potash.

Along these lines certain investigators have suggested, as far back as a century ago, that the peculiar algin bodies present in kelp might be profitably recovered and used in certain operations in place of gelatin, for the sizing of paper and textiles, the proofing of cloth, and in the production of rubber substitutes and admixtures. Another interesting suggestion is that of Prof. T. C. Frye, who made a conserve by first leaching out the potash and soluble salts and afterwards soaking the kelp in cane sugar solution flavored with lemon. In Japan a kind of sour pickle with vinegar is made from the fleshy parts of the kelp. The kelp fiber when compressed and dried also forms a hard substance resembling ebonite or vulcanized fiber, and at least one concern is working along these lines at the present time. The production of by-product iodine from kelp, however, has long been a practical proposition, although hampered somewhat by the competition of by-product iodine from the Chilean nitrate fields

The biggest practical advance in the economical production of potash from kelp was made in the year 1915, when the Hercules Powder Company started the construction of large gasoline-propelled marine kelp harvesters and a factory near San Diego, California. This equipment was designed primarily for the production of acetone, potash, and iodine from kelp. Kelp as a source of acetone was something entirely new to the chemical industry, and chemists all over the world have watched the growth and development of the undertaking with great interest. The plant since its inception has rapidly increased the number and range of its products and has placed upon the market some new materials which are full of industrial promise.

Reduced to its simplest terms, the basic principle of this process of kelp reduction lies in the destruction of the cellular tissue of the kelp leaf by fermentation, bringing the potash into solution, and producing acetic acid as the product of the

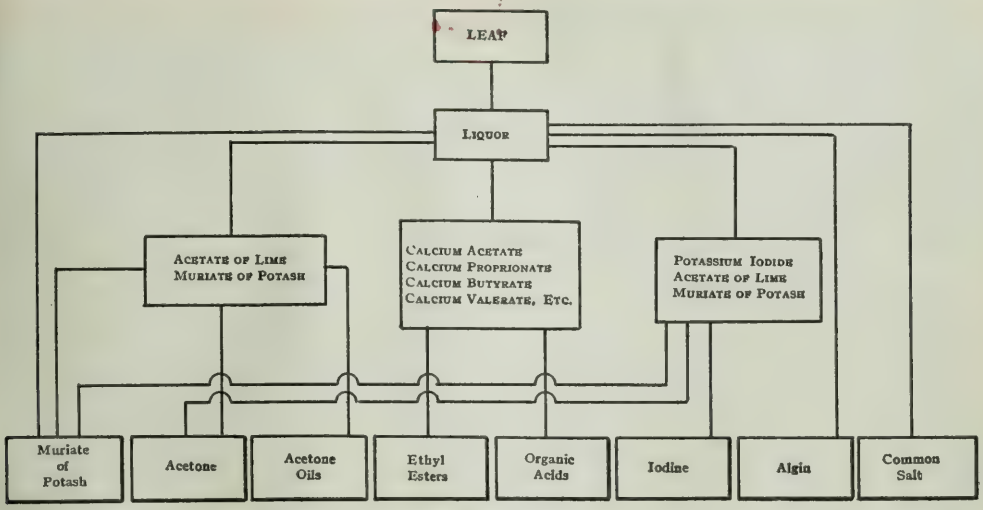


FIG. 1

fermentation of the kelp leaf. The acetic acid is neutralized with limestone, giving calcium acetate, potash, and iodides in the solution.

The products chart (Fig. 1) will give a general idea of the operations at this plant and will serve as an introduction to the more detailed descriptions of processes which follow. With this I think we can outline quite clearly the principal steps involved and the products produced in the fermentation of kelp. The kelp is harvested, brought to the plant, and pumped from the tank barges into the fermentation vats, where it is allowed to ferment until the kelp leaf goes into solution and a liquor is obtained which on evaporation and concentration yields, at various stages, three intermediate salts.

The first intermediate product, consisting of a mixture of acetate of lime and muriate of potash, is heated in regular acetone retorts. This produces acetone from the acetate, leaving as residue muriate of potash and calcium carbonate, from which the high-grade muriate is separated by leaching and subsequent crystallization. The fractionation of the crude acetone yields a certain amount of light and heavy acetone oils, in addition to the C. P. acetone.

Intermediate product No. 2, consisting of the calcium salts of the higher fatty acids, is mixed with alcohol and sulfuric acid and the corresponding ethyl esters and produced by the well-known methods. These esters are easily separated by fractionation. Ethyl acetate, ethyl propionate, and ethyl butyrate from this source in commercial quantities are now on the market and are finding very extensive application as solvents in the soluble cotton industry, in the manufacture of artificial leather, etc., etc.

Intermediate product No. 3, consisting principally of potassium iodide, is treated with chlorine and the precipitated iodine dried and resublimed.

The last of the final products is algin. This substance is at the present time being produced from at the residual unfermented leaves which are screened from the fermentation vats. These leaves are treated with sodium carbonate which extracts the algin in the form of a soluble sodium salt which is afterwards precipitated and purified. So far but little progress has been made in the commercial development of the use of this algin as an article of commerce. The perfection of extraction manufacturing methods, however, and the increasing cost of gelatin and vegetable gums lead to the conclusion that this material may find a very extensive use in the future.

In addition to the foregoing, valuable products promising experiments are now in progress whereby ammonia, valeric and caproic acids are being recovered as by-products in the fermentation of kelp. Nitrogen combined as ammonia exists to the extent of about 0.2 per cent in kelp, and is left in the liquor after fermentation of the leaf. Isovaleric acid is much needed at the present time in the treatment of nervous disorders, the supply of the valerian root from which the medicinal valerates were formerly made having been almost entirely cut off.

Sufficient has been said I think to indicate that the kelp industry from being conceived solely as a source of fertilizer potash will eventually develop along the lines of fine chemicals with high-grade muriate somewhat in the position of a by-product. It is doubtful whether the total potash production of all the kelp-harvesting concerns at the present time amounts to more than about 25 tons a day on the basis of 80 per cent muriate of potash. Of this, more than half is of a high grade of purity, about 95 per cent KCl, and is produced not by the original method involving the incineration of the kelp, but by the fermentation process already referred to.[1]

CONCLUSION

It may be a little early to speak definitely of the future of the kelp industry and its bearing on potash. Certain it is that with kelp reduction factories extending all along the Pacific Coast our domestic demands for potash cannot be met thereby. Certain it is too that kelp, solely as a source of potash, will never compete with unrestricted supplies from Europe or even with the potash recovered in modern cement or blast furnace practice. The utilization of kelp in such a way, however, as to realize on all the other possible values of kelp, some of which we have touched upon within the brief limits of this paper, may help to render the users of high-grade potash for chemical purposes outside of the fertilizer trade independent of foreign supplies.

[1] At this point there were exhibited about 300 ft. of cinema film and some 30 lantern slides showing kelp harvesting machines at work and the operation and equipment of the factory.

RECOVERY OF POTASH FROM IRON BLAST FURNACES AND CEMENT KILNS BY ELECTRICAL PRECIPITATION

By Linn Bradley, of the Research Corporation, New York City

The subject of potash recovery is becoming of more universal interest to the public as well as to the technical man. The daily press and the magazines frequently refer to what is being done and to what should be done in this country in order to offset and decisively defeat the Kaiser and his followers. Recently several news items and editorials have appeared in the metropolitan press calling our attention to what is being done in England toward making their country independent of Germany, and it appears that the British Government has furnished large sums of money to assist in recovering potash from their iron blast-furnace gases. It is predicted that this source will enable England to obtain enough potash to equal her entire prewar importation from Germany. France is reported to be as keenly awake to the possibilities along this line and we may see the time when France will be recovering large quantities of potash from iron ores which Germany has made such strenuous efforts to control. However, it is not surprising that interest in potash should increase, when we consider that this is the one big economic weapon which Germany has relied upon to regain her place in the sun after the war. She boasts that all countries will have to depend on her for potash. She claims that other countries cannot produce potash to compete with that supplied by Germany. But in this, as in many other instances, her reasoning is based on lack of information as to facts and possibilities.

The recovery of potash in this country is making rapid strides. The industry may be roughly divided into those plants in which the recovered potash is the main product and those in which the potash is recovered as a by-product. In this paper the latter phase will be considered, as it is believed that while the largest immediate tonnage may be obtained from desert lakes, kelp, alunite, and a few other sources, nevertheless a study of the economic problems will show that the surest way of making our potash industry a permanent and enduring one, able to supply all of our requirements, even against German competition, is to develop and rely upon the by-product potash.

After the installation of the Cottrell process at the plant of the Riverside Portland Cement Company in California was placed in operation for the purpose of eliminating the dust nuisance, it was noticed that the material collected in various parts of the precipitator differed in fineness. Natural inquisitiveness then called for an analysis of these products to determine if any impurities in the raw mix had become concentrated in any portion of the dust. The alkalies increased with the fineness of the material as shown by screen analyses. At that time considerable light fume was escaping from the precipitator exits and the suggestion was made and urged that some of this material be collected and analyzed as it might show even higher alkali content, since having been interested in agricultural and fertilizer problems it seemed to some of us that potash might be found in the escaping fume in percentages such as would warrant its recovery. Thus the first commercial potash-recovering plant in this country was established. The engineer in charge of this work was W. A. Schmidt, of Los Angeles. Since that time a number of improvements have been developed and the commercial success of the potash plant at Riverside has been the cause of several other cement companies installing potash recovery plants.

Early in 1912 the Research Corporation, of New York, started to develop the Cottrell process and apply it to various plants in the eastern portion of the United States. Shortly after work had been begun, a paper was read and a demonstration given at a meeting of the local section of the American Chemical Society near Allentown, Pa. The next day arrangements were made for a visit to the South Bethlehem plant of the Bethlehem Steel Company. Having in mind the experiences of the Riverside cement plant, curiosity was aroused by the appearance of the gases coming from the tall brick stack connected to the boilers. An investigation was undertaken by Mr. R. J. Wysor, and this resulted in extensive investigations thereafter to determine the possibility of cleaning these gases by the Cottrell process and recovering whatever of value could be obtained from the collected material. Mr. Wysor has published a very able and valuable article in the Transactions of the American Institute of Mining Engineers (1917) giving a great deal of data on ores, fluxes, slags, potash balances, and other items directly related to the recovery of potash as a by-product of blast furnaces. His paper probably served as an inspiration for much of the work which has been undertaken abroad.

Analyses of iron ores, cokes, limestones, and dolomites show a wide variation in potash content, and it is therefore advisable for one interested to make sure that his raw materials are sufficiently rich to warrant a potash recovery plant. Furnaces which produce a large tonnage of slag per ton of iron on account of the iron content of the furnace charge will, of course, carry more potash into the slag than furnaces which produce a relatively small volume of slag, other things being equal, except for composition of the charge. Some iron ores carry as high as 60 per cent of iron and are practically devoid of potash. Some cokes have a low ash and are low in potash. Some limestones and some dolomites may be quite pure. If, therefore, the ores are uniform and properly prepared and the fuel and flux are properly proportioned, the slag volume will be small and the potash in the gases may likewise be negligible. On the other hand, if the iron ore carries as much as two or even one per cent of potash (K_2O) and the coke ratio is high, and it and the flux contains as much as 0.25 to 0.50 per cent of potash, quite a large quantity of potash will be volatilized and carried off by the gases from which it can be recovered. The high temperature in the blast furnace and the length of time under treatment allows the silicates to be decomposed more readily than in a cement kiln where the temperatures are not so high. The potentialities of the by-product recovery from blast furnaces would, therefore, seem to surpass the possibilities of the Portland cement industry in this regard.

Numerous attempts have heretofore been made to recover potash from silicate rocks. The investment and operating cost, especially for fuel, are hard to overcome if one endeavors to volatilize the potash and recover it and nothing else. It therefore seems that the best way to recover the potash from these silicates by heat treatment is to charge these silicates into existing furnaces along with the regular charge and recover the potash as a by-product, thus eliminating the investment and operating cost for new and separate furnaces. This would be profitable up to a certain point, beyond which, however, this practice would not be desirable.

Since the investigations referred to were begun at South Bethlehem, numerous other furnaces have been investigated and potash balances made. Iron ores have been found in abundance in Alabama which carry from 1 to as high as 3 per cent in potash and carry enough iron to make them highly suitable for this purpose. The following tables show the results of one investigation:

Analyses of Materials

Material	Fe	SiO_2	Al_2O_3	CaO	MgO	Ash	Carbon	Na_2O	K_2O
Ore No. 1	46.36	17.42	4.19	5.03	8.33	...	...	0.62	1.27
Ore No. 2	54.69	12.78	3.49	4.04	6.00	...	...	0.39	0.74
Stone	...	1.56	0.58	46.24	7.25	...	...	0.64	0.26
Coke	...	5.82	3.49	0.51	0.24	13.01	86.15	0.39	0.32

Charged into Blast Furnace

Materials	Lbs. per ton iron	Total lbs. K_2O	Per cent of total
Ore No. 1	3115	39.56	61.0
Ore No. 2	1168	8.65	13.2
Stone	1440	3.74	5.8
Coke	4050	12.97	20.0
Total	9773	64.92	100.0

SUMMARY

Total K_2O charged into furnace per ton of iron produced	64.92 lbs.
Lost in slag per ton of iron produced	11.60 lbs.
Lost as fume from gas leaks per ton of iron produced (estimated)	1.16 lbs.
Total potash recoverable from gases per ton of iron produced	52.16 lbs.
Total potash in dust in gases as per analyses	34.11 per cent
Water-soluble potash in dust in gases as per analyses	32.10 per cent
Portion of total potash in dust, which is water-soluble	94.11 per cent
Total water-soluble potash recoverable per ton of iron by collecting the dust in the flue gases	49.09 lbs.
Total water-soluble potash as above per 500 tons iron per day	24545.00 lbs.
Total water-soluble potash as above per year of 350 days	4295.37 tons
Portion of total potash charged into furnace which is recoverable from gases in water-soluble condition	75.62 per cent
Safe estimate of above amount recoverable in operating practice	80.00 per cent
Safe estimate of above amount recoverable as above per year of 350 days	3436.29 tons

A study of the above figures will show that it is desirable to keep the potash content of the raw materials up to the highest point and to keep the slag volume and potash content as low as possible. It is clear that if the slag volume remained constant, as well as its analysis, that if only 11.6 lbs. of potash had been contained in the furnace charge there would have been nothing available for collection. With suitable slag volume and potash content and a rich potash charge the recovery of potash in quantities worth while is readily accomplished. Sodium chloride has been found helpful in liberating the potash in such way that it is recoverable in the dust in a water-soluble form. While working at a cupola furnace in which sash weights were made from old tin cans and other metal waste, it was found that the use of common salt greatly increased the fume volume and density and this later was shown to be due to the fact that chlorides of lead, tin, and zinc were formed and readily volatilized as such. The use of salt has been extended to cement kiln practice and to other uses in connection with the recovery of silver, lead, and zinc from low-grade ores and tailings, the values being recovered from the gases after volatilization as chlorides.

Consideration of data such as presented in the tables given herein resulted in an effort being made to find raw materials suitable for making iron and yet carrying high percentages of potash. Samples of ores, fluxes, and cokes were obtained from a number of furnaces and other sources, and later on this work was carried on much more extensively by the Bureau of Soils of the Department of Agriculture and by the Bureau of Mines, Department of Interior. It is probable that Mr. Frederick Brown, of the Bureau of Soils, has now collected data on nearly all of the raw materials available for iron making and that if such data were made public in the near future, it would be of great assistance in connection with the problems under consideration. Personal efforts to find materials such as described developed the fact that in the eastern part of Alabama there is a very large tonnage of iron ores carrying in some cases an average of 1 per cent of potash and in other instances an average of about 1.80 per cent of K_2O, several analyses showing a content of over 3 per cent of K_2O. I am indebted to Dr. J. S. Grasty for having brought these ores to my attention and for much of the data on their iron and potash content as given later in this paper. Mr. M. W. Bush, president of the Shelby Iron Company, has also contributed data on the iron situation of the South and the values of these iron ores in furnace operations. I have examined these properties and have interviewed blast furnace operators who have used them in their furnaces and hold the opinion that they constitute an asset of importance to the nation as well as to interested parties. They should receive the consideration of the Government in connection with our war problems and likewise our post-war problems so as to assist in rendering our country absolutely independent of Germany. The ores carry an average of from 48 to 52 per cent of iron, are very uniform, easily mined and shipped as they are directly on the railroad, and operate satisfactorily in the furnace, producing good iron at low cost. Their potash content also acts as a desulfurizer, thus improving the grade of iron. The phosphorus content is very low.

The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been based on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The table has been submitted to experienced iron blast-furnace operators for suggestions and criticisms. For comparison, other ores have been included in the table. The composition of the high-potash iron ore has been taken from the average of over 1000 tons of such ore shipped to furnaces on which K_2O was determined for each car of this particular shipment.

	SiO_2 Per cent	Al_2O_3 Per cent	CaO Per cent	K_2O Per cent	Fe Per cent
Coke	8.7	5.0	0.3	0.3	1.7
Stone	2.0	1.0	53.0	0.3	0.0
No. 1 Gray	19.2	4.8	1.3	1.8	49.8
No. 2 Red	15.0	4.0	17.0	0.2	36.0
No. 3 Brown	19.5	3.8	6.0	0.2	42.0
Ore required for 1 ton iron, pounds			4398	6039	5212
Percentage of burden			46.07	54.35	46.87
Coke required for 1 ton iron, pounds			2700	3900	3000
Percentage of burden			28.29	35.22	26.98
Stone required for 1 ton iron, pounds			2448	1159	2909
Percentage of burden			25.64	10.43	25.15
Total potash constant of burden per ton iron, pounds			99.5	29.57	33.97
Deduct for losses in slag and elsewhere			10.4	15.6	14.0
Total potash collectible from gases, pounds			89.1	13.97	19.97
Slag volume per ton iron, pounds			2715	3290	3090
Total potash in gases per day (500 tons iron), pounds			44550	6985	9985
Total potash in gases per 350-day year, tons			7796	1222	1747
Assume 80 per cent recovery, this equals			6237	978	1406
Value per annum at $500 per ton of K_2O			$3118500	489000	703000
Value per annum at $100 per ton of K_2O			623700	97800	140600

The total production of pig iron in this country is such that about 200 furnaces of such sizes as referred to above would be needed to meet our requirements if the furnaces were of the same capacity and the lower potash ores are used. Also it is easy to see that we now have sufficient furnace capacity to produce annually over 1,500,000 tons of potash, far in excess of our pre-war requirements, provided ores such as No. 1 are employed. The difficulty lies in the fact that we have not found that all furnace burdens carry the amount of potash shown under the No. 1 column. If the furnace charges and operations could be adapted so that one-fifth of the amount, or 300,000 tons, could be produced, this would meet our needs without assistance from any other source. The three constituents of the charge, ore, stone, and coke, contain more or less potash. By using those raw materials which carry more than usual amounts of potash, our recoveries can be considerably augmented. In cases where ores are smelted which are excessively limey, feldspar, potash-bearing slate, or other potash-bearing silicates could be fed into the furnace and thus increase the potash content of the furnace burden.

Mr. H. E. Brown, a chemical engineer of New York City, has developed a process for making a special cement from the slag obtained from a blast furnace and at the same time recovering water-soluble potash from the gases. He charges limestone, coke, and feldspar into the furnace. Now if iron ores of suitable kind could be used for a portion of the raw material, it might be possible to produce potash from the gases, also pig iron, and a slag which could be readily converted into a marketable cement. As the market varies with the supply and price, the furnace charge could be varied so as to increase the potash and reduce the iron, or *vice versa*. The process has been developed to the extent that both potash and the special cement can be produced, but investigations looking to a reduction in the operating cost have not been completed. It appears, however, that with an assured market for the cement at fair prices, the process can be operated successfully and show a good return on the investment,

especially when the price for potash is high. In this connection, it seems that consideration might well be given to the use of powdered coal introduced through the tuyères and thus reduce the coke required, possibly doing away with it altogether. It would materially reduce operating costs and increase production and recoveries.

It is natural to look to feldspar and other potash-bearing silicates for our potash. The cost of mining and grinding feldspar is one obstacle to be overcome which is not an obstacle for instance in the Cambrian slates of Georgia. It has been suggested also that efforts be made to recover potash from the tailings dumps in the Cripple Creek District of Colorado, these tailings carrying as high as 7 per cent of K_2O. Investigations as to the feasibility of this are now under way. Sufficient progress has not yet been made, however, to warrant any very optimistic statements. The fuel cost and the necessity for a long freight haul to the fertilizer-consuming districts are large items to overcome.

Serecites and Cambrian potash-bearing slates have been located in Georgia which carry potash in considerable quantity, several deposits analyzing as high as 8 or 9 per cent. Laboratory investigations have shown that the potash in these raw materials was more readily rendered water-soluble or volatilized by treatment with salt in a rotary kiln than the potash from feldspar. Furthermore, the amount of lime required to be added to the charge before the potash is liberated appears to be much less than required for feldspar. The cost of production is much less than in the case of feldspar and the cost of grinding is very much less and altogether these slates are much better adapted for the purpose here discussed than feldspar is. Dr. T. P. Maynard, of Atlanta, Georgia, who conducted these researches and developed the properties, reports that there is an enormous tonnage available. It is also reported that a company has been treating this material in a rotary kiln, adding 200 to 300 lbs. of salt per ton of raw material, volatilizing a good portion of the potash, and converting a large percentage of the balance into a water-soluble compound in the powdered calcines. One part limestone is used with two parts of ground slate. Freight rates should be very low since this material is located very close to a large market, namely, the cotton fields of Georgia and Alabama. Engineers state that cotton grows prolifically on these lands without any additional fertilizer, indicating the ease with which the potash is made available.

In all of the cases mentioned above, potash is volatilized and must be recovered from the gases. The Cottrell process has met with excellent success in this phase of potash recovery problems. The field of application which has been developed the farthest is in the recovery of potash from cement kiln gases. Several plants are now in successful operation and at the present time a considerable tonnage is being obtained in this manner. Other plants are under construction and the outlook for a much larger tonnage is very favorable. In *The American Fertilizer* for August 31, 1918, John J. Porter, General Manager, Security Cement and Lime Company, of Hagerstown, Maryland, in an article entitled "The Recovery of Potash as a By-Product in the Manufacture of Portland Cement," gives a great deal of valuable information concerning this problem. The following is quoted from that article:

Estimating Potash Recovery—For the benefit of those who may wish to figure on their own conditions, I give the following method of calculating the probable recovery of potash.

Let A = per cent potash in raw mix
Let B = per cent potash in clinker
Let C = per cent liberation $= \frac{600A - 380B}{600A}$
Let F = lbs. of potash recombined per bbl. clinker (= 0.7 to 1.5 depending on fuel consumption and per cent ash in coal)
Let P = per cent potash precipitated in treaters

Assume 600 lbs. of raw mix actually used to make one bbl. of clinker,
Then,
Lbs. of potash entering kilns per bbl. of clinker = 600A
Lbs. of potash volatilized in kilns per bbl. clinker = 600 AC
Lbs. of water-soluble potash entering treaters per bbl. clinker = 600AC-F
Lbs. of water-soluble potash collected in treaters per bbl. clinker = (600AC-F) = P

* * * * *

The cost of collecting potash at Security is now running about as follows:

	Per Unit of Potash
Collection, including labor, power, repairs and laboratory	$0.14
Packing and shipping	0.08
Total operating cost, exclusive of depreciation, royalty, and salt addition	$0.22

The cost of the salt addition is about $0.25 per unit of potash, but this is not a necessary element of cost and can be omitted whenever price conditions become such as to give an unsatisfactory margin of profits.

The article then goes on to show that from a 3000-bbl. cement plant, the operating profit per annum on the potash alone comes to about $458,000, the raw mix having 0.75 per cent of potash. The article is quite complete and those interested are referred to it for further details. The Bureau of Soils published the results of their survey of cement plants. The data given indicate that this industry can be counted on to furnish 80,000 to 100,000 tons of potash annually. By using materials which are higher in potash content, such as feldspar, serecite, or slate in part, the yield of potash can be materially increased. The additional cost for raw material should be weighed against the greater financial return from the plant operation as a whole and not allow first cost per ton of material to govern. The utilization of existing cement kilns and equipment for the manufacture of cement as a by-product, placing special emphasis on the potash yield and profits therefrom, should be urged by all citizens, and this should be more emphatically urged for the recovery of potash from blast-furnace gases. The feat of obtaining all of our potash from existing industries by recovering the by-products will be typically American and worthy of our "Yankee ingenuity." The by-product method will enable us to compete with potash from any other source, and the Kaiser's vain boast that all countries will be compelled to submit to his will because they must have his potash, shall receive its proper answer. It is not difficult to recall that the by-products of our packing house industries constitutes the source of a large tonnage of our fertilizers, whereas a few years ago these materials were annoying left-overs, difficult to dispose of.

Referring again to the iron industry and its relation to the potash question, it should be pointed out that in the Alabama district there is an abundance of excellent coal, labor is plentiful and cheap, and the climatic conditions are such that the district may be considered an all-year one as far as operating is concerned. Then when it is realized that there is immediately at hand an enormous tonnage of high-grade iron ore which carries such a large potash content and that the South produces our cotton and therefore is the large consumer of potash and thus provides a large market within a few miles, the economic importance of this situation can be better appreciated. Other iron ores contain potash, some of which may justify recovery plants, and we should be on the lookout for such material, keeping in mind that our goal is to obtain our potash as a by-product at such a cost as will enable us to ignore Germany forever and thus make the dreams of the American chemist and engineer come true.

The South produces pig iron cheaper than any other district in normal times. In fact their furnaces must do this in order to stay in the market. The South does not yet consume as much iron and steel products as its population justifies and therefore their iron must carry a high freight charge if it is

shipped North to the larger markets. The manufacture of cast iron pipe has, however, grown to a large industry. In the future more and more iron and steel will be consumed locally as it is evident that the South is coming into its own very rapidly. The additional profit which can be obtained from the potash will be of great assistance in keeping their iron furnaces in blast when the market sags. The South has a very fortunate combination of labor, raw materials, climate, and a large and near fertilizer market.

In France and in Great Britain the national governments have taken an active interest in the possibilities along the lines herein pointed out. It has been reported that investigations, extending over a period of three years, have shown that Great Britain can produce enough potash to satisfy all her requirements. The British Potash Company, Limited, has recently been organized for this purpose and the British Government has undertaken to provide at least half of the total capital required. The funds necessary for the enormous scale operations contemplated will be more than an individual would be anxious to supply in these times. Another reason is that the British Government is fully awake to the importance of the potash to their national interests. It does not seem that our own Government should falter or lag in this field, but on the contrary should immediately make comprehensive plans and take energetic action of such a character as will insure the proper solution of the problems under discussion. At the present time individuals shy at putting their money into a new enterprise which requires much labor and material without having adequate assurance that their efforts will meet with success. In order to do this, the full and continuing support of the Government must be had. Priorities, labor, material, and fuel allocation play an all-important part, and on top of this the new industry is handicapped by having to face an enormous taxation before the plant is fully paid for from earnings, and there is no positive assurance that potash will long remain above the pre-war level. Surely this situation should be corrected promptly. It seems ridiculous that the United States should be playing the rôle of food granary for ourselves and our Allies, also raising the cotton which is so necessary in connection with the war, and yet be doing nothing to provide the potash either for food purposes or for the cotton, except the limited and inadequate efforts due to private initiative. It ought to be emphasized that potash is a subject which should be understood and appreciated by everyone in the nation, and that it should be considered primarily from the national point of view. Does any one of us imagine that there is such ignorance of potash in Germany as exists among our own citizens? No, they have learned that potash is the big German raw material and economic weapon which they counted upon and are still counting on to help the Kaiser impose his will on you and on me. This must be defeated!

To all those who are assisting in the solution of the problem, I would state that we should soon take steps to solve our post-war problems. The question of the market conditions which will prevail is ever before us. Germany will do all within her power after peace is declared to break down that which will have been built up, the same as she has destroyed the beautiful cities of France. She will endeavor to regain control of the potash situation in this country. Even now she probably has her propaganda all prepared and ready for launching. One need not be surprised to learn that she has agents in the various Governmental departments and bureaus in Washington ever ready to interfere with efforts being made by our technical and business men. Even now we hear rumors to the effect that potash is not a plant food and is not needed for cotton, potatoes, and various other crops. Careful investigation of the southern cotton fields should be convincing evidence that this may be another piece of German propaganda. It is difficult to check up these rumors, but all of us should be on guard against these German efforts. It would be to the national interest in the broadest way for this country to take steps to forever exclude every ounce of German potash. Tariff, price control, and other methods should be earnestly considered. The farmer must be made to realize that he dare not use German potash even if he might obtain it a little bit cheaper than the local product. In other words he must not be a potash slacker. The politician hates to take any action which would have a harmful effect on the farmer vote, so we may look for strong opposition when legislation is urged for protection of the new potash industry. It will be short-sighted of our Congressmen to fail or neglect to fully protect this industry. It should be remembered that Germany will continually strive to break down any barriers which may have been erected, and it therefore behooves us to band ourselves together in an alliance which could fittingly be called the American Potash Alliance and see to it that our interests are at all times being taken care of. In unity there is strength, therefore let all parties interested form such an alliance and immediately organize and institute efforts to have the proper legislation passed, and also to conduct a publicity and an educational campaign throughout the country and, generally, to serve the combined interests of those who assist in rendering our country free from the Kaiser as far as potash is concerned. The hearty and active coöperation of the various technical societies should be readily obtained, and I commend these suggestions for the formation of the American Potash Alliance to their attention. The author would be pleased to hear from all who approve this suggestion.

BIBLIOGRAPHY

Articles from Miscellaneous Sources

Gale, "Our Mineral Supplies—Potash," U. S. Geol. Surv., *Bull.* 666–*N*.

Gale, "Potash in 1916—Part II," U. S. Geol. Surv., *Mineral Resources of the United States*, 1916.

Ross, Merz and Wagner, "The Recovery of Potash as a By-Product in the Cement Industry," U. S. Dept. Agr., *Bull.* 572.

Porter, "The Recovery of Potash as By-Product in the Manufacture of Portland Cement." Paper presented at Chicago Meeting of the Portland Cement Association, Sept. 10 to 13, 1917.

Wysor, "Potash as a By-Product from the Blast Furnace," *Trans. Am. Inst. of Mining Eng.*, 56, 257. To this article is appended a bibliography; also see discussion of article on pages 288–302.

Stockbridge, "The Potash Famine," *World's Work*, May 1918.

"Potash in Maryland Becomes a Reality," *Baltimore Morning Sun*, May 18, 1918.

Articles from Metallurgical and Chemical Engineering

Koepping, "Can an American Potash Industry be Established?" December 1, 1916.

de Beers, "Development of our Potash Industry," December 1, 1916.

"Glimpses of New Pacific Coast Industries in the Making," November 1, 1916.

"Potash from Cement Mills," June 1, 1917.

"Potash from Cement at Riverside Portland Cement Company, July 1, 1917.

Meade, "Possibilities of Developing an American Potash Industry," July 15, 1917.

Buck, "Bibliography on the Extraction of Potash from Complex Minerals—Feldspar, Leucite, etc.," January 1, 1918.

Articles from "This Journal"

Haff and Schwartz, "A Practical Revision of the Cobalt Nitrate Method for the Determination of Potash," August 1917.

Ross and Merz, "Recovery of Water-Soluble Potash as a By-Product in the Cement Industry," November 1917.

Anderson and Nestell, "The Volatilization of Potash from Cement Materials," March 1917.

Articles from the Manufacturers Record

Catlett, "Possibilities in Potash Production from Fumes of Cement Kilns," February 24, 1916.

Catlett, "The Blast Furnace as a Potash Producer," May 11, 1916.

"Potash-Making Possible in Iron Production," May 11, 1916.

"Recovery of Potash at Security Cement Plant," May 11, 1916.

"Widespread Interest in Potash as By-Product in Iron Production," May 18, 1916.

"Potash in Iron-Making as Viewed by Government Experts," May 25, 1916. Also letter from Catlett in same issue.

"Bethlehem Company Saving Potash as By-Product," June 8, 1916.

Grasty, "Southern Iron Ores as a Source of Potash," September 14, 1916.

Burchard, "Potash as a By-Product in Cement and Iron Industries," September 14, 1916.

"Potash as a By-Product in Cement- and Iron-Making," March 22, 1917.

Catlett, "Potash from Alabama Gray Ores," March 29, 1917.

"Potash as a By-Product in Cement," August 26, 1917.

Wilmer, "100,000 Tons of Potash Obtainable from Cement Dust Every Year," April 25, 1918.

"Large Potash Recovery at Clinchfield Cement Plant," May 2, 1918.

Hicks, "Production of Potash in the United States," June 20, 1918.

Catlett, "Potash as a National Asset against Germany's Damnation Plans," July 4, 1918.

"How We Can Become Wholly Independent of German Potash," August 15, 1918.

"American Potash for American Farmers," August 22, 1918.

"Potash Potentialities in America which if Utilized Would Make Us Independent of Germany," Open Letter to President, August 29, 1918.

"Potash Question and Its Bearing upon Peace Terms," Letter from Dr. Maynard and Editorial Comment, September 5, 1918.

See also the *Manufacturers Record* of September 12, 1918, and that of September 19, 1918, for a number of articles on potash.

POTASH FROM DESERT LAKES AND ALUNITE

By J. W. Hornsey, Consulting Engineer, Summit, N. J.

The arbitrary action taken by the German government some years ago in forcing Americans who had purchased interests in German potash works to join the German Potash Syndicate and the lack of tact displayed by those who handled the situation for Germany, created so much ill feeling that altogether it brought about the determination upon the part of the United States Government and of American buyers to find some source of potash other than the German, and plans were thereupon made for both governmental and independent searches. Fortunately for this country when war was declared in 1914 these searches had developed a large amount of valuable data.

Both the Geological Survey and the Bureau of Soils were granted appropriations and began active work which has proven to be of considerable value. The independent investigators made a somewhat more comprehensive survey without going quite so exhaustively into details, except where it seemed reasonably certain that a commercially workable supply would be found.

All probable sources of supply were investigated, including feldspar, kelp, desert lakes, leucite, and alunite. It was evident from the start that potash could not be produced profitably at ante-war prices from certain of these materials without the production and sale of by-products, and for some of these by-products there was only a limited market. In other cases a somewhat more careful study of the subject showed that potash was unquestionably the by-product.

This work has, however, definitely resulted in the development of a permanent potash industry in this country, and I say permanent advisedly. Some of the plants will, undoubtedly, be able to continue after the war.

DESERT LAKES

Investigation of many of the lakes of western deserts showed such percentages of potash as to make it improbable that potash could be produced commercially in competition with Germany at the price then prevailing.

SEARLES LAKE. Early in 1912 a company which had acquired control of Searles Lake found that their deposit contained a considerable percentage of potash, apparently in the form of chloride. This so-called lake consists of a deposit of crystals, resulting from the evaporation of a prehistoric lake which was at least 600 ft. deep when it ceased to overflow. In the course of time, as evaporation under desert conditions continued, the lower portion of the valley became filled with crystals permeated with a saturated brine. This body of crystals has been exhaustively investigated by the drilling of wells and its limitations are now well known. This crystalline body, averaging 75 ft. deep, has an area of 25 sq. mi. That portion near the edge is covered with mud, but $12^1/_2$ sq. mi. are uncovered, and here the crystal body is smooth, hard, and solid enough to carry any weight. It is, however, not dense, but composed of crystals varying in size from, say $^1/_4$ in. cubes, to the equivalent of 4 in. cubes. This mass of crystals is formed with openings and interstices between them, approximating 40 per cent of the contents of the crystal body.

This interstitial space is filled with a brine saturated with the salts of which the crystals are formed, comprising the chloride of potassium and the carbonate, borate, sulfate, and chloride of sodium. As these voids extend throughout the entire crystal body they form unobstructed channels through the deposit, and owing to the well-known principle of the diffusion of salts in solution, the brine is virtually uniform in composition through the entire crystal body. Analyses of many samples taken at widely separated points have given substantially the same result. The following is a typical analysis given in the form of the usual hypothetical combination, but which to-day in view of the large amount of work done on this deposit, can hardly be called hypothetical:

	Per cent
$Na_2B_4O_7 \cdot 10H_2O$	2.92
Na_2CO_3	4.92
NaCl	15.84
Na_2SO_4	6.72
KCl	4.36
Total Solids	34.76

Repeated analyses of brine taken from various parts of the deposit by pumping continuously 24 hrs. per day for periods of 30 days show that near the center of the deposit the potash content calculated as KCl will gradually increase from about 4.75 per cent to 5.25 per cent. In one case at the end of 30 days it showed 5.40 per cent. Near the edge of the deposit the percentage gradually lowered from about 4.75 per cent to 4.00 per cent.

A composite sample made up of 52 samples of the crystals taken from widely separated points and from various depths showed 5.00 per cent of potash calculated as KCl. Obviously this shows the brine to be saturated with potash and before its potash content can be lowered by pumping, the potash in the crystals will be dissolved.

The average level of the brine is 1 in. below the surface of the crystals, in consequence of which the surface crystals are always wet, and in the intensely hot desert atmosphere this is followed by a very high rate of the evaporation, which in turn is compensated for by a constant inflow of water from the sur-

rounding mountains, entering the crystal body at the bottom and flowing through the valley beneath an impervious clay layer.

The raw material in this case is the brine, and the mining cost is that of pumping. The separation of the various salts is greatly simplified by the differences in their relative solubilities. Potassium chloride and borax are much more soluble in hot water than in cold, while the solubilities of the other salts do not vary greatly with the temperature of the solution.

The question is often raised as to the total tonnage of potash in Searles Lake. It is not difficult to calculate with a greater degree of accuracy than would be possible in most mineral deposits. The following facts are known:

The deposit covers 25 sq. mi.

The average depth is 75 ft.

The volume occupied by crystals is 60 per cent.

The volume occupied by brine is 40 per cent.

The weight of 1 gal. is 10.738 lbs.

The average analysis of the brine shows a potash content of 4.36 per cent.

It seems perfectly safe and conservative to say that Searles Lake in the brine alone contains 30,000,000 tons of potassium chloride, calculated as 100 per cent pure.

The first company to produce potash from Searles Lake brine was the American Trona Corporation. Their operations have proven to be profitable and they will undoubtedly be able to compete with Germany after the war.

GREAT SALT LAKE—This is still a body of water or brine and has not progressed nearly so far in the process of desiccation as Searles Lake. It has, however, for some time been looked upon as a possible source of potash. In fact, the Diamond Match Company has had a plant in operation there for the past 2 or 3 years, and has recently doubled its output. The Virginia-Carolina Chemical Company, in coöperation with the Inland Crystal Salt Company of Salt Lake City, have also built a plant. However, the composition of the waters of the lake is such that a very large amount of evaporation is necessary before the bitter liquors are sufficiently saturated with potash to make them workable. The primary evaporation is effected in open air, clay-lined ponds, during which considerable quantities of sodium chloride are thrown out. The bitter liquor remaining is then worked up for the separation of potash, which is effected by evaporation, heating, and cooling, and depends upon the varying relative solubilities of the different salts. The principal difficulty encountered is to bring about a satisfactory separation of magnesium chloride. The total output from Great Salt Lake is so small that it is unlikely to become an important factor in the market.

OTHER AMERICAN LAKES—There are a number of lakes in the western deserts which are possible sources of potash, among them Owens, Abert, and Summer lakes. But these all require so large an amount of evaporation and contain contaminating salts of such a character that up to date nothing has been done commercially for the production of potash from them.

PINTADOS DEPOSIT IN CHILE—About 60 miles from the coast and directly on the railroad in northern Chile is a deposit which, while it cannot be correctly called a lake is essentially the same, and contains several hundred thousands of tons of workable potash in the form of a crystal body directly on the surface, averaging about 18 in. deep and covering many thousands of acres. The average analysis will show about 5 per cent of K_2O. This potash upon leaching and crystallization can be recovered as the muriate, or, if mixed with the raw material from which sodium nitrate is made and which immediately joins this deposit, can be recovered as the nitrate.

While this deposit is not in the United States, it is 1000 miles nearer to New York by water than California and is located where labor and other conditions are so favorable as to offset the high price of fuel. The climate is better than at some points in our western deserts and the country has a stable government. Revolutions are unknown and there has been less change in their constitution and general governmental methods during the past century than in the United States, England, France, or any other large country.

ALUNITE

Many centuries ago alunite was mined in Smyrna and for about 400 years in Italy and was used for the production of potash alum. When the search for potash began in this country it was felt that a deposit of alunite might be found and that it might be used as a source of potash rather than potash alum. About this time such a deposit was discovered in Southern Utah, a few miles from Marysvale. Later it seemed that it would be necessary to discover some means of refining the alumina before potash could be produced in competition with Germany. However, early in 1915, when the price of potash had risen to what seemed impossible figures, Mr. Howard F. Chappell and his associates, of the Mineral Products Corporation, decided to build a plant, and this has been in continuous and successful operation for 3 years, except for two shut-downs of 1 or 2 months each, caused by fires. They are now producing and shipping about 600 tons of sulfate per month, and the product is considerably better than 90 per cent pure.

Several formulas are given by various authorities to indicate the chemical composition of alunite as a double sulfate of potassium and aluminum, of which the following are representative: $K_2SO_4,3(Al_2O_3SO_3),6H_2O$; $(K,Na),(Al_2OH)_3,(SO_4)_2$; $K(AlOH)_3,(SO_4)_2,3H_2O$.

The first of the above formulas appears to be more nearly correct, *i. e.*, for the alunite now being worked at the town of Alunite near Marysvale. Several methods have been proposed for the treatment of an ore of this character for the production of potash, but probably the simplest one is that employed in this plant where the ore is calcined at approximately 1000° C. This drives off water of crystallization and sulfuric acid, leaving water-soluble potassium sulfate and alumina. Upon leaching and evaporation of the resulting solution, potash is recovered as sulfate with a very small percentage of soda and some infinitely fine alumina which has passed through the filter cloths.

The alunite from the Mineral Products Corporation's mine is of a distinctly crystalline nature and from 96 to 97 per cent pure alunite. There are other large deposits nearby but they are more nearly amorphous in appearance and carry more silica which seems to interfere with the calcination and also with the subsequent refining of the alumina.

The alumina residue, containing any silica present in the ore, is now discarded; but it is planned later to refine and use it. It has been discovered that the silica content may be reduced to less than one-half of one per cent by calcination with producer gas instead of pulverized coal and separation of the alumina from the silica by flotation. The average silica content of the ore used by Mr. Chappell's company is $3\frac{1}{2}$ per cent. The loss on ignition is approximately 40 per cent and the raw ore contains an average of approximately 10 per cent of K_2O, or $18\frac{1}{2}$ per cent of K_2SO_4. The plant is operated profitably, and by reason of improvements and refinements which have gradually been developed, will, it is believed, be able to compete with Germany after the war.

POTASH FROM SEARLES LAKE

By ALFRED DE ROPP, JR., of the American Trona Corporation

Searles Lake Basin[1] is a broad, roughly circular valley or depression 8 to 10 miles from east to west and 20 to 25 miles from north to south, bordered by the abruptly rising slope of the sur-

[1] For the topographical description of the Searles Lake Basin and its porous salt bed, we are indebted to *Bull.* 580 *L*, written by Hoyt S. Gale of the United States Geological Survey. His description of Searles Lake and the surrounding country is the clearest and most comprehensive of any that have come to our notice.

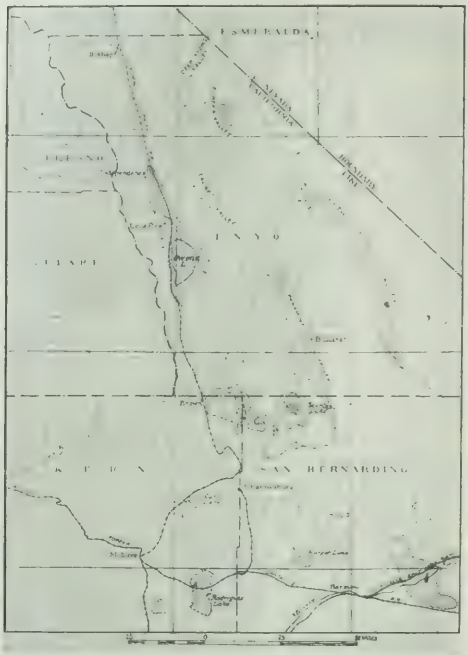


FIG. 1
Map of Owens, Searles, Panamint and Death Valley Basins

rounding ranges. This Basin lies between the Argus Range on the west and northwest, and the Slate Range on the east, the latter a narrow, rocky wall, which divides it from the larger and deeper depression of the Panamint Valley.

The Searles Lake Basin was, during a part of the glacial epoch, occupied by at least one deep lake, whose traces are still so distinct as to be indisputable.

While the waters stood at their highest position, the Searles Basin was flooded to a depth of 635 to 640 ft. above the level of the present valley bottom, and the lake extended back through the Salt Wells Valley to join with a broad, shallow lake that flooded the greater part of the Indian Wells Valley.

With the lowering of the water level less than 75 ft., the divide in the volcanic peaks between Indian Wells Valley and Salt Wells Valley became an actual division between two distinct water bodies, and for a time here also there was a period of overflow from Indian Wells Valley to the lower waters in the Searles Basin, in the same way that Owens Valley overflowed and spilled its waters into Indian Wells Lake. These are facts attested to by the records of the ancient shore lines and water channels

The determined elevation of the lowest part of the present salt flat in the main Searles Basin is 1617.6 ft. above sea level.

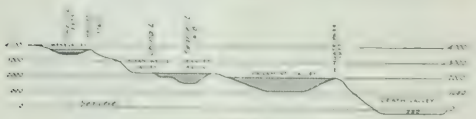


FIG. 2
Cross Section of Owens, Searles, Panamint and Death Valley Basins

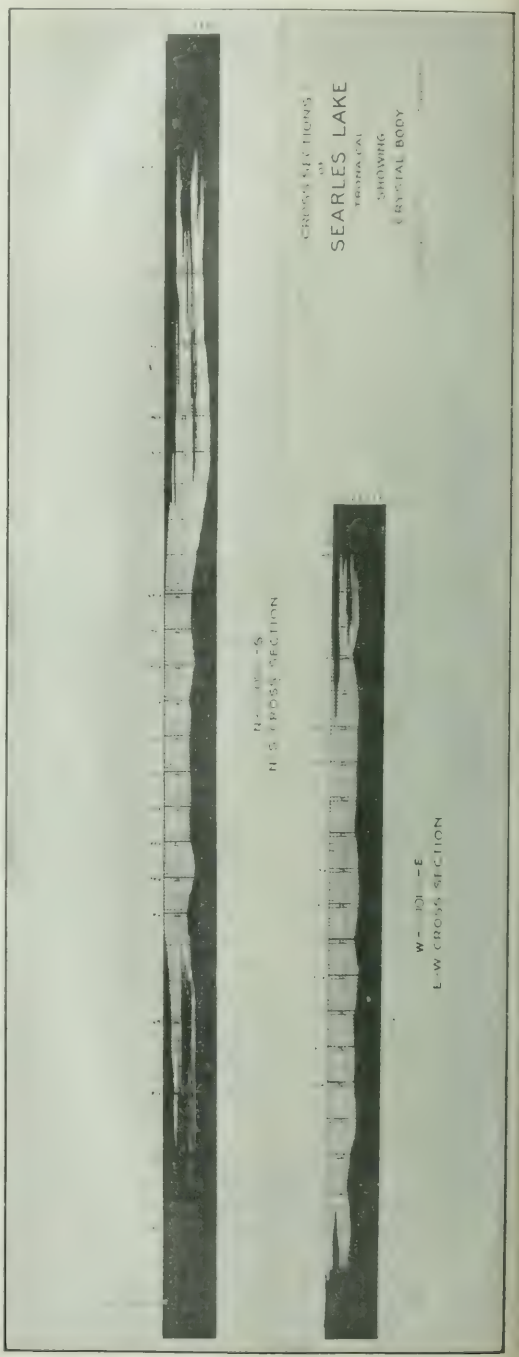


FIG. 3



FIG. 4
Pump House Showing Transformer House and Manifolds

The Owens Lake, during a period of former greater water supply, overflowed the divide at the south end of its basin and its surplus waters flooded in turn a succession of lower basins, of which the Searles Basin was one of the largest.

The Owens waters, after passing the Haiwee Divide, dropped some 1500 ft. in about 30 miles to Indian Wells Valley, and then spread out in a broad and relatively shallow sheet of water. This, in turn, also overflowed, its waters passing by way of Salt Wells Valley and a rock-cut gorge at the lower end of that valley into the Searles Basin.

Eventually, the waters rose in the Searles Basin to such a height that all three of these valleys were submerged in one continuous body of water. The maximum water level in this basin was clearly determined by the elevation of an outlet pass on the south side of the basin, whence its surplus waters flowed into the extreme south end of Panamint Valley.

In the Panamint Basin a history similar in some respects to that of the Searles Basin was repeated: the waters rose until the height of the lowest outlet was reached, and as they evidently remained stationary at about that level for a relatively long period, it is presumed that this level was determined by the overflow of its surplus waters.

The most distinctive feature of this desert basin is the immense sheet of solid white salts that lie exposed on its bottom. It is to this salt deposit that the name Searles Lake has been generally applied. So far as known at present, the deposit is unique in this country in the variety of its saline minerals.

Fig. 3 shows two cross sections of the crystal body. These were plotted from data obtained from the numerous wells which were drilled by the California Trona Company to comply with

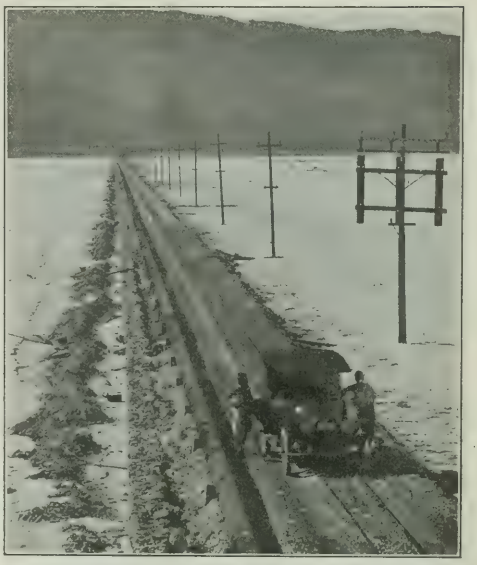


FIG. 5
General View of Pipe Line between Pump House and Plant

the assessment work necessary to hold its claims. Some 300 wells were thus drilled.

As may be seen, the crystal body underlies the surrounding mud flats found along the shore of Searles Lake.

The area of salt crust in the Searles Basin is some 12 sq. mi. in extent, and averages from 65 to 75 ft. in depth. The formation of the crystal body is such that the brine with which it is associated is absolutely free-flowing, and nowhere, even by extended pumping operations, have we been able to lower the level of the brine in the lake at any one spot to a noticeable extent.

The main or central salt deposit is a firm but extremely porous bed of salt crystals, so hard and compact that roads are built on the same; teams and motor trucks have no difficulty in driving over its surface; and even the concrete foundations of the American Trona Corporation's pump house were laid on the surface of the crystal body. The road built out to the pump



FIG. 6
View of plant from west showing from left to right: 2 Brine Storage Tanks of 500,000 gals. each. 1 Spray Pond. 1 Boiler House with 8 Babcock and Wilcox Boilers of 500 h. p. each. 2 Concrete Stacks, 150 ft. high and 9 ft. in diameter in the clear. 2 Evaporator Houses for housing two triple-effect 22 ft. in diameter and two double-effect 16 ft. in diameter Manistee vacuum pans. 4 Waste Salt Cones which at present are being replaced by Dorr Classifiers for washing the tailing salts and recovering some 10 to 15 tons of potash which was formerly lost. 1 Crystallizing House, 180 ft. wide and 800 ft. long. It is in this building that the new process for recovering potash from the concentrated pan liquors, as well as the new borax refinery, will be located.

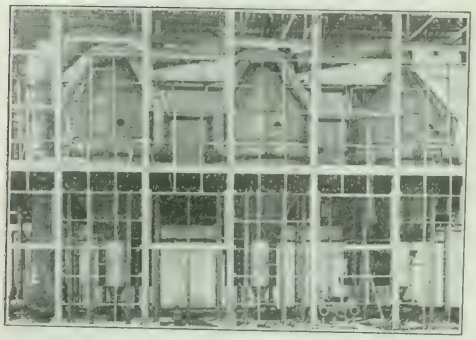


FIG. 7
A Triple-Effect Unit of Manistee Vacuum Pans

house is some 3 1/2 mi. long. Between 19,000 and 20,000 ft. of 10-in. iron pipe connects the pumps with two storage tanks of 500,000 gal. capacity each.

The pipe line is laid on concrete piers; it is insulated against changes in temperature by a 2-in. layer of hair felt and a 1-in. layer of wool felt, the insulation being protected against the elements by a thin sheet of black iron, which is fastened by narrow iron straps.



FIG. 9
Evaporator leg pipe and tailings elevator. These tailing salt elevators handle, roughly, 350 tons of waste salts per 24 hrs. These salts are dropped by gravity into waste salt cones from which they are flushed with brackish water back on to the lake.

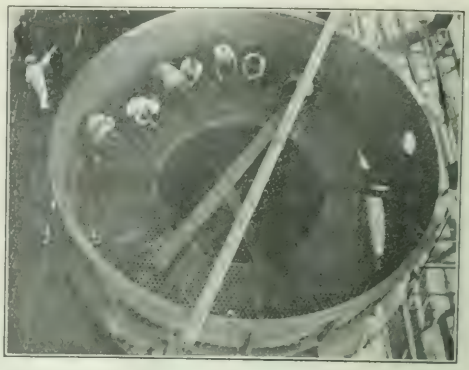


FIG. 8
Upper Flue Sheet of a 22 ft. Manistee Vacuum Pan

The first 15 to 20 feet of the crystal body is composed of cubical halite and will analyze 90 per cent (or better) NaCl on a dry basis. Below this are alternating and irregular layers of salts, respectively high in Trona (a sesquicarbonate of soda), sodium chloride, and sodium sulfate. The potash content of these layers is very irregular, layers of potash-bearing crystals having been discovered by various drilling operations which ran from 14 to 30 plus per cent potassium chloride. The average potash content of the crystal body is, roughly, 4 per cent potassium chloride.

In a report made to the American Trona Corporation by Charles S. Lee it is estimated that the crystal body contains 110,000 "million gallons," or 594,000,000 tons of brine. This does not include any incoming waters from either underground or surface sources. This brine will average 4 per cent potas-

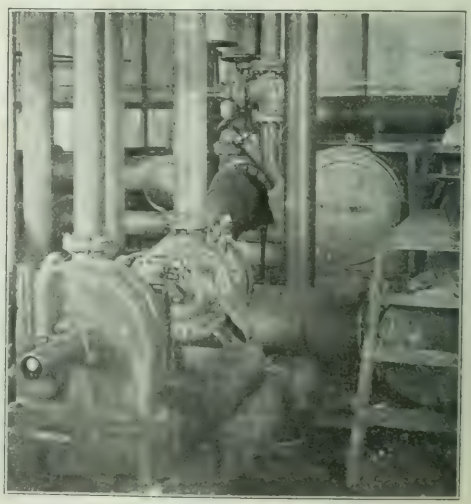


FIG. 10
Pumps for transferring partially concentrated pan liquors from one evaporator to another. In the background may be seen the Pelton-Doble water-wheel-driven pump with its set of connections for filling and draining the vacuum pans. It has a capacity of 6000 gal. per min. The suction and discharge openings are 16 in. in diameter.



FIG. 11

Set of six valves connected to filling pump by opening any two of which the pans may either be filled with raw brine prior to starting a run; drained into large storage vats prior to boiling out (which in the present cycle is done after every run of 36 hrs.; filled with brackish water for boiling out to clean pans; or drained of same after boiling out has been accomplished.

sium chloride. The potash contained in this brine alone amounts to 23,760,000 tons of potassium chloride.

The average brine pumped by the American Trona Corporation has the following composition:

	Per cent
Na	11.00
K	2.50
Cl	12.50
CO_3	2.65
SO_4	4.65
B	0.35

In view of the process in use, the brine is given the following arbitrary composition, based on the above values:

	Per cent
NaCl	16.50
Na_2SO_4	6.90
Na_2CO_3	4.70
$Na_2B_4O_7$	1.50
KCl	4.75
Specific gravity	1.290 at 30° C.

All the CO_3 is figured as normal carbonate, although the brine contains some bicarbonate.

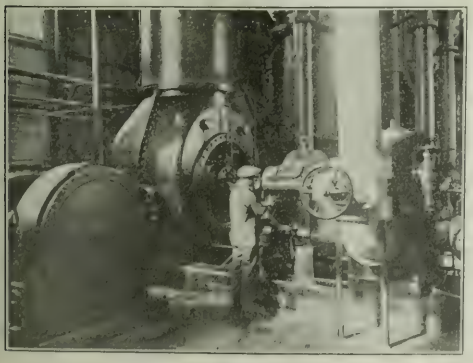


FIG. 12

Rotary jet condenser used on high-vacuum pan showing reduction gears and 500 h. p. Terry steam turbine for driving same. Booster pump for removing cooling and condensed waters in the background.

This brine is pumped to the plant from wells drilled in the crystal body of Searles Lake. The pumping equipment consists of two all-iron centrifugal pumps capable of delivering 750,000 gal. of brine each to the company's storage tanks per 24 hrs. The pumps are connected by short manifolds to the 6 wells drilled through the crystal body.

The pump house, and a raised road on which is operated narrow gauge, gasoline locomotive and dump cars, are built directly on the surface of the crystal body. The brine is pumped to storage tanks and from them directly to the evaporators. It passes first through a 16-ft. Manistee vacuum pan, which is used merely as a pre-heater. From this it is pumped to three pans of the same type, which are operated in triple effect. These pans stand 86 ft. high and are 22 ft. in diameter. The calandria or steam belt is comprised in the first section above the working floor, which is 30 ft. above the ground floor of the building.

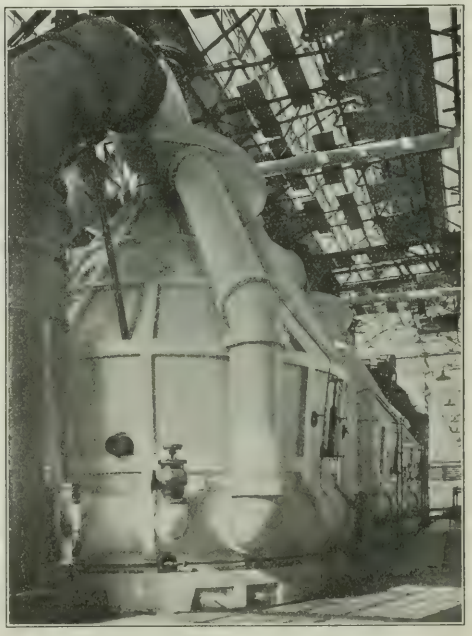


FIG. 13

Working floor of evaporator house. This shows a triple-effect unit of 22 ft. Manistee vacuum pans as they appear when completed. They are insulated with 2 in. corrugated air-cell asbestos. On top of this is spread a layer of plaster about 1 in. thick, and on top of this is a covering of 10 oz. duck, the whole being finished off with a coating of white paint. In the distance may be seen a part of the 16 ft. single-effect pan now used as a pre-heater for the raw brine fed to No. 3 pan.

The pans are numbered (see Fig. 7) from left to right, 3, 2, and 1. No. 3 is the low-temperature, high-vacuum pan and it is into this pan that the brine, after the pre-heating in the single-effect 16-ft. Manistee pan, is pumped, together with a proportionate amount of mother liquor from the pumps in the crystallizing house. The liquors pass from No. 3 pan through the intermediate No. 2 pan into the high-temperature, low-vacuum No. 1 pan in a steady flow. From No. 1 pan the new concentrated liquors, having a specific gravity of 1.385 to 1.390, are pumped over to the crystallizing house. Exhaust steam from Terry steam turbines is fed to No. 1 vacuum pan from a mixing drum.

To the left of No. 3 pan is shown a rotary jet condenser. This pump, operated by a 500 h. p. Terry steam turbine, functions both as a vacuum pump and condenser, handling the vapors from No. 3 pan. The condensed vapors and cooling waters are pumped from the condenser and returned to the spray pond by an auxiliary booster pump. Some 7000 gal. of condensed and cooling waters are forced through the sprays every minute.

The pans handle from 200,000 to 250,000 gal. of raw brine and about 100,000 gal. of mother liquor per 24 hrs. This total of 300,000 to 350,000 gal. of liquor is concentrated to about 100,000 gal. of "concentrated liquor" before being sent to the crystallizing house to cool.

Fig. 8 illustrates the upper flue sheet on one of these 22-ft. Manistee vacuum pans. The men shown in the photograph are expanding the 6-ft. charcoal iron flues (2 in. in diameter) into the upper flue sheet of the calandria. One 22-ft. pan contains some $3\frac{1}{2}$ mi. of such flues.

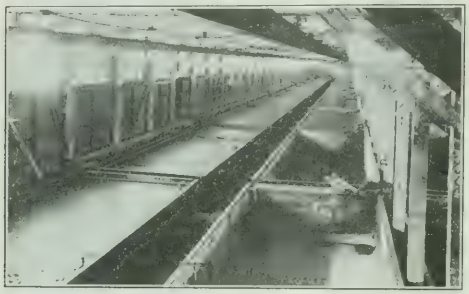


FIG. 14

Interior of crystallizing house. This shows two of four rows of crystallizing vats. These vats are 54 ft. long, 15 ft. wide, and 6 ft. deep. They hold 30,000 gal. of concentrated liquor. An average of 15 tons of crude potash salts is taken from each vat. There are 36 such vats in use for the one unit which is now operating.

A propeller shaft, extending through the length of the pan from the top of the pan to well below the calandria, and making 30 revolutions per minute increases the circulation of the heavy pan liquors through the flues. Foaming is kept down by the addition of a medium heavy mineral oil.

During the boiling, sodium chloride, sodium sulfate, and sodium carbonate are salted out. These tailing salts drop to the bottom of the vacuum pans and are removed by salt elevators of the regular Manistee type. The elevators discharge their salts into waste salt cones, from which they are washed away by water.

Machinery is being installed by Dr. H. W. Morse, Technical Manager, by which we will recover 95 per cent of the potash formerly carried away by these waste salts. This will increase our output by some 10 tons (or better) of potassium chloride per unit per 24 hrs. Operating under the old system this was previously lost to us.

The liquor in the pans is boiled down to the point where potassium chloride begins to salt out, and is then sent to crystallizing vats in this condition at a temperature of 90° to 95° C.

The triple-effect pans are operated with constant flow, liquor entering the pan next the vacuum pump (where the vacuum is highest and the boiling point lowest) and passing in a constant flow from this pan through the intermediate pan to the final high temperature, low vacuum pan, and from this pan to the crystallizing vats.

The temperatures and vacuums are about as follows:

Pan No.		Vacuum In.	Temperature Deg. C.
4		24.5	72
3	Of triple-	24.5	72
2	effect	21.0	86
1	units	12.5	102

Cooling and crystallization takes place in crystallizing vats whose dimensions are 54 x 16 x 6 ft. There are 36 such vats in the unit now operating, and the day's run of hot concentrated liquor fills from 3 to 4 of these. The vats cool for about 8 days, and the liquor, now nearly at atmospheric temperature, is then drained off.

The crystal crop is shoveled into a traveling box and is carried to a drain floor, where it is allowed to lie for about a week or so before shipment.

The following table gives the average composition of raw brine, concentrated liquor, mother liquor returned to the system, and crude potash salts ready for shipment:

	Raw Brine	Concentrated Liquor	Mother Liquor	Crude Potash Salts
$Na_2B_4O_7$, per cent	1.50	8.81	7.82	10.91
Na_2CO_3, per cent.	4.70	10.82	10.53	1.70
NaCl, per cent...	16.50	9.67	9.43	10.93
Na_2SO_4, per cent.	6.90	2.58	2.08	0.44
KCl, per cent....	4.75	14.87	10.82	66.34
H_2O, per cent....	...	...	...	9.66
TOTAL.....	34.35	46.75	40.68	99.98
Sp. Gr.....	1.290 (30° C.)	1.384 (38° C.)	1.362 (34° C.)	

The American Trona Corporation is producing to date some 1800 tons of crude potash salts per month. Additional equipment, such as a nearly completed second unit together with a 300-ton ice plant[1] for refrigerating purposes and new methods for treating the concentrated liquor (devised under the direction of Dr. H. W. Morse), will enable the American Trona Corporation to produce by the end of October some 4500 tons of potash salts a month, analyzing from 75 to 80 per cent potassium chloride and containing less than 3.5 per cent borax, figured as anhydrous sodium tetraborate.

By the first of 1919 the American Trona Corporation will be producing some 40 to 50 tons of refined borax daily, analyzing 99.50 per cent $Na_2B_4O_7.10H_2O$ (crystal borax).

SYMPOSIUM ON CERAMICS

September 26, 1918

RECENT DEVELOPMENTS IN CERAMICS[2]

By A. V. BLEININGER

Bureau of Standards, Pittsburgh

One of the most important functions of the ceramic industries is the supply of refractories for the metallurgical operations of the country, steam power plants, by-product coke ovens, gas plants, glass works, and many other purposes too numerous to enumerate here. The demand for these products has been enormous and has been met by the refractories industries in a very satisfactory manner. Although at times the need of No. 1 fire bricks has been greater than the production, such a condition does not exist at the present time, owing to the expansion of this branch of the industry. In many instances the extraordinary demand was caused, in part, by the unwillingness of consumers to use anything but No. 1 refractories even for purposes where lower grade products would serve equally well. Fire bricks of the lower refractory grades are available in abundance, especially since a considerable number of face and building brick plants have taken up the production of this type of ware. One of the urgent needs in this connection is the establishment of a classification and specifications for the several grades of clay refractories. This task is being undertaken at the present time by the War Industries Board. The work of standardizing the

[1] The equipment in this refrigerating unit consists of three 100-ton De La Vergne ice machines, driven by three Corliss engines of 300 h. p. each.

[2] By permission of the Director of the Bureau of Standards.

shapes of fire brick has already been accomplished in a satisfactory manner.

The demand for silica bricks has been greatly increased through the development of the by-product coke oven. Meeting this demand involves not only large quantity production of these refractories, but high quality as well. It is necessary that the transformation of the quartz to cristobalite be largely completed, as indicated by the lowering of the specific gravity to a value of not more than 2.38, and that the product possess good mechanical strength, corresponding to an average modulus of rupture of about 500 lbs. per sq. in. These requirements are exacting and may not always be met in bricks made from silica rock other than quartzite. Certain materials, like chert and flint, transform to cristobalite more rapidly than quartzite, but do not yield as strong a product. Sandstones usually transform more slowly and likewise tend to give inferior strength.

The manufacture of silica refractories is certain to expand still more, both in the Eastern States and in the Middle West. If the war continues for any considerable period, additional emergency production in connection with the erection of new coke oven plants will certainly be necessary.

Difficulties have been met in supplying the basic magnesite refractories from the available American materials. This has been due to the nature of our magnesite, which differs from the Austrian ore in being very low in iron oxide and sometimes higher in lime. This makes it necessary to add the iron synthetically, a procedure which adds to the cost of production, since it requires intimate blending and grinding of the mixture and a higher calcination temperature than is needed with the European raw material. In addition, the magnesite must be transported across the continent from California or Washington. The latter state produces at the present time large quantities of magnesite quite low in lime and the quality of the material is of a character which is making it possible to reduce operations to a uniform practice. It has been found possible also to replace magnesite bricks in certain operations by bauxite refractories. The production of magnesia spinal refractories of the composition $MgOAl_2O_3$ has made a beginning, and it is not unlikely that for many purposes it will prove a very desirable material. There has naturally been a shortage of chromite refractories, even though the quantities really needed are small. This has been overcome by the use of thinner partings and in many cases by doing away with this refractory entirely, without, apparently, any serious effects

Much has been said on the question of graphite crucibles. The graphite problem is undoubtedly the more important one in this connection. It is a difficult matter to replace Ceylon graphite altogether with the domestic mineral. In the first place the greater density of the imported material, 2.25, which imparts to it the characteristic resistance to oxidation, its foliated structure, and the low ash content of the best grades combine to make it extremely satisfactory for the purpose of crucible making. This graphite can be bonded together with a comparatively small amount of clay, since the surface factor per unit weight is smaller than for that of any other kind of graphite. This point may be illustrated by the volumes occupied by the same weight of several types of graphite. Thus, 100 g. of ground Ceylon graphite after thorough shaking occupies a volume of 90.7 cc., Canadian graphite 119.6 cc., and Alabama graphite 152.0 cc. In other words, it would be impossible to make graphite mixtures of maximum carbon content from the two American materials. Since they offer a much larger surface the amount of clay used must be greater. From this it follows that the ultimate density and thermal conductivity are certain to be lower. To what extent American flake graphite can be admixed with the Ceylon graphite remains to be seen. The writer has seen mixtures in which the flake added amounted to 20 per cent of the total graphite content and gave fair foundry results. It might be possible, however, to perfect processes which will enable the crucible maker to employ larger percentages of domestic graphite, and at the same time secure practically the same results as with Ceylon graphite. On the other hand, there is no reason why a large quantity of domestic graphite should not be used in the making of stoppers and similar articles. The comparison made between the Ceylon and flake graphite is, of course, relative, and refers to crucible value obtained per dollar at the present time. If this country could no longer obtain Ceylon graphite, the production of metal certainly would not be diminished in any way as we could get along very well with flake and amorphus graphite, furnace carbon and coke.

The lack of the German Klingenberg clay for crucible making is not as serious a matter as has been thought. It has been shown conclusively that it can be replaced both by English and American ball clays.

Similarly, the German Gross Almerode clay used in the making of glass pots has been replaced by American clays and synthetic mixtures in a very satisfactory manner. In fact, it is quite probable that the new techniques now being developed will yield results superior to those formerly obtained with the use of imported clay. The shaking up caused by the war will, in the end, be of distinct service to the glass refractories industry. At the same time, the glass industry will gain in pot service through the realization that the control of the heating-up process of the pots in the arches is essential in preventing loss.

Special clay refractories have been developed also with reference to improved thermal insulation, including materials highly refractory, light in weight, and possessed of good insulating qualities. The saving in fuel consumption and weight through the use of such products is bound to be considerable.

The manufacture of hard-fire, true porcelain has received a powerful impetus through the war. Three plants are already operating successfully on the production of chemical porcelain and are making rapid strides with respect to quality. The manufacture of hard porcelain tableware on a large scale is to be begun in the very near future. It is very fortunate that the pioneers in this work have realized the importance of putting their production on a firm basis with reference to foreign competition. By the use of automatic machinery, mechanical dryers, and tunnel kilns, they will be enabled to meet foreign competitors on equal terms. The plants now in course of construction excel all European potteries in the elimination of unnecessary labor cost and expenditure of fuel. The development of a hard-fire porcelain industry is, indeed, a national duty. It would be preposterous and humiliating to contemplate any further dependence on Germany and Austria for these products. By establishing this industry we shall be in position to seek the South American markets to which we have a fair right.

The demand for ordinary tableware at the present time is greater than has ever been known before and difficulty is being experienced in supplying the requirements of the Army and Navy and at the same time those of the country. The simpler shapes such as cups and mugs are now being produced by the one-fire process, which incidentally results in an appreciable saving of fuel.

Porcelains for special purposes have been developed successfully. Thus, the National Bureau of Standards has introduced the manufacture of the refractory Marquardt porcelain, essentially sillimanite, formerly produced by the Royal Porcelain Manufactory at Berlin and used so largely for pyrometer tubes and similar articles. Likewise, we have succeeded in making porcelains possessing remarkably high electrical resistance at elevated temperatures. Several of the bodies produced in the Pittsburgh Laboratory of the Bureau of Standards showed a resistance of one megohm per cc. at 780° C. and at the same time a coefficient of thermal expansion of only 3.81×10^{-6} per degree C. between the temperature range 30° to 400° C. The

same materials showed none of the variation in thermal expansion common to most porcelains, the coëfficient remaining practically constant throughout the range 30° to 520° C. It is evident that such properties, coupled with good mechanical strength, are essential for such uses as aeroplane spark plugs. There is every reason to believe that the principles thus worked out will greatly assist in producing special grades of electrical porcelain for use under severe conditions. These developments have been assisted greatly through the use of the petrographic microscope in the study of porcelain structures.

The manufacture of electrical porcelain is undergoing improvements at a more rapid rate than ever before in the history of this industry. The methods of preparation are more thorough, the details of shaping are being studied more carefully, the drying process is being controlled with greater accuracy, and the methods of testing developed towards more exact differentiation as to quality. The casting process is finding application to an increasing extent. Further developments are to be expected with reference to the composition and firing of electrical porcelain, based on more recent studies on the subject of the function of feldspar as an electrolyte and the volume changes induced by the transformation of quartz to its several crystalline modifications.

Considerable work is being done also with regard to the complete survey of the resources of the country in kaolins and ball clays for use in the ceramic and paper industries, through the agencies of the Association of State Geologists, the Bureau of Mines, the United States Geological Survey, the American Ceramic Society, and the Bureau of Standards. It is believed that this survey will enable us to take stock of our resources with the final object of making ourselves independent of any foreign sources. A considerable number of new clay deposits have been located within the past two years, to say nothing of glass sand and other ceramic raw materials.

One of the clay industries vital in the prosecution of the war is the manufacture of chemical stoneware. The production of this type of ware requires particular skill, owing to the complicated designs, large size, and the necessity of the tight fitting of the pieces. But few realize the magnitude of the task which confronted this industry, especially when handicapped by shortage in labor, fuel, and other necessities. It is very gratifying, indeed, to be able to say that the stoneware manufacturers have met the situation so well and have been able to supply the needs of the chemical industries. This statement applies equally to the manufacturers of acid-proof, enameled cast iron, and sheet steel, products which have played an important rôle in recent chemical developments.

Another industry having a direct bearing upon war work is that engaged in the manufacture of abrasives and grinding wheels. The rapid growth of this branch of manufacture and its technical development are characteristic of America. Its work has been done with such quiet efficiency and it has met the demands of the present conditions so promptly that but few realize the magnitude and importance of its accomplishments. Research has played a large part in this development and to the utilization of scientific facts we owe the highly specialized grinding tools made available for large production, as well as for the most delicate processes, such as the grinding of optical lenses.

The industries engaged in the production of ceramic structural materials have naturally been hard hit by the decrease in building activities and by the fuel orders. The manufacturers of building bricks, hollow tiles, sewer pipe, paving bricks, terra cotta, floor and wall tile, etc., are endeavoring to hold their organizations together. In districts where war activity prevails the plants are operating to capacity, in others new branches of manufacture have been taken up, such as the production of refractories, crucibles, and certain specialties for war use. But even under such conditions interesting developments are taking place. Much attention is being given to the question of fuel economy through more rapid firing and the utilization of waste heat. New applications of clay are being found, such as the use of crushed, vesicular, vitrified brick material as an aggregate for concrete, having the advantage of light weight, low thermal conductivity, and constancy of volume when heated.

With reference to the glass industry the three most interesting developments are those relating to the optical, colored (signal), and the resistant or chemical glasses. When it is realized that at the beginning of the war but little optical glass was being produced in the United States, the rapid development of the art presents an inspiring example. The necessity of war brought together the manufacturers on the one hand and scientific and technical organizations like the Geophysical Laboratory of the Carnegie Institute and the Bureau of Standards on the other. Although some of the manufacturers had brought their furnace practice to a very satisfactory state it was not realized fully that the raw materials must be practically free from iron, sulfur, chlorine, and other impurities. Likewise methods for the rapid examination of the glass were lacking, so that frequently poor glass was brought to the grinding and polishing rooms of the optical shops and again, good product was by chance rejected. The necessity of temperature measurement and control was not fully realized and the method of stirring had not been brought to a satisfactory development. At the same time the commercial glass pots were the source of much grief, due to their high iron content which discolored the glass in the absence of decolorizers which are not allowable, and their failure to resist the corrosive action of the flint and barium glasses. These things have been overcome to a very large extent.

Through the use of sand of great purity and constant checking of the composition of the other constituents the primary difficulties have been removed. The composition of the glasses has been correlated with the optical properties, the index of refraction, the dispersion value, and the light absorption. Time-temperature schedules have been worked out for the melting and cooling periods and satisfactory stirring machines designed. Rapid inspection even of the glass in lump form is now possible by the use of immersion methods and examination with monochromatic light in addition to the examination through the polished edges of blocks.

The pot problem has been solved through the use of white burning clays like the kaolins and even more satisfactorily by the production of semi- or true-porcelain pots. Containers of the latter type are now being made in several works and have proven eminently useful. In fact, it has been possible to melt in such pots dense barium crown glasses which have proven exceedingly destructive to the ordinary types of refractory material.

The annealing process is being studied by a number of workers and some interesting information has already been obtained. It might be said, then, that in the United States we have mastered the essentials of the production of optical glass and about seven types are being manufactured commercially. Problems dealing with the cutting down of the losses due to certain optical phenomena, etc., of course, still remain, and it is to be expected that continued progress will be made in this art.

It is a source of pleasure to note the fact that scientific and technical researches dealing with the technology of silicates are being continued at the present time, even though they have more or less bearing upon conditions brought about by the war. We are mastering more and more the control of the class of dispersed systems represented by clays floated in water, their drying behavior, and the changes which they undergo upon vitrification and fusion by resorting to the methods of the scientific investigator.

In this brief survey it has not been possible to emphasize

some of the more important technical advances, nor is it permissible at this time to dwell upon certain developments, such as a new rôle played by clay in chemistry, but it is hoped that this hasty contribution may afford some conception as to the activities in the ceramic industries.

CARBORUNDUM REFRACTORIES

By S. C. Linbarger

Ceramic Engineer, The Carborundum Co., Niagara Falls, N. Y.

Ever since its inception one of the vital problems of the ceramic industry has been the question of suitable refractory materials, both for use in its own factories and as a product which will meet the demands of the other industries which require the highest grade of refractories. These materials must have sufficient strength under normal conditions to carry the weight of the structure of which they are an integral part and must, furthermore, have sufficient refractoriness to carry this same load under the extreme heat conditions to which they are subjected.

It has always been customary to regard heat insulation in a refractory material equally desirable with resistance to fusion, probably because these properties are intimately associated in the case of the common type of fire brick or saggar mix of the aluminous silicate type which are highly refractory and are such poor conductors of heat that in comparison with metallic substances they can safely be classed as heat insulators. However, only a superficial study of the problems involved in the burning of ware in saggars or muffle kilns reveals the fact that heat conductivity of the refractories used, besides being highly desirable, is a potent factor in the economical operation of the process.

For many years men connected with all branches of the clay-working industry have been seeking a more effective means of burning clay products in a shorter time and with less fuel. Especially is this true, and the need for it was never greater than at the present time when the vital needs of the country must be met with a maximum of fuel economy. Most of the efforts have been along the line of improving kiln design so that the maximum amount of heat is extracted from the gases of combustion before they pass into the stack. In most cases this is accomplished by passing the gases from the hot zone or chamber over ware in other zones which is at a much lower temperature, and thereby gradually raising the temperature of the ware by the utilization of the sensible heat of the gases after they leave the combustion zone. All agree that when ware is being burned at a high maturing temperature one of the vital points of fuel economy is to get as much as is possible of the heat of the gases transferred from them to the ware.

In the pottery and allied industries where the ware is burned in saggars or by setting on shelves or bats, a solution of this problem resolves itself into the proper selection and utilization of a refractory material which will more quickly and more easily absorb the heat from the surrounding gases and transmit and deliver it to the center of the bearing structure. The essential physical properties which govern the selection of the best refractory for this purpose are strength, specific heat, thermal conductivity, and emissivity. Of course in connection with these it must have the required refractoriness and be able to withstand the necessary handling without breakage.

The element of strength, both transverse and compressive, is one of the properties which is too often overlooked in the selection of the proper refractory material. By using a material of high mechanical strength, both under normal and heat conditions, not only is the loss by breakage materially reduced, but primarily the walls of the building material can be very much thinner, with the consequence that the heat is conducted to the ware much more readily, to say nothing of the saving in kiln space and the smaller amount of heat required to bring the building material up to the maturing temperature of the kiln.

The specific heat of the refractory is the important physical property required in calculating the number of thermal units that are really wasted in bringing the large mass of the supporting material from normal temperature up to the finishing temperature of the kiln. In some instances where the weight of the bats and saggers is equal to or more than the weight of the ware which it protects and supports, it means a considerable item in the burning cost.

As a concrete example of the exact factors involved in the transfer of heat from the hot kiln gases to the ware, let us consider the specific case of a plant which is burning ware in saggars, the saggars being set in stacks so arranged in the kiln that their entire peripheral surface is exposed to the kiln gases. The spaces between the saggar stacks can be assumed to be chimneys and the velocity of the gases through them will depend upon their size and shape and also upon the draft of the kiln. Assume:

1—That the turbulence is such as to make a fairly uniform temperature in the kiln at any point on one of a system of surfaces which is symmetrical about the gas passage; and

2—That the average temperature on these surfaces is the average of the temperature of the gases at ingress and egress.

It is evident that these hypotheses mean that the turbulence is controlled by some finite law and that a graph indicating the temperature gradient through the kiln would be a straight line. These hypotheses hold fairly well if the motion of the gases is so slow as to make the turbulence negligible or if the motion of the hot gases is so great as to make the turbulence very great. The quantity of heat then that will pass through the walls of the supporting refractory medium in a given time and be delivered to the center of the saggars will depend upon the excess temperature of the gases over the ware and the thermal conductivity of the refractory and will be a direct function of the emissivity of it.

When heat waves strike a body some of them are absorbed and some of them reflected, unless the body be what is known as a black body, in which case all of the heat rays are absorbed. All other bodies absorb a definite percentage of the heat waves which strike their surfaces and reflect the rest, the exact ratio of conduction and radiation being dependent upon the surface and the character of the body. This ratio for any material is what is known as the emissivity factor of that material. Under like conditions the same ratios hold true for the radiation of heat units from any solid body into a gaseous medium. The emissivity factor for any substance can then be determined experimentally by finding the radiation per second per unit surface area per degree difference in temperature. As the quantity of heat that will cross the boundary plane between the solid and the gas per unit time is dependent upon a factor other than the thermal conductivity of the solid, it is readily observed that the emissivity factor of the refractory which is usually neglected is an important consideration in the absorption of the greatest amount of the sensible heat from the gases which come in contact with it.

Crystallized silicon carbide or carborundum, as it is most commonly called, has long been recognized as having unique physical properties which make it peculiarly adaptable in the construction of highly refractory materials. However, up to the present time it has not had a very wide application in this field owing to its high price and also to the lack of sufficient quantities to supply other than the abrasive industry, which of course is its field of primary importance.

At the present time there are two types of crystallized carborundum refractories which have been highly developed. The first type which goes under the trade names of "Refrax" and "Silfrax," depending upon whether the crystallization of the aggregate is large or small, is made according to patents which in general cover the silicidizing of mixtures of carbon and silicon carbide or carbon forms and their subsequent conversion into

carborundum by subjecting the carbon to silicon-containing vapors at the heat of the electric furnace. The carbon is converted into carbide of silicon forming a dense interstitial binder or matrix between the crystals. Of course there are many modifications of this process but the essential characteristic of this type of refractory is that the final products obtained are pure silicon carbide.

The other type which is known as "Carborafrax" is the type most generally applicable for use in the ceramic industries. It is made by bonding graded crystallized carbide of silicon grains with various percentages of a mixture of special refractory clays or other bonding substances.

When bonded with even a high percentage of clay binder, brick which contain carborundum give very great refractory values. However, since the refractoriness of a conglomerate refractory mass is a direct function of the amount and character of the least refractory constituent, it is recognized that the ideal condition to be obtained is that the amount of binding material used be the least which is consistent with the requisite strength; and that the vitrification temperature of the binder be as high as is commercially practicable. Mixtures of grits and methods of bonding are employed which insure a very dense body of low porosity with but a minute percentage of refractory clay binder and at the same time allow the manufacture of large and intricate shapes.

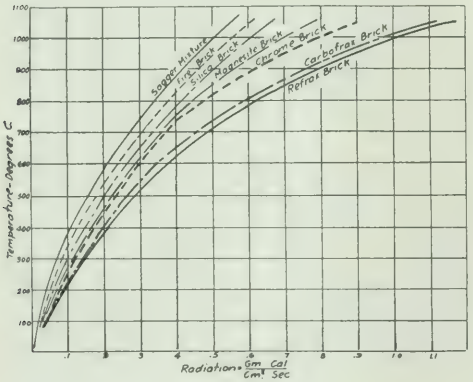


FIG. I

Experimentation has shown that crystalline silicon carbide forms at 1840° C. and dissociates at 2240° C. into its elements, the silicon being volatilized and the carbon remaining as graphite. No softening or fusing occurs below the dissociation temperature which is shown by the sharp and perfect forms of graphite pseudomorphs or skeletons which are left when silicon carbide dissociates. This is in direct contrast to most other refractories, such as silica, chrome, and fireclay brick, which soften at a temperature several hundred degrees lower than their fusion point.

Fig. I shows the emissivity curves of several common refractories. The curves for this factor were accurately plotted from results obtained by very complex experimental methods which are too cumbersome to describe in this paper. It will be noted that the emissivity of both classes of crystallized carborundum brick is much higher than either magnesite or chrome brick and almost double that of clay brick at a temperature of 200° C. and higher.

Table I shows the results of some tests made on the most common types of refractory materials. The specimens tested were selected at random as being representative of the average product of that particular class of refractory. No attempt was made to compare different brands of the same material.

TABLE I

MATERIAL	Specific Heat	Thermal Conductivity	Compressive Strength, Lbs. per sq. in.
Fire Brick	0.192	0.0034	1,050
Saggar Mix.	0.187	0.0033	1,340
Magnesite	0.220	0.0071	4,500
Chrome	0.174	0.0065	3,900
Refrax	0.162	0.0275	12,500
Carbofrax	0.180	0.0243	14,700
Silica	0.191	0.0020	2,300

A comparison of the thermal conductivities of the materials reveals the fact that the carbofrax brick will conduct about three times as much heat as magnesite, seven times as much as the saggar mix, and twelve times as much as a silica brick in the same period of time.

Fig. II graphically represents the relative efficiencies of various refractory materials as obtained by using the values of specific heat, thermal conductivity, and emissivity in the formula for the law governing the transmission of heat from a gas to the interior of a solid body. The table is arbitrarily based with the abscissas representing relative efficiencies while the ordinates give difference of temperature. A study of the results demonstrates that the materials with a high emissivity factor and high coefficient of heat conductivity show several times the efficiency of those with correspondingly lower values with the same thick-

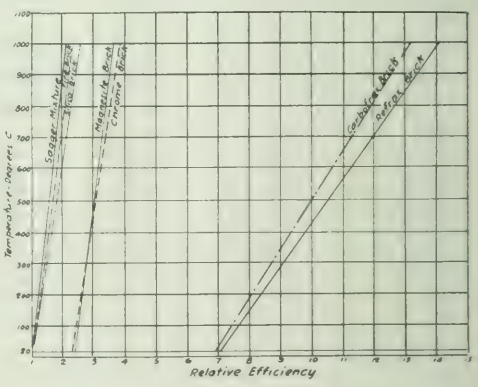


FIG. II

ness of wall. Compressive tests of the materials show that the carborundum refractories have a load-carrying capacity over ten times as great as the saggar mixture under normal temperatures. Under heat conditions this ratio are considerably increased because there is absolutely no softening of this class of material at 1350° C., while the saggar mix at the same temperature shows a deformation with a load of 50 lbs. per sq. in. In fact, blocks of bonded silicon carbide are used as bearing blocks in making load tests on refractories at high temperatures. It would then be possible to use refractories for supporting ware in kilns with walls one-tenth as thick as are ordinarily used with the aluminous silicate type of refractories. Since the amount of heat transmitted by a solid is inversely proportional to its thickness, the efficiency already demonstrated by high thermal conductivity and emissivity would be multiplied by ten.

Aside from the importance of fuel economy, the high thermal conductivity and heat capacity of crystallized carborundum impart to refractories made from it the property of withstanding the most sudden temperature changes because any variance in the temperature of the surface is quickly communicated to the whole mass and the heat is rapidly dissipated. Thus, the

molecular work resulting from it is uniform, and refractory shapes of this type can be subjected to the most sudden variations of temperature without being cracked or disintegrated.

As silicon carbide is not subject to any molecular changes being formed at 1850° C. in a crystalline state, and has an extremely low coefficient of expansion, no porous structure is necessary and a high density can therefore be obtained. This is not possible with most refractories since they contain ingredients which have one or more allotropic forms and must be made open and porous to withstand successfully the internal stresses. The low coefficient of expansion and high density of carborundum brick permits the construction of solid structures in places where the leakage of heat and gases through cracks in the walls due to alternate contraction and expansion is a detriment to the successful operation of the process.

In an effort to obtain the complete combustion of a fuel there is a growing tendency to increase the temperature of the fireboxes or furnaces. Ordinary firebrick, even of the best grade, fuse under the high temperatures developed and are attacked by the fluid ashes of the coal. This fluid ash which so violently attacks fireclay brick forms a brownish coating or glaze over the exposed portion of the carborundum brick which is unattacked by any additional fluid ash which is formed in the firebox. Owing to their extreme hardness this type of brick does not suffer from deterioration as do the common refractories when struck by the tools of the firemen during the process of cleaning the fires.

Carborundum is manufactured by passing an electric current through a mixture of sawdust, sand, and coke in a long rectangular resistance furnace. By the utilization of an enormous amount of electrical energy, the central portion of the furnace is brought up to about 2200° C., at which temperature the silica is volatilized. One molecule of silicon combines with one of carbon, forming a core of pure crystallized silicon carbide between the electrodes in opposite ends of the furnace. Immediately surrounding this is a zone of the amorphous variety of carborundum which is commercially known as firesand. Chemically it is a mixture of several silico-carbides which vary in composition from Si_2C_2O to Si_6C_6O. This represents a partial reduction of silica by carbon or a solid solution of silicon carbide in silica.

This material is also highly refractory but, owing to its lower heat of formation and lack of definite crystalline structure, it is not as stable under extremely high temperature as the crystalline variety. However, it has a wide application in places where a higher degree of refractoriness is required than can be obtained in the best grade of fireclay brick.

Finely ground firesand when mixed with a bonding material, such as kaolin or high-grade plastic fireclay, makes a refractory which can be moulded in place or plastered over the surface of a lower grade refractory to protect it from the cutting action of impinging flames. Owing to the fact that even the intense reducing heat of an oil flame does not cause any modification of the firesand, it has come to be a recognized material for the linings of brass furnaces of all types. It is also used as a protective coating for the brickwork of furnaces, bag and baffle walls, and the walls of potter's kilns. For this work it is mixed with water and sodium silicate, and often a small amount of clay to increase the adhesion, and applied to the walls in a slip condition.

Refractory materials made of mixtures containing silicon carbide are now being used in various capacities in the ceramic as well as the metallurgical industries. When the thermal efficiency and the increased permanance of structures made from it are recognized it promises to have a much wider application in the burning of ceramic wares.

SYMPOSIUM ON METAL INDUSTRIES

September 27, 1918

THE PYROPHORIC ALLOY INDUSTRY

By Alcan Hirsch, Consulting Chemist, New York City

The pyrophoric alloy industry is a very young industry and is intimately associated with the rare earth industry which is also a comparatively young one. In order to make the situation clear, it will be necessary to briefly outline the meaning, foundation, and history of the rare earth industry. The term means the industries which mine, separate, purify, and use the earthy metals or salts of metals formerly considered rare, *i. e.*, cerium, lanthanum, didymium, yttrium, zirconium, and thorium. The rare earth industry was founded in 1885 by an Austrian, Baron Auer von Welsbach, who while investigating certain ores noted the brilliant light-emitting qualities of their oxides, and invented the incandescent gas mantle. This gas mantle was made from oxides of lanthanum and zirconium to which a little cerium oxide was added. Welsbach secured patents in various countries and sold them to investors. About 1887 the industry took root in the United States with the formation of the Welsbach Light Company. The early gas mantles proved somewhat of a disappointment. Welsbach was in danger of being discredited and pushed his research further, particularly investigating ores of thorium. The early mantles gave only about 10 candle power per cu. ft. of gas, but the use of thorium salts considerably improved this, and purer and still purer thorium salts were tried until finally the salts were made so pure that they emitted no light at all. To make a long story short, it was found that while thoria should be the main and almost the whole constituent of a mantle, the presence of 1 or 2 per cent of other oxides, chiefly cerium oxide, was essential to high light-emissive value. This leads us to the present incandescent gas mantle, with which we are only indirectly concerned in so far as its production leads to the making of by-products from which pyrophoric alloy is produced.

The original sources of thoria (thorite) found in Norway proved totally insufficient in quantity to supply the demand of thoria for use in gas mantles. The manufacturers of gas mantles, therefore, turned to monazite sand, found rather plentifully in Brazil and India and to some degree in North Carolina as a source of thoria. About 15 to 30 per cent of monazite sand is phosphoric acid, and most of the rest is made up of various oxides of the rare earths, 20 to 30 per cent cerium oxide, 20 to 30 per cent oxides of lanthanum and didymium in varying proportions, and small percentages of the yttrium and zirconium oxides. All of these are practically useless in any quantity in the gas mantle business. It is the 2 to 10 per cent of thorium oxide, generally about 6 per cent, for which the monazite sand is bought and worked up. More than a quarter of a million pounds a year of thorium oxide is made in the United States from about 5,000,000 lbs. of monazite sand with the by-product mostly wasted. This by-product of so-called "cerium oxides" or "mixed rare earth metal oxides" is considerably more than 1,000,000 lbs. per annum, and this by-product constitutes the raw material for making pyrophoric alloy.

It should here be made clear that what is called "metallic cerium" and used as such is really a mixture of cerium, lanthanum, didymium, samarium, etc., all very closely allied and very similar metals. It is not necessary to separate them, but the salts for making the metal must be purified. The process for making metallic cerium and the like is described in U. S. Patent 1,273,223, patented July 23, 1918, to Alcan Hirsch and Marx Hirsch, inventors.

The metal is made in an electric furnace by electrolysis which consists in passing an electric current in a certain manner through a molten salt of the metals to be produced, called the electrolyte.

The first problem is, therefore, the making of the electrolyte. We have found that to secure an electrolyte suitable for the

prolonged, regular commercial production of metallic cerium, certain peculiar precautions are necessary. We have found that certain rather limited ranges of temperatures are required for efficiently performing the two classes of work to be carried out in the electrolytic cell, and these are denominated "separating temperature" and "agglomerating temperature." The electrolyte is prepared preferably by utilizing the oxides described above which are the by-product from the incandescent gas mantle industry. These oxides are preferably dissolved in commercial hydrochloric acid, reasonably free of sulfuric acid and sulfates, using during the solution process as little heat as possible, and preferably maintaining an excess of the oxides so as to make the chlorides of the metal. The resulting chloride liquor consists not of cerium chloride, but of a mixture of the chlorides of cerium, lanthanum, didymium, samarium, yttrium, thorium, and other rare earth metals, of which cerium is the chief single constituent.

Contrary to common belief, the general purity of this solution is immaterial, but the percentages of sulfur and phosphorus compounds on the one hand, or of chlorine carriers of dual valency, such as iron and aluminum compounds, on the other hand, should each be reduced below 3 per cent. Addition of an excess of cerium oxide may be used to throw out the iron and aluminum, and calcium chloride, or better barium chloride, may be used to throw out the sulfur and phosphorus compounds.

The solution is then clarified, preferably hot by filtration or settling, and evaporated to dryness. The preparation of electrolyte should be so carried out as to secure the proper tension conditions between the fused electrolyte and the fused metal when produced in the electrolytic bath. An excess of certain impurities including oxy-chlorinated products, such as cerium oxy-chloride, I believe tends to so far reduce the surface tension between the metal and electrolyte in the electrolytic bath and alter the viscosity as to produce emulsification or colloidal solution of metal in the fused electrolyte and prevent amalgamation of the metal in the bath. The oxy-chlorides may be removed in either of two ways.

(1) The chloride solution obtained as above may be evaporated to solidification, and then fused in an atmosphere of hydrochloric acid gas to produce complete dehydration while preventing oxidation by the air, or decomposed steam, from the electrolyte, the aqueous acid in the vapors being, if desired, condensed hot and separated, and the concentrated hydrochloric acid gas may be dried and used over again, or may be recovered with water as hydrochloric acid.

(2) The known method of making for electrolysis the double chloride of sodium and cerium does not yield a desirable electrolyte. If, however, about 15 per cent sodium or potassium chloride (insufficient to make the double salt) and 15 per cent of ammonium chloride by weight, based on the dry weight, of the dissolved rare earth chlorides, are both added to the chlorides after the excess of iron, aluminum, sulfur, and phosphorus impurities are removed and before the evaporation, the solution may then be evaporated to dryness and the dehydration carried through to fusion of the chloride without the production of characteristics resulting in objectionable tension phenomena in the electrolytic bath when the material is later subjected to electrolysis. The ammonium chloride is volatilized in the above treatment, and forms a chlorinating agent as does the hydrochloric acid gas in the first way, and may be similarly recovered and re-introduced into the process. When the electrolyte formed in this way is subjected to electrolysis, the alkali metal chloride accumulates in the electrolytic cell, and after the removal of the metallic cerium or mischmetall, it may be thrown away or dissolved in hydrochloric acid, clarified, purified as above explained, and added to fresh electrolyte being prepared.

The electrolysis is preferably carried out in pots of similar cast iron, although it may be carried out in suitable clay crucibles, about 1 ft. in diameter and 12 to 18 in. deep, usually set in brickwork and externally heated. Heat should not be applied to the sides of the pot, as would ordinarily be the case. It should be applied almost wholly to the bottom of the pot, so as to regulate its intensity and volume. It is very objectionable to fill the pot with fused electrolyte, as is described in experimental literature. We begin the electrolysis with a nearly empty pot, heat a small amount of electrolyte with the outside gas flame nearly to fusion, and apply the electric current to complete the fusion. Thereafter continue the electrolysis and the gradual addition of electrolyte, building up the charge in the pot continuously by gradual increase in the contents of the pot, until it is practically full, and a termination of the run is brought about. Either carbon or graphite anodes may be used, but they each show a critical density, that is, one above which current may pass without valuable effect. For graphite this is about 6 to 7 amperes per sq. in. of anode surface, and for carbon about $5^1/_2$ amperes per sq. in. of anode surface. Furthermore, we find it desirable to maintain a relation between current density at the anode and at the cathode, the latter being about $^1/_4$ to $^1/_3$ of the former, in order to secure a desirable electrical circulating and heating effect. By adding solid lumps of electrolyte to the bath, the temperature of the cell is regulated when it becomes slightly too hot and this also contributes a portion, at least, of the fresh electrolyte required for building up the charge which is being decomposed.

As the run approaches 24 to 26 hrs. in duration, if electrolyte made according to the second way is used, the sodium salt accumulates in the charge to such an extent that it becomes advisable to terminate the run. We have found that certain precaution for this termination is necessary to secure good yields of metal. Therefore, preparatory to shutting down the run, we turn on the heating torch full blast, and we also increase the current, stirring up the charge in the cell thoroughly about every half hour for the last two or three hours of the run. The contents of the cell should be in a nice liquid condition if the electrolysis has been properly carried out. The current may be shut off, the anode taken out, and the bath gently but thoroughly stirred for about 5 min., care being taken to cease stirring well before the bath begins to stiffen up at all. If iron pots are used, it is generally most practical to break up the pot after cooling, in order to separate the button of metal from the electrolyte.

This relatively pure mixed metal or mischmetall is soft and does not spark easily on scratching. Consequently, to make pyrophoric alloy it must be made harder, and it is, therefore, alloyed with about 30 per cent of other metals, chiefly iron, to make the commercial sparking metal or pyrophoric alloy which is formed into small pieces to make the "flints" used in making lighters, igniters, mechanical fuses, etc. The alloy enters into commerce in the form of small strips, rectangular or round, of varying lengths, varying from 200 to 2000 pieces to the pound. The most general form is a round piece approximately about $^1/_8$ in. in diameter and $^1/_8$ in. long, of which there are from 1500 to 2000 pieces to the pound.

In this connection, I might mention that the manufacture of these small pieces, the only form in which mischmetall is saleable, is a most difficult operation, requiring what is comparable to equipment for the manufacture of fine jewelry.

Baron Auer von Welsbach developed the improvement of hardening the relatively soft metal with iron, in order to make a hard metal which would emit sparks when scratched. He took out patents on this invention the world over. The German and English patents were litigated and held restricted to the use of iron and its equivalent in substantially the 30 per cent amount named. This is to say that in Germany and England the court held that Welsbach was entitled to protection only on the iron alloys. The United States courts have sustained the patent much more broadly to include any cerium-containing materia

hardened with any alloyed metal to make the pyrophoric alloy. When Baron Auer von Welsbach and his associates developed the pyrophoric alloy business, they did not form separate companies in each country, but centralized the manufacture of cerium and pyrophoric alloy in the Treibacher Chemische Gesellschaft of Treibach, Austria (a part of the rare earth cartel or trust). As stated above, they established branches of this Austrian company, namely, the Treibacher Chemische Gesellschaft in England, France, Russia, United States, etc., for the purpose of alloying the metal to meet local requirements and selling the alloy. It was not until some time after the first attack on France that a pound of cerium was made anywhere in the world outside of the Central Powers so far as I can learn, and then such cerium was made by the New Process Metals Company, which company operates under our basic patent on metallic cerium. Therefore, to reiterate somewhat for the sake of clearness, until the start of the European war the pyrophoric alloy business of the world was operated as follows:

The German and Austrian rare earth gas mantle cartel or trust turned over to the Treibacher Chemische Gesellschaft a large part of their cerium residues, which the Treibacher Company made into metallic cerium. This metallic cerium the Treibacher Company exported to its branches in France, England, United States, etc., which branches alloyed the metallic cerium with about 30 per cent of iron and other metals, and made the alloy into small pieces, selling these pieces of alloy to the manufacturers of pocket lighters, miners' lamps, gas lighters, etc. The business of marketing the small pieces of pyrophoric alloy was protected by the patent under discussion which has been contested, and, as stated, very broadly sustained in this country. The American branch of the Treibacher Chemische Gesellschaft was established about 1907, and handled all the pyrophoric alloy business in this country.

After August 1914, the efficiency of the British Navy made it impossible for the Treibacher Chemische Gesellschaft to deliver cerium metal to its agency in the United States. They tried by every means to secure cerium metal from Austria, even trying to import it by the submarine Deutschland, but were unsuccessful.

In 1915 the American agency of the Treibacher Chemische Gesellschaft got in touch with a chemical company in this country and tried to have this company produce metallic cerium for them. The company, after working several months, was wholly unable to do so. The president of this chemical company then learned that I had secured my degree from the University of Wisconsin as the result of experimental work on the electrolytic preparation of metallic cerium, and engaged my firm to work out a process for the commercial manufacture of this metal. With me in our joint laboratories were associated my brother and other assistants. After several months of intensive work in the laboratory, metallic cerium was commercially produced of satisfactory quality and in regular quantity, and thereafter the New Process Metals Company was formed which manufactured and sold this material. From that time until April 1917 the New Process Metals Company furnished metallic cerium to the American branch of the Treibacher Chemische Gesellschaft located in New York City.

In April 1917 the manager of the American branch of the Treibacher Chemische Gesellschaft formally notified the New Process Metals Company that he personally, doing business as the American Pyrophor Company, had purchased the business of the Treibacher Chemische Gesellschaft. From April until December 1917 the New Process Metals Company further furnished metallic cerium to this manager doing business as the American Pyrophor Company.

After war against Austria was declared, the property of the American Pyrophor Company, or the Treibacher Chemische Gesellschaft, which ever you choose to call it, was taken over by the Alien Property Custodian of the United States.

From the foregoing it is seen that the New Process Metals Company developed the cerium business in America. From shortly after the start of the war until the autumn of 1917 it was the only company in the world, outside of the Central Powers, making metallic cerium, and the pyrophoric alloy made from this product supplied the needs of the armies and civil populations of Russia, France, England, South America, United States, etc. In this connection, it is interesting to note that the cerium lighters have been extensively used in the trenches, first because of the great scarcity of matches in Europe, and second because of the effect of dampness on matches We are glad to be able to say that for several years prior to 1918 we supplied the British and French armies with their requirements of pyrophoric alloy. Now this metal, we understand, is being made in France.

The future of the pyrophoric metal business in this country is an interesting field for speculation. We hope to be able to maintain this business to some degree at least. Frankly, it is our potential ability to market our alloy in the form of lighters upon which we rely for the maintenance of our company and it is our hope that our lighter facilities will become so economical as to enable us to successfully meet Austrian competition after the war.

THE FERRO-ALLOYS

By J. W. Richards, Professor of Metallurgy, Lehigh University

A large industry has grown up within the last 50 years, most of it within the last 25 years, which furnishes to steel makers alloys of iron with some of the rarer metals, in order to introduce these rare metals into steel. Such alloys are known as ferro-alloys, because they all contain iron (ferrum); some of them, however, contain more of the rare metal than iron. They were originally made in crucibles, cupolas, or blast furnaces, but are now being made principally in electric furnaces, and their manufacture is one of the principal electric furnace industries.

They are of great importance to the steel industry. The steel maker uses them for one of two purposes: (1) As reagents to take oxygen out of melted steel and thus ensure sound solid castings (ferromanganese, ferrosilicon, ferro-aluminum) or (2) to put into the steel a small or large percentage of the rare metal (ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, ferrotitanium, ferro-uranium, ferroboron).

Let us discuss these two uses. Melted steel, just before taking from the furnace, always contains some oxygen dissolved in it (like the dissolved gas in charged soda water). If this is not removed, the casting made is more or less unsound from cavities or blow-holes. The addition of a small amount of an element or metal with a high affinity for oxygen removes this oxygen and makes the casting sound. Manganese (1 per cent or less) is the cheapest and most generally used reagent for accomplishing this; silicon ($^1/_2$ per cent or less) is more powerful but also more expensive, and is often used to supplement the action of manganese; aluminum (0.1 per cent or less) is still more powerful and still more expensive, and is used in very small quantities as a final addition to complete the action of the manganese and silicon. All steel makers use one, two or all three of these reagents; manganese and silicon in the form of ferro-alloys, aluminum more often as the pure metal, but ferro-aluminum is sometimes used.

The second use is to make special steels, that is, steels containing such quantities of the rare metal as give to them properties different from plain carbon steels deoxidized by manganese, silicon, or aluminum. Thus we may make manganese steel by putting in 12 to 14 per cent of manganese, making a very tough, hard steel such as is used in mining and grinding machinery, burglar-proof vaults, etc.; chromium (2 to 4 per cent) makes a very hard tool steel; tungsten (15 to 25 per cent) makes high-speed tool steel, which cuts iron while red hot; molybdenum (6

to 10 per cent) has powers similar to tungsten, and is also used in steel for lining large guns. Vanadium ($^1/_{10}$ to $^1/_2$ per cent) makes a very strong steel which resists shock extremely well, as when used for automobile axles; titanium, uranium, and boron impart valuable properties not so easily described. Every one of these materials is used for producing some specific result which is not produced by any other; sometimes combinations of two, three, or four are used in one steel, producing a particular combination of special properties for some special purpose. Some of these materials cost $5 per lb., and the special steels produced cost up to $2.50 per lb., but their particularly valuable properties justify the expense. The value of these special steels to the industries, and particularly for military purposes, is very great, so great that the supply of ferro-alloys for their manufacture is an important factor in winning the war.

FERROMANGANESE

This is the oldest of the ferro-alloys. Its manufacture was begun about 50 years ago. It was first made in crucibles, had for a long time been made in blast furnaces, but is now being produced in many places in electric furnaces. It is made with 30 to 85 per cent manganese, 3 to 5 per cent carbon, a little silicon, and the rest iron. The rich grades, 75 to 85 per cent, are preferred by the steel maker, but they require rich manganese ores for their manufacture. The United States has very little rich manganese ore, but large quantities of low-grade ores; one of the present burdens of the steel maker is to use low-grade ferromanganese, in order that we may not have to use ships for importing the high-grade ores from Brazil.

The usual manufacture in blast furnaces is wasteful of both fuel and manganese; the furnace must be run hot and slowly, with very hot blast in order to reduce the manganese oxide ore as completely as possible and not waste manganese in the slag. Yet, in spite of all efforts, from 15 to 25 per cent of the manganese going into the furnace escapes reduction and is lost in the slag. This waste of fuel and manganese has led to the use of the electric furnace, in which fuel is required only as a chemical reagent and not to produce heat, thus saving about two-thirds of the fuel requirements of the blast furnace, while the higher temperature available causes the extraction of manganese to reach 90 per cent, *i. e.*, slag losses drop down to 10 per cent or less. Against these economies must be set the considerable expense for electric power and the smaller scale on which the furnaces run. At the present high prices of coke and manganese ore, and in view of the scarcity of manganese and the high price of ferromanganese, the electric ferromanganese industry is able to exist and make large profits. Whether it can do so when normal conditions return, after the war, is questionable; it is to be hoped that it will be able to do so, because of the economy which it undoubtedly possesses in regard to fuel and manganese.

Steel producers use ferromanganese particularly for making the low-carbon or soft steels, because they can thus introduce the required manganese for deoxidation without putting in considerable carbon. For higher carbon steels spiegeleisen (15 to 20 per cent manganese), a cheap blast furnace alloy, can be used, and is being used at present wherever practicable, in order to save ferromanganese. The best practice with either spiegeleisen or ferromanganese is to melt them in a small electric furnace, and tap from it the required weight to be added to the heat of steel. The melted alloy mixes quicker with and reacts more actively upon the melted steel, while less of it is necessary because less is oxidized by the furnace gases. The saving in manganese by the use of the electrically melted ferro is alone sufficient to justify the expense of melting it in an electric furnace, while better and more homogeneous steel is produced.

FERROSILICON

This alloy may run 15 to 90 per cent silicon, but the most commonly used is the 50 per cent grade. It is made from ordinary silica (quartz or sand), reduced by carbon in the presence of iron ore or scrap iron. The blast furnace is able to make only the lowest (15 per cent) grade, because silica (SiO_2) is exceptionally difficult to reduce, and under conditions which would reduce 99 per cent of the iron ore in a furnace, or 75 per cent of the manganese ore, only 15 to 20 per cent of the silica present can be reduced, and only a low-grade silicon alloy produced. The higher grades must all be produced in the electric furnace.

The raw materials are ordinary silica, the most abundant metallic oxide on the earth's surface, iron ore or scrap iron (iron or steel turnings or punchings), and coke. Electric furnaces up to 10,000 h. p. have been operated on ferrosilicon (50 per cent grade). At the high temperature required, a not inconsiderable proportion of the reduced silicon vaporizes, and burns outside the furnace to a white silica smoke. This can be largely prevented by skilful furnace supervision. In normal times, the 50 per cent alloy sells at $45 to $50 per ton, which is a low price for an alloy so difficult to produce.

Steel producers use ferrosilicon principally for the great activity with which the silicon removes dissolved oxygen from the steel. It is about four times as active as manganese in thus reducing blow-holes and producing sound castings. It is usual, however, to use manganese first to do the bulk of the deoxidation, and silicon afterwards, to finish up the reaction completely. It is particularly useful in making sound steel castings which are cast into their ultimate form and do not have to be worked into shape, because a slight excess of silicon may make the steel hard to forge or roll, whereas an excess of manganese does not have so bad an effect on the working qualities. A particular kind of steel called silicon steel carries 1 to 2 per cent of silicon and yet forges well; this would be classed as a special steel.

The ferrosilicon industry has attained large proportions in countries where electric power is cheap, particularly, therefore, in Switzerland, the French Alps, Norway, Canada, and parts of the United States. Under present conditions it is even profitably run where electric power is relatively dear, as at Anniston, Alabama, and Baltimore, Md. It is a large, interesting, and rapidly growing industry.

FERRO-ALUMINUM

This alloy, with 10 to 20 per cent of aluminum, was made in the electric furnace and used in considerable quantity in steel about 1885–88, but was displaced by pure aluminum as the latter became cheaper. Aluminum is about 7 times as powerful as silicon and 28 times as strong as manganese in acting upon the oxygen dissolved in steel; therefore only minute quantities are necessary, say 1 oz. or up to a maximum of 1 lb. of aluminum per ton of steel. Its use gives the finishing touch to the deoxidation of the steel.

About 1885 the Cowles Brothers, operating the first large electrical furnaces run in America, at Lockport, N. Y., made and sold considerable quantities of ferro-aluminum, selling the aluminum in it at the rate of about $2.00 per lb., while the pure metal was then costing $5.00. When, a few years later, pure aluminum sold for 50 cents per lb., the steel makers turned to using the pure metal instead of the ferro-aluminum, and at the present time aluminum is so used in practically every steel works in the world.

There seems to me a distinct opportunity for makers of ferro-alloys to revive the manufacture and sale of ferro-aluminum. Such great advances have been made in the construction and operation of large electric furnaces since 1890, and so much experience has been had in reducing the difficult oxides to ferro-alloys, that the production of 50 per cent ferro-aluminum at say $100 per ton may be a distinct electric furnace possibility. That would furnish the contained aluminum at about 10 cents per lb., as against 30 cents for the commercial aluminum now used. The alloy should be broken up small before using and thrown in the runner or on the bottom of the ladle, in order that the melted steel may quickly dissolve it as it runs into the ladle.

Such ferro-aluminum would require bauxite (aluminum ore) with iron ore or scrap iron for its manufacture, but there are large deposits of low-grade bauxite rich in iron in Southern France, which could be reduced directly to the alloy, without any additions, and thus furnish very cheap raw material for the operation.

In conclusion, ferro-aluminum is not now being made, but its electric furnace production is a real possibility.

FERROCHROMIUM

Ferrochromium is used for making what is familiarly (but erroneously) called "chrome steel." It makes steel exceedingly hard. Very hard cutting tools, and armor plates to keep out projectiles, are made of it. Only 2 to 4 per cent of chromium may be used.

Several grades are made in the electric furnace, depending on the per cent of chromium (25 to 75 per cent), and the content of carbon (2 to 8 per cent). This alloy takes up carbon so actively in the furnace that it has to be treated subsequently to remove the carbon, down to what can be endured by the steel into which it is introduced.

The raw material for its manufacture is a black ore known as chromite, an oxide of both chromium and iron. If this is mixed with carbon and smelted in the electric furnace, it reduces directly to ferrochromium alloy (often misnamed "ferrochrome"), and highly saturated with carbon (6 to 10 per cent). Steel makers want lower carbon than this, so the alloy is re-melted in another furnace, with more chromite, and the excess of carbon oxidized out. The low-carbon alloy sells for 2 to 3 times the price of the high-carbon crude material.

The cutting off of importations of high-grade chromite ore from Asia Minor has led to intense prospecting in the United States for chromite. Fair material has been found in many places, and at present our country is nearly independent of foreign sources of the ore.

FERROTUNGSTEN

Tungsten (also called "wolfram") imparts curious and valuable properties to steel. A small amount (2 to 5 per cent) has been used for half a century or more, to make the steel self-hardening; that is, a tool of this steel need only be allowed to cool in the air, and it becomes hard, without the ordinary quenching or chilling operation. Larger proportions (10 to 25 per cent) make a steel which stays hard even when red hot. A tool of this material can be run so fast on a lathe, for instance, that it gets red hot from the friction and work, yet keeps hard and keeps on cutting. It is called "high-speed tool steel," and its use alone has more than doubled the output capacity of the machine shops of the world.

The ore used is either wolframite, a black oxide of iron and tungsten, or scheelite, a white oxide of calcium and tungsten. It is found in considerable quantities in Colorado, and some other western states, and imports of this ore have not been necessary during the war. In this respect we are much more favorably situated than the European nations. A plentiful supply of tungsten ore may indeed be regarded as a large factor in the production of cannon and fire arms and all kinds of machinery, and therefore a considerable factor in winning the war.

FERROMOLYBDENUM

Molybdenum has only recently come into large use in steel. Its action being somewhat similar to tungsten, scarcity of the latter metal, particularly in Europe, has led to the manufacture of ferromolybdenum on a comparatively large scale.

The ores are widely distributed but not very plentiful. Molybdenum sulfide, the mineral molybdenite, looks almost exactly like shiny graphite, but it is a shade lighter in color and nearly twice as heavy. It occurs usually as flakes in granite rock, and might easily be mistaken for graphite. Lead molybdate, the mineral wulfenite, is a compound of lead and molybdenum oxides, a yellow to red mineral very prettily crystallized in thin square plates. It occurs abundantly in a few lead mines in the West. It is usually first treated to extract its lead, and the residue then worked for molybdenum. The sulfide used to be roasted to molybdenum oxide, and this reduced by carbon in the presence of iron ore or scrap iron in an electric furnace. It is now smelted directly in the electric furnace with carbon and a large excess of lime along with iron ore or scrap iron. Ferro with 50 to 60 per cent of molybdenum is tapped from the furnace like other ferro-alloys, but with molybdenum up to 80 per cent the alloy has such a high melting point that it cannot be tapped out without freezing; it is necessary to make a furnace full of this alloy and then let the furnace cool down and take it apart, taking out a large mass of solidified alloy; the furnace is then rebuilt.

The large use of molybdenum in steel has been so recent that not much has been made public about it. Rumor says that the large German guns (the "Black Berthas"), which bombarded Liege, were lined with molybdenum steel (6 to 7 per cent) to increase their resistance to erosion. It seems certain that Germany drew considerable supplies of molybdenite from Norway to compensate for shortage of tungsten for high-speed tool steel. Parts of guns, gun carriages, motors, and automobiles have also been made of molybdenum steel of most excellent quality. Canada has been especially active in the manufacture of ferromolybdenum, most of which it exported to Europe. This alloy is therefore another preëminently valuable war material.

FERROVANADIUM

Without vanadium the modern automobile or auto truck would be a much weaker machine. When steel is desired to withstand the heaviest shocks and vibration, nothing is quite so effective as adding vanadium. This is another comparatively rare metal, found principally in the radium ores of Colorado and as a black sulfide on the highlands of Peru. The canary-yellow Colorado ore is treated for radium, and the residues for vanadium and uranium. The United States Government (Bureau of Mines) operates this process for the radium supply. The black ore of Peru is rich and unusual; it is a sulfide with some asphaltic matter, and it is roasted and gotten into the condition of iron-vanadium oxide before reduction. The oxides are best reduced by metallic aluminum. Vanadium oxide plus aluminum produces vanadium plus aluminum oxide slag. This is the well-known thermit (Goldschmidt) method of reduction. Electric furnace reduction by carbon is not advantageous because of the large amount of carbon taken up by the alloy; powdered silicon is therefore put into the charge as the reducing agent, together with iron, lime, and fluorspar, and then a 30 to 40 per cent vanadium alloy is obtained with seldom over 1 per cent of carbon, a very desirable composition (R. M. Keeney).

Only small amounts of vanadium are necessary in improving the steel; 0.1 to 0.4 per cent are the usual quantities. This is fortunate, because the vanadium costs $5 per lb. and over. Metallurgists suspect that part of the improvement of the steel may be due to the vanadium combining with and removing nitrogen dissolved in the melted steel. This is probably true, yet some advantage undoubtedly must be ascribed to the final vanadium content in the steel; both avenues of improvement function. Steels thus treated are unusually resistant to shock and alternate stresses, making them very useful for axles, cranks, piston rods, and such severe service.

FERROTITANIUM

Titanium is an abundant element in nature. It occurs in immense amounts as a double oxide of titanium and iron, known as ilmenite, or titanic iron ore. This ore can be reduced directly by carbon, in electric furnaces, to ferrotitanium. The reduc-

tion proceeds more easily if some aluminum is put in as a reducing agent, but this is expensive and unnecessary. The alloy running 15 to 25 per cent titanium is sold for use in steel, as a refining agent to remove oxygen and nitrogen. Thousands of tons of steel for rails have been thus treated, the tests showing considerable improvement in the mechanical properties by the use of quite small amounts (0.10 to 0.20 per cent) of titanium. Only one firm in America makes this alloy, and its use in steel has not yet gained universal approval.

FERROBORON

This is another alloy whose valuable qualities have not yet been entirely determined. Boron is the metallic base of borax, which is a sodium boron oxide. Borax is very difficult to reduce to the metallic state. Another raw material, not so abundant, is colemanite, containing lime and boron oxide. Many attempts have been made, none very successfully, to reduce this with iron oxide to ferroboron. The American Borax Company offered a prize, for several years, for a process which would accomplish this. Boron oxide occurs rarely in nature, but it can be manufactured from borax and colemanite. When the oxide is obtained, this can be combined with iron oxide and the resultant boron-iron compound reduced by carbon in the electric furnace to ferroboron. Small quantities of this alloy have thus been manufactured.

Experiments on steel have shown that ferroboron acts somewhat similarly to ferrovanadium. Experiments in France showed remarkably strong and tough steels were thus made, using 0.5 to 2 per cent of boron. The results have not been properly followed up, partly on account of the difficulty in getting ferroboron; no one, as yet, has taken up its regular manufacture, and steel makers can hardly be blamed, in these stirring times, for not having as yet thoroughly explored its possibilities as an addition to steel.

FERRO-URANIUM

This is the latest of the ferro-alloys to enter the lists. Uranium is a very heavy and, chemically, very active element. It is found in small quantity as a black oxide, the mineral pitchblende, the mineral in which radium was first discovered. It is found more abundantly in the Colorado radium ore, a bright yellow oxide and silicate of vanadium, uranium, and lime. After extracting the radium and vanadium, the uranium remains in the residues as a by-product, usually as a soda-uranium compound. This is treated so that uranium oxide is obtained, and this can be reduced by carbon in an electric furnace in the presence of iron ore or scrap iron, to ferro-uranium (30 to 60 per cent). The recovery of uranium is not high (50 to 70 per cent), the rest being lost in the slag. Mr. R. M. Keeney has recently described these processes in detail, for the first time, in the August bulletin of the American Institute of Mining Engineers.

The results of tests showing the influence of uranium on steel are not yet completely known. Some firms have claimed for it wonderful strengthening power and resistance to shock. The subject is now receiving expert attention from steel makers and valuable results are confidently expected.

CONCLUSION

The ferro-alloys are exceedingly important materials to the steel maker, either in the making of ordinary steel or for producing special alloy steels. They are indispensable to the steel industry. They are important factors in producing both ordinary and fine steels, and therefore in winning the war. The country well supplied with them has a great advantage over the country in which they are scarce. They are deserving of all the expert attention which they are receiving from the War Industries Board, the steel makers, and the economists. The possession by the United States of large supplies and resources in the ferro-alloys line will be one of the important factors in determining the quick ending of the war.

SYMPOSIUM ON INDUSTRIAL ORGANIC CHEMISTRY

September 28, 1918

ADVANCES IN INDUSTRIAL ORGANIC CHEMISTRY SINCE THE BEGINNING OF THE WAR

By Samuel P. Sadtler

Consulting Chemist, Philadelphia

Many ordinarily intelligent people with no special acquaintance with scientific matters will confess to having had the belief that the United States had no established chemical industries at the outbreak of the present great world war, or if we had any, they did not cover the field of what is known as organic chemistry. Organic chemistry was to them the field of coal-tar dyes and synthetic medicines, and was not this the peculiar and exclusive domain of the German chemical manufacturer? We rather think that this expresses the actual knowledge on the subject on the part of our non-scientific newspaper and magazine writers at the outbreak of the war.

However, the elements which go to favor the establishing of a chemical industry are a wealth of raw materials and a market for the manufactured product, and with these the coöperation of intelligent chemical effort and capital. All four of these elements existed in the United States and the result of their coöperation had already been quite effective long before the beginning of the war in giving us flourishing chemical industries based upon organic raw materials and involving applications of organic chemistry. When we recall the great wealth of this country in petroleum and asphalt, in all varieties of coal, in vegetable and animal oils and fats, in cereals of all kinds, and in fibers of indispensable character, we would be surprised if flourishing chemical industries had not been established.

Let us briefly view some of these industrial organic developments as they existed prior to 1914.

The American petroleum industry easily ranked as the first in importance in supplying the world with the various products of mineral oil.

Of a total annual world's production in 1914 of over 400,000,000 bbls., the United States produced 265,762,000 bbls., or just about two-thirds, while Russia, the next in rank, produced 67,000,000 bbls., or 16.7 per cent of the total amount.

But it is not only the raw material production that is to be considered. By far the larger proportion of this crude oil was refined in the United States and from it were made gasoline, kerosene, lubricating oils in great variety, paraffin and paraffin candles, vaseline and similar products. These products were not alone for the American market but went all over the world.

We also had a great and well-developed industry in the extraction, refining, and working-up of vegetable and animal fats and oils. A peculiarly American industry was the cotton-seed oil and cake industry. Hundreds of mills throughout our southern states were devoted to the crushing of the seed and the preparation of the cake, while the refining of the oil and the making of the finest edible products were carried out in large plants. The enormous production of lard and lard oil by our great packing companies and the preparation of oleo oil for foreign shipment was also an important and well established American industry. As a side product, the extraction and refining of glycerin had also become well established and the American soap industry was also well developed and a large export business already inaugurated.

The utilization of linseed oil for paint oils and in the manufacture of linoleum and oil cloth had also reached a high development at the hands of American technologists.

The great naval stores industries involving the production and utilization of American turpentine and rosin had also been well developed and many minor chemical industries based upon them. America was also one of the largest consumers in the world of rubber, and thanks to the manufacture of all classes of rubber and water-proofed goods and to the utilization for automobile tires, the working of rubber had been extensively developed

The refining of sugar, in part produced in the United States and the neighboring West India Islands, and in part from imported European raw beet sugar, had become an extensive industry with the most modern of plant equipment and under scientific chemical control.

As America is in large degree the granary of the world in its production of cereal foods, we had large chemical industries already occupied with the preparation of the special classes of food products of cereal origin. One of the best instances of a distinctively American industry developed from American material is the corn products industry. From the maize or Indian corn is produced corn starch for food purposes, and for technical purposes, glucose or commercial dextrose, corn or maize oil, and commercial dextrines. This industry has been developed from a distinctively American cereal and on lines quite peculiar to it as an industry of American growth.

Turning to the textile industries, we have as an American production, one of the world's most useful fibers, *viz.*, the cotton fiber. I have already referred to its peculiar by-product, the cotton seed, and its utilization. However, we have many important industries utilizing the cotton fiber in which its bleaching, dyeing, and other treatment are controlled by accurate chemical knowledge and practice.

The textile industries using wool and silk as well as cotton have also attained a high development in the United States and the chemical side involving the cleansing and after-treatment of the fibers has been thoroughly worked out.

The products of destructive distillation remain to be spoken of. Our American wood distillation industry will be specially presented by another speaker during this Exposition and so I will pass this by. Coal distillation for gas making had been practiced by the most accurate scientific methods and great varieties of special gas-making processes had been developed. It will be remembered that the Lowe water-gas process was an American invention which has been copied and adopted since in various other countries. However, we were slow to discard the old wasteful beehive oven for coking of coal for by-product ovens which collect the valuable residuals including gas, tar, and ammonia. The production of coal-tar crude ingredients was therefore only moderately developed and of what we term the "intermediates" for the color industry hardly at all.

An American dye color industry using imported intermediates therefore existed, but it existed under difficulty and played but a subordinate part in supplying the American market with the dyes required for our textile industries.

This brief survey shows that it is a great mistake to assume that there were no organic chemical industries existing in this country in 1914 at the outbreak of the war. Nevertheless, the general public knew little of the chemist and his actual or potential value to industry or commerce. Capital, which frequently made large investments in mining and similar enterprises, many of which were largely speculative, had not made the acquaintance of the chemist to any notable extent, perhaps because the language of chemical reactions was something foreign to its experience or training and hence distrusted. The war came and we soon learned how great a disturbance such a great war could be to the world's commerce in which the United States played a vitally important part. We also learned promptly how chemical industries were the foundation stones for this great commerce. It soon developed that war in its modern form was based upon the chemical activity and scientific development of a country and then the chemist began, as it has been repeatedly said, to come into his own.

Our special topic therefore is to note briefly how our American chemical industries, and in particular those involving organic chemistry, have responded to this war impulse and demand in the four years that have elapsed since the beginning of the war in 1914.

Our petroleum industry, which we have shown was already in a highly developed state, had important problems at once presented to it. Great as was our refining capacity, it was utterly inadequate to produce in normal course the quantities of gasoline that were required. Besides the growing automobile consumption, the war demands for motor trucks and for aeroplane and tractor engines came as an added load on the industry. Because of the demoralization of the Russian oil production and the German occupation of Roumania, the whole gasoline supply for the allied nations has to come from America. To meet this demand we have in addition to what may be called "straight refinery" gasoline, blended "casing head" gasoline and "cracked" gasoline. Under the pressure of the great demand, large quantities of volatile hydrocarbons are washed out by suitable solvents or condensed out of natural gas and then blended with heavy naphtha to bring down the gravity to a proper average. Such a gasoline will necessarily have a wide volatility range, but is available for most uses that the normal refinery gasoline is. Most of the areas producing natural gas are available for this gasoline extraction but it has developed particularly in West Virginia, in Oklahoma, and in California. It is furnishing a rapidly increasing amount of gasoline yearly. The third source of gasoline mentioned is from special cracking processes and it is this class of processes which have been attracting the most interest and giving the greatest promise of large results. The whole subject was discussed from a theoretical and historical point of view in *Bulletin* 114 of the Bureau of Mines by Rittman, Dutton, and Dean. Since the date of that publication in 1916, a great deal additional has been published in the journals and much has been done in a practical way. The Burton process adopted by the Standard Oil Company is now in operation on a large scale in several of the largest refineries of that Company; the Rittman process has been tried on a working scale, although not yet developed to a final form for large scale production; the McAfee process of decomposition in the presence of aluminum chloride as catalyst has been developed by the Gulf Refining Company, and the Snelling process has also been brought forward. That heavy petroleum oils can be cracked so as to produce much light oil or gasoline is beyond question, but the problem is to avoid the production of large proportions of unsaturated hydrocarbons which require acid treatment in the product. McAfee claims to avoid this production of unsaturated compounds and that his gasoline requires no acid treatment, but the success of his process is dependent on the economical recovery of the anhydrous aluminum chloride available for use. Enormous quantities of other special petroleum products have also been called for by reason of war demands, such as high-grade lubricating oils. I had brought to me for testing some time back a "recoil oil," required by the Government for use with heavy guns, which with a high viscosity had to stand a cold test of —5° F. (—20° C.).

Then the demands of the English and the United States Navy for fuel oil has drawn upon the Mexican oil fields, as well as those of Louisiana and Texas, and pushed production to the maximum.

Meanwhile a new raw material has been brought to notice that is capable of adding enormously to our available petroleum supplies in the oil shales of Western Colorado and Eastern Utah, the deposits also being found to some extent in Nevada, Wyoming, and Montana. These shales readily yield by distillation a crude oil capable of furnishing gasoline, kerosene, and paraffin and in addition large amounts of ammonia, so that sulfate of ammonia may be obtained as a by-product. In *Bulletin* 691–*B* of the United States Geological Survey, D. E. Winchester has described this occurrence and gives records of distillation. These shales are said to be like the Scotch shales but richer in oil. With the gradual exhaustion of the oil fields they will prove a welcome addition.

The vegetable and animal oil markets have been greatly

affected by the war and the industries based upon them have been changed in a revolutionary way in many cases. The first cause may be said to have been the export embargo established by Great Britain upon all glycerin-containing oils with the beginning of the war. Following this came a shortage in the cottonseed crop in 1915 and the introduction of soy bean culture in the South. As the refined cottonseed oil took more and more the position of an edible oil, commanding correspondingly higher prices, the soy bean oil took its place for industrial uses, for soap and paint manufacturers, and as a constituent of compound lard and oleomargarine. The soy bean cake has also been readily taken up for stock feed and for fertilizer. The soy bean contains more protein than either cotton seed or peanuts, as much fat as cotton seed, and only one-fourth as much fiber as cotton seed or peanuts.

It has a lower iodine number than linseed oil and is slow in drying, so that it cannot completely replace linseed oil in the paint industry but can be admixed with it. Besides the production in the South, which according to Government reports in the year 1917 was from 531,000 acres, we have had an enormous development of the soy bean oil importation as the following figures will show. Importation for year 1914, 12,500,000 lbs.; for 1917, 264,900,000 lbs.; and for 1918, 336,824,646 lbs.

Most of this coming from Manchuria enters Seattle and other Pacific coast ports. All available storage facilities at Seattle and other coast points have been overtaxed in the handling of this supply.

Another great development in oil supplies has come from the greatly increased production of peanut oil. This has come to the fore as a salad oil and for soap making. The crop in the United States rose from 3,500,000 bu. before the war to 40,000,000 bu. in 1916. For 1917, the Government reports show that 3,277,000 acres were devoted to its culture in the South, and for the year of 1918 it is estimated in the state of Texas alone 3,000,000 acres will be devoted to it. The importations have also increased sixfold since 1914, now amounting to over 8,000,000 gal.

A year ago we had no castor beans grown in this country to speak of, to-day we have at Government instigation hundreds of thousands of acres devoted to it in Florida and elsewhere and the product contracted for by the Government. As illustrating the greatly increased demand for oils capable of yielding food products we may also note the remarkable growth in the coconut oil and copra importations. In 1914 the importations of coconut oil amounted to 74,386,213 lbs, in 1918 it had grown to 289,194,853 lbs.; of copra for the expressing of coconut oil we imported 45,437,155 lbs. in 1914 and in 1918, 486,996,112 lbs. Similar changes have taken place in the fish-oil markets with the decrease in the menhaden catch due to the commandeering of fishing boats and scarcity of men to man them. Through our Pacific ports chiefly are imported quantities of dogfish, halibut, salmon, sardine, shark, tuna fish, candlefish, and walrus oils, largely new to the market, while whale oil, seal oil, and porpoise oils are again appearing in large quantities. These fish oils have moreover an added value as sources of supply since the general application of the hydrogenation process whereby they can be changed into hardened fats without offensive odor and of the greatest value as soap stock and for glycerin production.

With regard to the increased production of glycerin because of the war demand I have no figures, but it has been very great, so that the use of glycerin in pharmaceutical preparations has been discouraged in order to conserve the glycerin for nitroglycerin production and for export to our allies, 21,000,000 lbs. having been exported in 1918.

In the field of essential oils there are a few items of interest to note. With the study of wood turpentines as distinguished from gum turpentine it has been recognized that spruce-wood turpentine, now a waste product of the sulfite process of making paper pulp, has a peculiar composition. It consists largely of one aromatic hydrocarbon, cymene (iso-propyl-methyl-benzene). On subjecting this to the Friedel and Crafts reaction with aluminum chloride in the presence of an excess of benzene, toluene and cumene (propyl-benzene) are formed. The toluene is readily converted into TNT (trinitrotoluene) and the cumene may be oxidized directly into benzoic acid. The work as reported in THIS JOURNAL for May 1918 is still in a purely experimental stage but it has much promise.

One of the newer uses of essential oils which has particularly stimulated the production in the last few years of pine oil in the South is for the ore flotation process. The concentration of both copper and zinc ores in the United States as in other parts of the world is now effected by agitating the finely pulverized ore with water in the presence of a small quantity of oil. While fatty oils, mineral oils, coal-tar and wood-tar creosotes have been used, certain essential oils have been found to be specially adapted for this treatment. In this country pine oils, both steam-distilled and destructively distilled have been especially used and quite an industry in these oils has developed. The magnitude of our copper and zinc production is such that although the amount of oil used in this flotation is relatively small (less than 1 per cent on the ore) the aggregate consumption of oil is very large.

The war demand has greatly increased the call for rubber goods of all kinds, especially automobile tires, and consequently the consumption of crude rubber has grown rapidly. The importations of rubber in 1914 amounted to 132,000,000 lbs. but grew to 390,000,000 lbs. in 1918. The exports of rubber boots and shoes amounted to $1,113,495 for 1914 and to $5,774,341 in 1918; the automobile tire exports were valued at $4,068,639 in 1914 and at $15,128,294 in 1918.

In this connection reference may be made to the greatly increased demand for organic solvents and the work done to meet this demand. The most important work of this kind is probably the production of acetone and similar solvents from the Pacific Coast kelp by the Hercules Powder Company, and this fortunately we will have specially presented at this time in a paper dealing fully with the subject.

Another promising line is the manufacture of amyl acetate from petroleum pentane recently described in THIS JOURNAL.[1] This work has been carried out at the Mellon Institute in Pittsburgh, Pa. The use of these organic solvents is manifold, but we may note the extensive use of pyroxylin solvents and the greatly increased use of lacquers of this description in the last four years. From aeroplane wing dope to artificial leather we have a variety of utilizations and some of these have grown to extensive industries within the past few years.

Closely allied to this industry is the artificial silk industry, one variety of which is made from a nitrated cotton or pyroxylin. Besides this variety we have the viscose variety, the cellulose acetate, and the cuprammonium artificial silk. The development of these products has been very great in this country in recent years, both for films and for artificial silk as a fiber increasingly used in the textile trade.

Industrial alcohol production has developed greatly in the past few years and numerous new plants have been established for its production from a variety of sources. Much attention has been given to a revival of the Classen process for hydrolyzing the cellulose of sawdust and fermenting the sugar produced therefrom. I have no reliable information, however, as to whether the difficulties which developed when it was first tried in this country some years ago have been sufficiently overcome to make it a dependable manufacturing process although it has attracted much newspaper attention. More reliable are the processes based upon the use of low-grade molasses and cereals of various

[1] THIS JOURNAL, 10 (1918), 511.

kinds and a large production, at present taken over by the munition manufacturers, has been the result.

In addition to this direct war use much alcohol is made for denaturing and use in the manufacture of pharmaceutical products. Some 27 denaturing formulas have been allowed by the United States Internal Revenue Office and these adapt it for use in a wide variety of cases where tax-paid pure alcohol is inadmissible on account of its cost. This form of utilization is not of temporary character as is the use in munitions manufacture, but is destined to grow and require an increasing amount of alcohol properly denatured.

We come now to the industry which may be said to be the touchstone of our ability to achieve results under difficult conditions when confronted with an imperative necessity, *viz.*, the building up on American soil from American raw materials with American capital and American chemical effort an independent dyestuff industry. In speaking of the conditions in the United States in 1914, I said that we had a small dyestuff industry, working under trade difficulties, for the most part with imported intermediates. There were, to be exact, five manufacturers, large and small, of dyestuffs in 1914. The tariff census of coal-tar products, as reported for 1917, shows that there were at that time in the United States 81 establishments engaged in the manufacture of coal-tar dyes and 117 firms manufacturing intermediates. While these figures are striking and cannot fail to arrest attention, it is only when we look more fully into the details that we get an adequate understanding of the great industrial achievement that has been wrought in the last four years.

First, as to our dependence upon foreign sources, chiefly German, for our dyestuffs at the beginning of the war in 1914: we were then making in this country a bare one-fifth of our needs out of foreign materials and had neither crudes nor intermediates to speak of. Dye imports from Germany in 1914 were valued at $5,965,537; in 1916 they were valued at $849; in 1917 at $464,499; and in 1918 at $3,048. The relatively large amount for 1917 represents shipments held at first in Great Britain but released later on appeal. Do we still import any dyestuffs? Yes. There are two reasons for importing, from Switzerland and Great Britain mainly, certain dye colors.

The new American dye industry did not at once attempt to duplicate the 900 or more supposedly distinct synthetic dyes of the German dealers, but took up the most important classes and produced a moderate number of representative dyes covering as far as possible the coloring or tinctorial needs of the textile trade, and some of the finer shades are still missing, hence the Swiss importations.

The other reason and perhaps the more important one was that Congress, in the enactment of our present tariff law, cut off the *ad valorem* duty on indigo and alizarine products, which caused manufacturers to leave the production of these very important products until they had covered the need in the other groups more fully.

However, synthetic indigo of American manufacture is already on the market and there will be three sources of supply for it in 1918, one of which promises to supply at least one-half of what the American trade will need for the year. Similarly artificial alizarine of American manufacture, made in Brooklyn, N. Y., will be available in large quantities from this time on.

Meanwhile approximately three-fourths of the dyestuffs needed are being produced and some colors in such quantity that an export trade has been started. Let us note that for the year ending June 1916 the exports of all varieties of dyestuffs, aniline dyes, logwood extract, and all others totalled $5,102,002 in value, but the bulk of these were vegetable colors. In 1917, the valuation of the exports had leaped to $11,709,287, with an increasing amount of such colors as sulfur black and the simpler aniline colors. In 1918, and this shows the quality as well as quantity of development, the total exports of dyestuffs were valued at $16,921,888. Of this, total aniline colors make $7,298,298, logwood extract $2,339,480, and all other $7,284,110. It will be noted that the aniline colors alone exceeded in value the dyestuff importations from Germany in 1914.

But the main market for which these dyes are being made, and for the permanent relief of which a great American industry has been created is the United States market and the way in which this has been done is deserving of a more detailed examination.

With the shutting off of the foreign sources of supply in 1914, not only was the need of an American dye industry made clear, but the manufacture of munitions and the filling of foreign orders for the same called for coal-tar products. The manufacture of phenol, of picric acid, and of trinitrotoluol all demanded an immediate supply of coal-tar crudes. So the gas works, the by-product coke ovens, and the tar distillers all united to increase and intensify production. I need only refer to the lists of such great companies as the Semet-Solvay Company, the United Gas Improvement Company, and the Barrett Manufacturing Company as illustrating the achievements in this production of coal-tar crudes. For the increased production of benzol and toluol the Ordnance Division of the War Department has also started to establish plants for by-product coal distillation because of its special needs. However, for the dyestuff manufacture we go from the coal-tar crudes to the "intermediates." Some of these require very special apparatus for their manufacture and it was these that had not been made in this country prior to 1914. Our chemical apparatus manufacturers (several of whom are very well represented in this exposition) responded to the call for this apparatus and gradually these important products, mostly new to American trade, were supplied. The tariff census of 1917 states that the production of intermediates for that year was contributed to by 117 firms and that the production amounted to 322,650,531 lbs. valued at $106,942,918. These figures, however, involve considerable duplications because of the use of some as the starting point in making others. That the amounts of many are very large is, however, shown by the statement published by the National Aniline and Chemical Company that their Marcus Hook works has a producing capacity of aniline oil five times as great as the total consumption in this country prior to the war, and that this company is now the largest producer of aniline oil in the world.

The coöperation of producers of coal tar and its "crudes" with the manufacturers of "intermediates" and the dyestuff manufacturers was obviously a very desirable thing in the building up of the new industry and establishing it on a firm foundation. Such coöperation has been planned in the organization of our largest American dye manufacturing company. As they announce in their statement, "the various plants of this company are engaged in producing everything necessary for dye manufacturing, commencing with the basic raw materials or 'crudes' derived directly from coal with the acids and other chemicals converting these crudes into dye 'intermediates,' which are also used for explosives and the manufacture finally of the several classes of dyes demanded by the industries."

In this combination we have the Semet-Solvay Company, the Barrett Manufacturing Company, the General Chemical Company, the Benzol Products Company furnishing "crudes" and "intermediates," and the Schoellkopf Aniline and Chemical Works, Buffalo, N. Y., the W. Beckers Aniline and Chemical Works, Brooklyn, N. Y., the Century Color Corporation, Nutley, N. J., and the Standard Aniline Products Company, Wappingers Falls, N. Y., producing "intermediates" and finished "dye colors." All the raw materials are the product of American factories as well as the finished products.

The "intermediates" listed by the National Aniline and Chem.

ical Company amount to 58 distinct substances and the dyes named to nearly 200.

Other of our American color manufacturers have additional distinctive dye colors as well as many which are the equivalents of those in the list referred to—truly a satisfactory showing for what is practically a newly created industry at the end of the fourth year since the start was made.

The Tariff Census of 1917 before referred to makes the following statement:

The annual production was reported for the following groups of products made in whole or in part from material derived from coal tar; 45,977,246 lbs. of dyes valued at $57,796,027; 5,092,558 lbs. of color lakes valued at $2,764,064; 2,236,161 lbs. of medicinal chemicals valued at $5,560,237; 779,416 lbs. of flavors valued at $1,862,456; 263,068 lbs. of photographic chemicals valued at $602,281; and 19,545 lbs. of perfume material valued at $125,960.

Of course the manufacture of munitions begun on allied account and continued later by the Ordnance Department on our own account, means the production of numerous organic compounds on a scale totally beyond any previous experience. Picric acid, trinitrotoluol, nitrocellulose and nitroglycerin for smokeless powder, fulminate powders, and other preparations are manufactured by tons, but as this is a war industry and not one that will continue, we have omitted it from our discussion.

CONCLUSION

What is the outlook for industrial organic chemistry in the immediate future in this country? I would say that it is most encouraging. The exigencies of the war in Europe have caused a widespread search for independent sources of raw materials and with very satisfactory results in many cases. Our large corporations have established research laboratories with the best up-to-date equipment and have planned real and thoroughgoing research in a broad intelligent spirit which does not ask for hasty results but emphasizes the wish for thoroughness. Our Government has recognized in a very satisfactory way its need of chemical service and has thus publicly endorsed the fundamental importance of the chemist in industrial achievement. Capital has come forward willingly in support of properly planned chemical undertakings and thus made the establishment of new industries possible in a way far beyond what had been possible before the war period. Lastly, the disturbed condition of all European trade relations has made it possible for the United States to inaugurate very promising export business in quarters not previously practical or only so under conditions distinctly unfavorable.

These new achievements we have every reason to expect to continue in future and no doubt with added momentum.

SOLVENTS FROM KELP

By C. A. Higgins, of the Hercules Powder Company

The serious shortage of acetate of lime and its derivatives is now causing solvent users considerable anxiety. The past four years have seen a tremendous increase in the demand for acetone, acetic acid, acetic anhydride, etc., for purely war purposes, and this has caused a corresponding diminution in the quantity available for commercial uses. Since the war, acetate of lime has increased to three or four times its normal pre-war price, and its solvent derivatives such as acetone, ethyl methyl ketone, acetone oil, acetic acid, ethyl acetate, etc., have advanced correspondingly.

Considerable interest has accordingly been shown in the huge kelp or seaweed fermentation plant built and now being operated by the Hercules Powder Company on the coast of Southern California, where acetone, ketones, and a long line of acetate derivatives are being obtained from kelp. This factory, so far as I know, is the only one of its kind in existence. The data are therefore rather limited and resolve themselves into a description of the methods and results obtained at this factory by the Hercules Powder Company.

You will realize, therefore, there is no historical background to the manufacture of solvents from kelp. There is, however, record of experiments carried out by Stenhouse in the year 1851, when he produced acetate of lime by allowing kelp to ferment under suitable conditions. While his experiments as recorded in the *Philosophical Magazine and Journal of Science* did not have any immediate practical application, they contained the germ of an idea which found manufacturing expression about the year 1915.

The attention of potash users was rather focused at this time on the huge beds of perennial kelp which stretch along the Pacific coast. About this time, too, the Hercules Powder Company needed acetone, and needed it from an entirely new source. We needed it to make smokeless powder for the British Government. Experimental work was immediately started on the production of acetate salts by the fermentation of kelp. Shortly afterwards ground was broken for a factory capable of producing acetone and ketones from kelp at the rate of about 3 to 4 tons a day with potash and iodine as valuable by-products.

The Hercules process of producing solvents and their intermediates from kelp is really very simple. The kelp is mowed and garnered from the marine beds by special harvesting boats. It is then macerated and pumped to the tank at the factory on shore, where it is diluted and allowed to ferment at about 90° F. with the addition of finely ground limestone to neutralize the acids formed in the fermentation. After a period of about 15 days, the leafy structure of the kelp has been entirely destroyed and a liquor is obtained containing chiefly acetate of lime, muriate of potash, and iodides in solution. The crude salts recovered therefrom by evaporation are heated in retorts to obtain acetone and the muriate of potash is recovered by leaching and crystallization.

That is the process in its essentials and stripped of all its details. A glance at the products chart (page 833) will show, however, that a great many new and additional products have been isolated. In addition to the acetone, ketones, potash, and iodine already referred to, the higher acids of the acetic series are also being produced, together with their ethyl alcohol esters.

The fermentation of kelp by the Hercules method is productive, therefore, of not only acetate salts, but also of propionates, butyrates, valerates, and even of the higher acids of this series. It is this series of salts which by conversion into their ethyl esters is providing the trade with an entirely new source of ethyl acetate and an entirely new series of amyl acetate substitutes in the ethyl propionate and ethyl butyrate, which latter have never before been made in commercial quantities for the solvent trade.

The principal solvent product of a kelp fermentation plant along the lines developed by the Hercules process must necessarily be acetone and the higher ketones. This is explained by the fact that the bulk of the salts obtained in the evaporation of the fermented kelp liquor already mentioned consists of a mixture of acetate of lime and muriate of potash. By far the simplest and most economical way of separating this mixture or realizing the values of both salts is to heat the mixed salt in retorts. Acetone is thereby obtained, and muriate of potash and calcium carbonate is left behind as residue. The potash is leached from the insoluble calcium carbonate and recovered by crystallization.

In the process of concentrating the fermented liquor, however, a scum collects on the surface of the liquid. This scum consists of a mixture of calcium acetate, propionate, butyrate, valerate, etc., all of which are less soluble in hot than in cold solution. This scum holds very little of the potash and can accordingly be used in the manufacture of solvents such as esters, where the recovery of any residual potash salt would be difficult

Use is therefore made of this scum or "taffy," as it is called by the workmen on account of its plastic nature when hot, in the manufacture of solvent esters which are in such demand in the soluble cotton and lacquer industries. The taffy is mixed with ethyl alcohol and sulfuric acid and the resultant esters separated by fractionation.

A word now as to the nature and uses of these solvent esters. Ethyl acetate is an old friend among us. Its use as a solvent of soluble cotton or nitrocellulose in the manufacture of imitation leather, in finishing celluloid, and in a thousand and one other directions are too widely known to need mention. Ethyl propionate and butyrate are not so widely known. Several investigators have mentioned their excellence as solvents for nitrocellulose gums, resins, etc. Worden, in his "Nitrocellulose Industry" mentions this fact and states that the only bar to their use is the high price, or that they are not commercially obtainable. Ethyl propionate boils at 100° C. and appears to resemble in its properties a mixture of ethyl acetate with about 10 to 20 per cent amyl acetate. Ethyl butyrate boils around 120° C. and resembles amyl acetate very closely in its physical properties. These two esters now produced for the first time in large quantities will doubtless find wide application in the soluble cotton celluloid, artificial leather, paint and varnish trades, where neutral solvents of pleasant odor and possessing a moderately slow rate of evaporation are desired. The use of these esters is also contributing materially at the present time to the War Industries Board's program for the conservation of acetate of lime.

Special mention might be made of the valerates, caproates, etc., which are now being isolated in this process. Valerian and its salts and esters are well known to the drug and pharmaceutical trade, to whom a new source at this time will be welcome, while the esters of these acids will doubtless be much sought after by the essence and perfume trade.

The kelp industry is in its infancy, and although somewhat of a war baby, it has in it the makings of a vigorous adult. Heralded as the savior of potash users, it has come to the aid of users of high-grade solvents and pharmaceuticals, and bids fair in the future to continue to develop new and valuable organic chemicals.

WOOD WASTE AS A SOURCE OF ETHYL ALCOHOL

By G. H. Tomlinson

Manager, Kinzinger Bruce and Co., Ltd., Niagara Falls, Ontario

For some years we have been hearing more and more regarding waste wood as a source of ethyl alcohol. The amount which is thus being made, however, is still but a fraction of the nation's supply and within the past few years has not been extended, irrespective of the great and increasing demand which the war has developed.

It may be advanced that sufficient capital is available and competent technical skill can be secured and if the proposition is therefore all that has been claimed, the question naturally occurs, why has more rapid progress not been made? Is the proposition fundamentally unsound or does it still offer the very considerable possibilities which have been predicted?

We all realize the distance to be traveled between the discovery of a chemical reaction and its successful commercial development and application. In this case, as a matter of fact, 100 years have already elapsed. The pitfalls to be crossed, both technical and commercial, are legion, and the more unusual, attractive, or revolutionary the proposition may be, the more difficult may its pathway become. Premature development and extravagant or unsound exploitation can prostitute an undertaking, no matter how promising it may be, and when this occurs in connection with a process, which has not been already established, disaster is invited.

I think I may safely say that such a condition of prostitution represents the present status of this particular industry, and explains to a large extent its present position of apparent stagnation, even at this time when its further development should offer such unusual opportunities.

In this connection the several company flotations which have occurred have been initiated by promoters having no particular interest in the business itself. This has resulted in only a small portion of the relatively large amount of capital which has been raised in connection with the undertaking filtering through for its actual development. Adequate research has not been undertaken, the plants, which already have been constructed, have been started prematurely in locations having little regard to the commercial conditions involved, all in order that a rapid showing might be realized, and a quick turn made by the promoters. Any complete consideration of this aspect of the proposition can only lead to the conclusion that the miracle is that anything has survived. The fact, however, that several million gallons of alcohol have actually been produced from this source, and that at least two plants have been operating more or less continuously over a period of years, irrespective of the technical and commercial handicaps from which they still suffer, justifies the belief that ultimate success is established, and that the undertaking offers much promise for the future.

It was originally assumed that almost every sawmill represented a possible location for the establishment of such a plant. Since there were almost innumerable sawmills at which the disposition of wood waste was a problem, even constituting in most an element of expense, it was also assumed that this material could be purchased at a purely nominal figure. It therefore seemed logical that favorable contracts for wood waste could be made and having sufficient capital, the company controlling the process could establish an endless chain of plants producing ethyl alcohol, and thus soon secure entire control of the alcohol market.

On this basis and plan the business was projected. It was soon found, however, that while there was no question regarding the number of sawmills or the extent of the waste wood which is produced, there are nevertheless, very few at which conditions are entirely favorable for the establishment of the extensive plant which the manufacture of ethyl alcohol requires. The life of the lumbering operations may be uncertain, the water supply deficient, labor or transportation conditions unfavorable, or any one of a number of such factors may be found which jeopardize success.

The fact that sawdust and all the other forms of waste wood are so bulky and difficult to handle precludes transportation, and therefore confines its processing to the point at which its production occurs. When approached, the lumberman who has a suitable location soon recognizes the advantage which he enjoys, and any outside company wishing to do business must pay his price; and if once established, has no other source of supply. It can at once be seen that any large or general development along these lines was impractical and bound to fail.

In the manufacture of our lumber we know that many millions of tons of waste wood are annually produced, and the potential asset which this waste represents is being recognized. If any considerable part of this, however, can be converted into alcohol, there is probably no more important industrial use which it can be made to serve. That this can be done in a limited way has now been completely proved, but in order to greatly extend its application, the development, it would seem, must follow different commercial lines from those along which the start was made.

The process which has been developed naturally divides itself into two very distinct and separate steps: We first convert a

certain portion of the wood, amounting to a maximum of about 28 per cent, into soluble carbohydrates which are then separated in the form of a clear solution which normally contains from 10 to 12 per cent. As a second step, we have the fermentation and distillation of this product for the production of ethyl alcohol. It is not essential that both of these operations be conducted at one point, since the sugar solution can be evaporated, and then becomes quite the equivalent of cane molasses, which at present constitutes the principal source of our alcohol supply. Molasses, as we know, is transported to, and assembled at the most favorable locations for alcohol production, there to be manufactured on the largest scale. Applying this same principle, we immediately find that the scope of the wood process is greatly extended. Not only can wood waste be utilized at those comparatively few locations at which suitable conditions for the manufacture and distribution of alcohol are found, but almost every sawmill with an assured capacity for a reasonable period can be considered as a possibility. At the most desirable locations, complete installations for manufacturing alcohol can, of course, be made; at the others, molasses plants can be installed and their product transported to existing distilleries, or to new ones at which the product of several such units can be assembled and used.

The investment required for such a molasses plant is small compared with that which the complete distillery involves, and the importance of this in extending the scope of the undertaking can at once be seen. Furthermore, smaller units can be operated economically, less skilled labor is required, and it does not come under the exacting regulations and control of the Internal Revenue Department, as is the case if alcohol is produced. Furthermore, if the molasses product is sold to those already engaged in the distilling business, many market and other trade difficulties are removed which only those having experience in the alcohol business fully appreciate and which the smaller producer might be unable to overcome.

It would seem, however, that proper headway cannot be made in the carrying out of such a plan unless the lumbermen themselves assume the initiative, or at least give it their most sympathetic coöperation and support

Such a plant, to operate to the greatest economy, should preferably constitute a part of the lumber operation itself, being operated under the same management and on the same premises, thus avoiding all unnecessary handling and storing, as well as duplication of equipment or staff. In addition to this, the lumberman, controlling as he does the raw material, can alone determine and regulate its most economical disposition and use, and unless he is financially interested in the subsidiary company, its supply of raw material can never be fully assured.

The lumbermen, however, are naturally cautious about engaging in enterprises apart from their regular trade. In the past numerous by-product ventures which have been taken up in connection with the lumber industry have failed and very few have succeeded. That this has been due either to their being entirely impractical or to incompetent technical advice is probably true, but nevertheless these failures have seriously retarded others from embarking in the like.

In this case, however, the uncertain and costly experimental expense has already been borne by those who have been blazing the trail, and the success of the enterprise, from its technical aspects at least, is demonstrated. It now remains for some one to make a fresh start and thus step in and take advantage of the mistakes of the past. If this is done along sound business lines by one of our progressive lumber concerns, complete commercial success appears inevitable. Should it be found that progress along these lines is blocked, as the result of patents, those controlling such patents would be well advised to accept an equitable royalty in order that a proper start should be made. Once this step is taken, others will follow, and real headway will then be made.

From the lumberman's point of view, the production of molasses should offer a very strong appeal. While there are at least several profitable uses to which his waste can be applied, aside from its use as fuel, the others, as far as I know, demand sorting or selection. In the case of producing molasses or alcohol, any part, or all, of his waste can be used, even including that which constitutes his fuel supply, since the residue left after extracting the sugars, representing 70 per cent of the original amount, is not depreciated in fuel value. In other words, that portion which is actual waste and is being destroyed can be combined with the amount being burned for fuel, and 70 per cent of this total still be available for power development. In considering and comparing the values extracted, it is therefore necessary to consider also the much larger tonnage which this process utilizes. The cost of production compared with the cost of cane molasses is, however, the vital element upon which this development must ultimately depend.

In June 1913, the costs given below were obtained in the alcohol plant then operated by the Standard Alcohol Company at Fullerton, La. The actual cost of this plant at that time amounted to $456,920.56. Of this sum, about $200,000.00 represented the expenditure for the plant and equipment involved in the conversion of the wood into sugar and the separation of this in the form of a solution. The balance was required to provide the necessary plant and facilities for fermenting and distilling the latter and converting it into alcohol.

Operations were conducted 22 days, at three-fourths capacity. During this time 6,125 tons of green waste wood, containing 48 per cent moisture, were processed, giving a yield of 1,688,600 gal. of sugar solution averaging in strength 10.3 per cent.

The cost of processing this, exclusive of the cost of the wood, but including all other material, labor, power, factory and overhead expense, together with proper allowances for depreciation, amounted to a total of $5,371.56 or 31.8 cents per hundred gallons of the strength stated. To convert this into molasses the cost of the equipment for this purpose would have to be added to the cost of the plant and the cost of its operation to that of the product. Since the residue from the process, however, supplies the necessary fuel, this concentration can be affected at very little cost.

Assuming a concentration of 8 to 1, the resulting 12½ gal. of molasses which 100 gal. of the dilute solution will yield, may be figured at 2.5 cents per gal. or say 3 cents, including the evaporation. This is, of course, a lower figure than that at which cane molasses has been sold in recent years and very much lower than any price which may be expected to prevail in the future. What this price may be is problematical, but 12 cents is probably none too high.

When we compare the fermentable contents of the product of this run with that of cane molasses, the showing is not so favorable. During the month the average production of spirit amounted to only 4.87 proof gal. per 100 gal. of dilute solution. Using this same percentage, a gallon of wood molasses would yield only 0.39 gal. of proof spirit, whereas cane molasses yields practically gallon for gallon. This gives a cost of 7.7 cents for wood molasses to yield the spirit given by a gallon of cane molasses. While even on this basis it appears that a profit is fully assured, the result which this comparison gives is far from representing the best which can be obtained since the quality of this product was poor. From the figures given it can be calculated that only about 8.5 per cent of the dry wood was converted into sugars which were fermented, although approximately 24 per cent of the wood was extracted in the solution obtained. It has been repeatedly demonstrated, however, on both large and small scale experimental operations, that 26 to 28 per cent of the wood can be converted into water-soluble

carbohydrates as a result of simple acid hydrolysis and that under the best conditions over 80 per cent of this is obtainable in the form of fermentable sugar. In place of realizing this result, not over 50 per cent of the water-soluble carbohydrates obtained has actually been fermentable in the product of the plant which I have mentioned, and the average has been less.

It remains to translate such experimental results, depending as they do upon the conduct and control of the chemical reactions involved, into commercial practice. To do this requires little change in the mechanical methods of handling which were used at Fullerton and largely developed by myself. The mechanical efficiency of these is indicated by the very low per gallon cost which I have given and which there is no reason to believe should be increased in effecting the much more complete hydrolysis which it is easily possible to obtain. That this has not already been done, I attribute principally to patent conflict which has directed this development along unnatural lines in the effort to avoid infringement and permit exploitation. In undertaking any new installations, however, if full advantage is taken of existing knowledge and the experiences of the past, the production of a wood molasses equal to cane molasses in fermentable value is assured, and at a cost per gallon which certainly should not exceed that of the low-grade Fullerton product which we have considered.

The lumberman already can see a limit to his timber supply, and is rapidly being forced, for this reason, to recognize the necessity of conserving all that is left. Nevertheless, he is still burning 50 per cent of his logs either under his boilers, or in his refuse destroyer. Every ton of this waste can be made to yield over 30 gal. of molasses without disturbing in any way existing methods of operation, unless it be that of the expensive destroyer which every large sawmill still maintains. Allowing but 3 cents per gal. profit on the molasses which can thus be made, this would be equivalent to an additional profit of almost $2.00 per thousand feet of lumber, an amount probably quite equal to the average profit normally realized on the lumber itself. In this, it would appear that we may have an almost unlimited source of molasses within our reach which the distiller can readily convert into the highest grade of ethyl alcohol without any, or little, modification in the equipment which he already has at hand.

With drastic prohibition as a probability of the future, as well as the necessity of conserving everything which can be used, either directly or indirectly, for food, this should offer a means by which the distilling business can readjust itself to meet these conditions, and at the same time provide alcohol in such quantities and on such a basis that its much wider industrial application becomes a possibility, with all the consequent commercial advantages to which this would lead.

With proper coöperation to this end between the lumber and distilling interests, it should be possible to rapidly realize this condition to their mutual advantage, and at the same time release for other use the immense quantities of food products now used for alcohol production.

When the facts which I have attempted so inadequately to present are more fully recognized and the proposition is taken in hand by those having a vital interest in its development and success, it may be expected to become a business of the greatest magnitude and importance, and wood waste should become the principal source of ethyl alcohol.

CURRENT INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

IRON AND STEEL INDUSTRY IN JAPAN

The British Commissioner at Seoul writes that, in order to encourage the iron industry in Corea, exemption from import duty on coal, machinery and implements imported for the use of iron foundries, has been announced by the Governor General. The total quantity of iron ore now obtained in Corea is put at some 200,000 tons a year and a large output of pig iron and steel is expected from the new foundries in the Chinnampo district which are now on the point of completion. The annual output of pig iron from the new Mitsubishi Foundry there, which has just started operations, is estimated at 100,000 tons, of which 50,000 tons will be made into steel.

GOODS IN DEMAND IN AUSTRALIA

It seems scarcely necessary to enumerate the very large variety of goods which have been getting in short supply in the Commonwealth, says the *Times Trade Supplement*, as a result of the interference with normal trade. Australian importers would now welcome the largest possible consignments of building materials, ironmongery, tools, locks, aluminum ware, hollow ware, and hardware lines generally. It may, therefore be imagined what the demand will amount to when building operations are resumed after the war. Again, in connection with the expansion of industry generally, which has been mentioned above, eager inquiries have been in the market for some time past for all lines of industrial chemicals used by brewers, tanners, soap manufacturers, textile mills, photographers, etc., including such articles as litharge, tartaric acid, citric acid, soda, dyes, waxes. As regards soft materials, an absolute shortage of silk goods was reported recently from Sydney, while buyers in that city and in Melbourne have been clamoring for means of replenishing their stocks of cotton piece goods, woolen goods, linings, handkerchiefs, shirtings, hosiery, and many other such articles. Jewelry, cutlery, glassware and fancy goods are also in demand.

JUTE PRODUCTION IN CHINA

According to returns of the Chinese Maritime Customs, the export of jute from China amounted to 94,481 piculs (picul = $133^1/_3$ lbs.) in 1916. Of this amount 67,000 piculs were shipped from Tientsin, North China, 15,000 from Hankow, Central China, and 13,000 from South China. A small amount was also exported from Manchuria. It is probable, however, that a considerable proportion, if not all, of this jute is in reality "Abutilon" hemp, the two plants being constantly confused by the Chinese. The Ministry of Agriculture can give no information which locates the area of production of jute with any accuracy. According to catalog of the Vienna Exhibition, jute fiber is produced in China and is exported from Shanghai. It is also mentioned as being cultivated near Canton, in the Province of Szechuan and in the Yangtse Valley.

CRANES AND TRANSPORTERS

In a catalog issued by Sir William Arrol & Co., Ltd., Glasgow, illustrations and short descriptions are given of shipbuilding cranes and shipbuilding berth equipment manufactured by them. The first part deals with various types of derrick and tower cranes, and the pictures represent installations of such machines in various important shipyards at home and abroad, while the second gives brief descriptions of various arrangements of cranes for building and fitting out ships in covered and uncovered berths in which the Olympic and her sister ships were constructed. Another list from the same firm shows installations of different types of Temperley transporters—some mono-rail, others fixed, others moving on rails, and others designed to be fitted in ships—which have been erected in various parts of the world for handling coal and other materials.

NATURAL INDIGO INDUSTRY

With the cutting off of the synthetic indigo supplies from Germany since the outbreak of war, the natural indigo industry has come into its own and the cultivation of the crop has considerably increased. While the total area under this crop in 1914–15 was only 148,400 acres, in 1915–16 it rose to 353,100 acres, and in 1916–17 to 756,400 acres. The greatest increase, both absolute and relative, occurs in the Madras Presidency and in the United Provinces, where the industry is mainly in the hands of small holders and the dye manufactured is of inferior quality. In Bihar, where a superior dye is manufactured, mainly in large factories, the increase of area in 1916–17 was about 33 per cent as compared with 1915–16. The yield of indigo increased from 55,000 cwt. in 1915–16 to 95,000 cwt. in 1916–17, Madras contributing two-thirds of the total production. Both the average and the output in 1916–17 were, however, only half of what they were in 1895, when the synthetic product came into the market. The forecast for 1917–18 puts the average at 690,000 acres and the output at 87,000 cwt. The future of the indigo industry, says the *Board of Trade Journal*, depends (1) on a good and sufficient supply of seed, (2) on an increase in the output of green leaf, (3) on improvement of manufacture, (4) on organization in marketing, (5) on elimination of the practice of adulteration.

REFRACTORY MATERIAL FROM BAUXITE

At the Sheffield meeting of the Refractory Material Section of the Ceramic Society, a paper was read by Dr. A. Bigot on "Corindite" which is described as a new refractory and abrasive material. Corindite is obtained by heating a mixture of bauxite and anthracite in a cupola, the heat developed by the reaction being such that the mass fuses in successive layers. The point of fusion of corindite from French white bauxite taken from the War Department is 1950° C., a point higher than the melting point of the bauxite. The crushed corindite, according to the *Chem. Trade Journal*, **62** (1918), 431, is mixed with refractory binders, finely pulverized, such as bauxite, kaolinic clay, etc. Binding of the material with such bases as lime, magnesia, and calcined dolomite must be avoided as these lower the fusing point of the mixture. The corindite can be suitably moistened and mechanically mixed and is then employed as an ordinary refractory mixture for making firebricks. The dried bricks are baked between 1350° C. and 1400° C. and undergo no shrinkage. Between 1700 and 1730° C. they lengthen by about 0.5 per cent. Above 1750° C. they begin to undergo a shrinkage attaining 3 per cent at 1850° C. The porosity depends on the mechanical composition of the mixture and on the compression it varies from 9 to 12 per cent. The product is said to be three and a half times more resistant to wear than good magnesia bricks. Refractory products based on fused bauxite are attacked by slag and scoria in the same way as refractory matter made from iron-fused bauxite. The action of slag and scoria is being investigated but results are not yet completed. Tests have been carried out with white bauxite from Ireland and these seem to give as good results as the French bauxite in many respects, but refractory power is a little less, due to a smaller proportion of alumina in the Irish bauxite.

SUBSTITUTE FOR SHELLAC

According to the *Z. angew. Chem.* it has been found that naphthol resin can be used as a substitute for shellac and that the products of condensation of α- and β-naphthol have a number of characteristics in common with shellac, such as capacity for taking a polish and suitability for use as an alcohol varnish, and as an insulating material. The substitutes are particularly useful if the residues are cleaned by filtering from an alcoholic solution, the alcohol being distilled from the filtrate.

ELECTRICITY IN SILK INDUSTRY

The application of electrical methods in the weaving industry and especially in connection with silk are discussed by M. Ch. Vallet in *L'industrie Electrique*. The chief advantage is said to be the avoidance of breakage of the fine threads, which appears to be inseparable from the use of steam and gas engines. The essential factor is regularity of speed and the better results secured in this respect through the electric drive have led to an increase of 5 to 20 per cent. The question of the best arrangement of drive receives some consideration. Generally speaking, the author inclines to the view that control by groups is preferable in a workshop where a large number of machines are working on identical processes.

VEGETABLE OILS IN JAPAN

According to a report from the British representative at Shimonoseki, a new company for the exploitation of vegetable oils, established in July 1917, with a capital of $500,000, has completed the first section of its works at Warkamatsu, and manufacturing operations will be started shortly. In Japan, the oil industry is still in its infancy. The better qualities of glycerin, soap and paint are still imported, while imports of Manchurian bean oil are valued at over $500,000 annually. It is evident, therefore, that there is an important future for the industry. The consumption of raw material will, it is stated, be 100 tons per day, or approximately 30,000 tons per year, and will consist principally of soy beans. The output of bean cake and bean oil is expected to be 24,000 tons and 4,200 tons, respectively. On the completion of the second section of the works, the consumption of soy beans will be 150 tons daily, or 45,000 tons annually, and the output of bean cake 37,000 tons and bean oil 6300 tons. The land for a third section is being prepared and on this site will be erected works for cake crushing, for the manufacture of stearic oil, glycerin, soap, candles, etc. The output of the works will be all taken by the Mitsui Bussan Kaisha under a contract. The refined oil will be exported and the bean cake sold to Japanese farmers.

ALUMINUM

Writing upon the supply of aluminum in Switzerland, *Metall und Erz*, of March last, stated that the war had given a powerful impetus to the aluminum industry in all countries. As a substitute for other metals and for new uses, that metal is in great and increasing demand. Hence its production was becoming one of the great industries of the world. The annual report of the Swiss Co., at Neuhausen, shows that the output has increased greatly during the past year and that means of production are being taken to meet the growing demands. Five million francs have been set aside out of the gross profits for the year to provide additional water power with a view to an extension of the works.

A NEW HEAT INSULATOR

A new heat-insulating material is being produced in Sweden, says *Electrician*, **81** (1918), 200, which is said to be promising. The chief constituent in this new material is a kind of fine clay found on the island of Mars. This "Molera," as it is termed, is very porous and each grain appears to be hollow. This fact is no doubt largely responsible for the good heat-insulating properties. After it has been burnt the molera becomes extremely light and therefore a poor conductor of heat. Before it is burned, however, it is mixed with cork, bricks of the mixture being burned while the cork is consumed. The new insulator is said to be primarily suitable for covering steam pipes and boilers, but may also have uses for the production of sound-proof chambers and as a medium to check the transmission of vibration.

SCIENTIFIC SOCIETIES

FIFTY-SIXTH MEETING AMERICAN CHEMICAL SOCIETY CLEVELAND, SEPTEMBER 9–13, 1918

PROGRAM OF PAPERS

GENERAL SESSION[1]

Address of Welcome. A. W. SMITH.
Response. H. S. MINER.
The American Chemist's Place in Warfare. CHARLES L. PARSONS, Chairman Committee on War Service for Chemists.
The Work of the Chemical Section of the War Industries Board. CHAS. H. MACDOWELL, Director of Chemicals Division, War Industries Board.
War Disturbances and Peace Readjustments in the Chemical Industries. GRINNELL JONES, Chemist, Tariff Commission.
Chemical Warfare Research. WILDER D. BANCROFT, Chemical Warfare Service.
The Place of the University in Chemical War Work. EDWARD W. WASHBURN, National Research Council.
President's Address—A Retrospect and an Application. WILLIAM H. NICHOLS.

AGRICULTURAL AND FOOD CHEMISTRY DIVISION

T. J. BRYAN, *Chairman* F. F. FLANDERS, *Secretary*

1. **Some Chemical and Economic Aspects of the American Food Supply.** H. C. SHERMAN.
2. **The Rôle of Oxidases and of Iron in the Color Changes of Sugar Cane Juice.** F. W. ZERBAN. (See p. 814, this issue.)
3. **A Centrifugal Method for the Separation of Cottage Cheese Curd from Buttermilk.** A. E. PERKINS.
4. **Influence of Conditions upon the Polarizing Constants of Sugar Cane Products.** C. A. BROWNE.
5. **The Effect of Manganese on the Growth of Wheat; Basic Slag a Source of Manganese.** (Lantern.) J. S. MCHARGUE.
6. **A Comparison of Barium Sulfate Results on Feeds and Feces by the Benedict Wet Solution Method (Wolf and Ostenberg) with the Modified Sodium Peroxide Method, Silica Being Removed.** J. O. HALVERSON.
7. **The Thermo-Stability of the Water-Soluble Vitamines.** A. D. EMMETT AND G. OESCHGER.

BIOLOGICAL CHEMISTRY DIVISION

W. J. V. OSTERHOUT, *Chairman* I. K. PHELPS, *Secretary*

I—Special Program on Plant Chemistry

1. **A Contribution to the Classification of Peat Based on Botanical Composition, Physical and Chemical Characteristics. Quality and Value of Important Types of Peat Material.** A. P. DACHNOWSKI.
2. **The Effect of Temperature and Aeration on Carbohydrate Changes in Sweet Corn.** C. O. APPLEMAN.
3. **The Comparative Respiratory Activity of Stored Cereals.** (Lantern.) C. H. BAILEY AND G. M. GURJAR.
4. **Imbibition by Seeds.** R. A. GORTNER.
5. **The Pectin Relations of *Sclerotinia cinerea*.** J. J. WILLAMAN.
6. **The Nutrition of *Sclerotinia cinerea*: Evidence of the Existence of a Growth-Promoting Substance.** J. J. WILLAMAN.
7. **Effect of Low Concentration by Sulfur Dioxide on the Protein Content of Plants.** P. J. O'GARA.
8. **Physiological Balance in the Soil Solution.** R. P. HIBBARD.

II—Papers

1. **The Effect of Thymol-Chloroform Solution as a Preservative on the Chlorine Content of Urine.** J. O. HALVERSON AND J. A. SCHULZ.
2. **Influence of Hydrogen-Ion Concentration upon the Enzyme Activity of Three Typical Amylases.** H. C. SHERMAN, A. W. THOMAS AND M. E. BALDWIN.
3. **The Composition and the Nutritive Value of the Corn Plant at Different Stages of Growth.** (Lantern.) H. S. GRINDLEY AND H. C. ECKSTEIN.
4. **Vitamine Studies. I. Some Observations on the Catalase Activity of Tissues in Avian Polyneuritis.** (Lantern.) R. ADAMS DUTCHER.
5. **On the Forms of Nitrogen in "Protein-Free Milk."** CORNELIA KENNEDY.
6. **The Determination of Tyrosin in Proteins.** C. O. JOHNS AND D. B. JONES.
7. **The Elimination of Tartrates.** G. E. SIMPSON.
8. **Salmon Oils.** M. R. DAUGHTERS AND F. W. NESTELL.
9. **Absorption Index of Protoplasm for Fluorite Rays.** W. T BOVIE.
10. **The Localization of the Physiological Effects of Radiation Within the Cell.** W. T. BOVIE.
11. **Sensitization of Protoplasm to Heat by Actinic Radiation.** W. T. BOVIE.
12. **The Mechanics of the Physiological Action of Rays.** W. T. BOVIE.
13. **The Rate of Recovery from the Action of Fluorite Radiation.** W. T. BOVIE.
14. **Action of Enzymes upon Starches of Different Origin.** H. C. SHERMAN, FLORENCE WALKER AND MARY C. CALDWELL.
15. **Efficiency of the Proteins of Cereal Grains in Adult Human Nutrition.** H. C. SHERMAN, E. OSTERBERG, J. C. WINTERS AND V. PHILIPS.
16. **Reduction of the Quantity of Human Nitrogen Formed in the Hydrolysis of the Nitrogenous Constituents of Feeding-Stuffs.** (Lantern.) H. C. ECKSTEIN AND H. S. GRINDLEY.
17. **Composition of "Glidine" by Nitrogen Distribution into Seven Groups.** (Lantern.) H. C. ECKSTEIN AND H. S. GRINDLEY.
18. **The Nitrogen Metabolism of Two-Year Old Steers.** (Lantern.) SLEETER BULL AND H. S. GRINDLEY.
19. **Vitamine Studies. II. Does Water-Soluble Vitamine Function as a Catalase Activator?** R. A DUTCHER AND F. A. COLLATZ.
20. **Vitamine Studies. III. Observations on the Curative Properties of Honey, Nectar, and Corn Pollen in Avian Polyneuritis.** R. A. DUTCHER.
21. **The "Gold Numbers" of "Protalbinic" and "Lysalbinic" Acids.** R. A. GORTNER.
22. **On the Origin of the Humin Formed by the Acid Hydrolysis of Proteins. IV. Humins from Substituted Indoles.** R. A. GORTNER.
23. **The Nutritive Value of Cocoanut Globulin and Cocoanut Press Cake.** C. O. JOHNS AND A. J. FINKS.
24. **The Nutritive Value of the Proteins of the Chinese Velvet Bean.** C. O. JOHNS AND A. J. FINKS.
25. **The Hydrolysis of Arachin.** C. O. JOHNS AND D. B. JONES.
26. **A Preliminary Report upon Some Halophilic Bacteria.** E. LEFEVRE AND L. A. ROUND.
27. **The Zinc Content of Some Food Products.** V. BIRCKNER.
28. **Investigation of the Kjeldahl Method for Determining Nitrogen. VII. The Determination of Nitrogen in Aromatic Nitro Compounds.** (Read by title.) I. K. PHELPS AND H. W. DAUDT.
29. **The Estimation of Tartaric Acid after Separation from Citric and Succinic Acids.** I. K. PHELPS AND H. E. PALMER.
30. **The Utilization of Waste Fruits in Vinegar Making.** L. A. ROUND AND E. LEFEVRE.
31. **The Protein Extract of Ragweed Pollen.** F. W. HEYL.
32. **Standardization of Amylolytic Digestion.** (Preliminary Paper.) J. C. BLAKE.

INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS DIVISION

H. S. MINER, *Chairman* S. H. SALISBURY, *Secretary*

I—Symposium on the Chemistry of Dyestuffs.

1. **America's Progress in Dyestuff Manufacture.** LOUIS JOSEPH MATOS.
2. **The Production of American Dyes and Coal-Tar Chemicals During 1917.** GRINNELL JONES.
3. **The Development of the Dyestuff Industry Since 1914.** J. F. SCHOELLKOPF, JR.
4. **The Development and Importance of Anthraquinone Dyes.** (Not presented.) M. L. CROSSLEY.
5. **The Quantitative Estimation of Important Constituents of Crude Anthracene.** (Not presented.) HARRY F. LEWIS.
6. **The Application of Dyestuffs in Cotton Dyeing.** J. MERRITT MATTHEWS.
7. **Natural Dyestuffs—An Important Factor in the Dyestuff Situation.** EDWARD S. CHAPIN.
8. **What is Necessary to Make the American Dyestuff Industry a Permanent One?** (Not presented.) HERMAN SEYDEL.
9. **Manufacture, Use, and Newer Development of the Dyewood Extracts.** CHARLES R. DELANEY.
10. **Photographic Sensitizing Dyes—Their Synthetic and Absorption Spectra.** L. E. WISE AND E. Q. ADAMS.
11. **The Color Laboratory of the Bureau of Chemistry—A Brief Statement of the Objects of Its Works and the Accomplishments to Date.** H. D. GIBBS.
12. **Problems in Testing Dyes and Intermediates.** E. W. PIERCE.
13. **Quantitative Analysis of Dyestuffs.** A. H. HOLLAND.

II—Potash Symposium

1. **Experimental Kelp Potash Plant of U. S. Department of Agriculture.** J. W. TURRENTINE.
2. **American Potash.** J. W. TURRENTINE.
3. **On the Preparation of an Active Decolorizing Carbon from Kelp.** F. W. ZERBAN AND E. C. FREELAND (See p. 812, this issue).
4. **The Extraction of Potash from Cement Mill and Blast Furnace Dust.** WM. H. ROSS.
5. **The Potash Situation.** A. W. STOCKETT.

[1] Papers presented at this session appear in full in this issue.

III —Papers

1. Valuations of Raw Sugars. W. D. Horne (See p. 809, this issue.)
2. The Citric Acid Industry. Grinnell Jones and S. D. Kirkpatrick.
3. The Deoxidation of Steel by Ferromanganese. Allen L. Feild.
4. The Cotton Oil Industry in the War. (Lantern.) David Wesson.
5. A New Illuminator for Microscopes. (Second paper.) (Lantern.) Alexander Silverman.
6. An Industrial Research Laboratory. (Lantern.) H. E. Howe.
7. Gilsonite. Robert J. Moore and Gustav Egloff.
8. The Steam Distillation of Gasoline. Gustav Egloff.
9. The Quantitative Estimation of the Important Constituents of Crude Anthracene. Harry F. Lewis.
10. The Preparation and Properties of "Yttrium Mixed Metal." J. F. G. Hicks.
11. An Investigation of Stenches and Odors for Industrial Purposes. V. C. Allison and S. H. Katz.
12. Eckhart Method of Sugar Production. A. D. Little.

ORGANIC CHEMISTRY DIVISION

W. J. Hale, *Chairman* H. L. Fisher, *Secretary*

1. The Influence of Catalysis on the Chlorination of Hydrocarbons. V. R. Kokatnur.
2. On the Detection of Small Quantities of Trichlorotertiarybutyl Alcohol (Chloretone) in the Fluids and Tissues of the Body. T. B. Aldrich.
3. Studies on Derivatives of Trihalogentertiarybutyl Alcohols. II. The Propionic and Butyric Esters of Tribromotertiarybutyl Alcohol (Brometone). T. B. Aldrich.
4. The Identification of Acids. J. B. Rather and E. Emmet Reid.
5. The Solubility of Liquids in Liquids. N. E. Gordon and E. Emmet Reid.
6. A New System of Nomenclature for Four-Membered Cyclic Ureas. William J. Hale.
7. The Synthesis of 3,4-Diphenyluretidone. William J. Hale.
8. Aluminum Oxide as an Absorbent for Water in Organic Combustion. Harry L. Fisher.
9. A Modified Form of the Inner Tube Absorption Bottle for Use in Organic Combustion. Harry L. Fisher.
10. Methane. William Malisoff and Gustav Egloff.
11. Ethylene. William Malisoff and Gustav Egloff.
12. Reaction Products of Alkali-Sawdust Fusion—Formic, Acetic and Oxalic Acids and Methyl Alcohol. (Lantern.) S. A. Mahood.
13. Quino-Isomerism. Oliver Kamm.
14. Misrepresentation in German Technical Literature. Oliver Kamm.
15. The Reaction Between Dimethyl Aniline and Benzene Sulfonyl Chloride. Oliver Kamm and N. W. Wroby.

PHARMACEUTICAL CHEMISTRY DIVISION

F. O. Taylor, *Chairman* George D. Beal, *Secretary*

1. The Proximate Composition of *Rumex Crispus*, and a Comparison of Its Anthraquinone Content with Other Drugs of the Same Class. Ruth E. Okey and George D. Beal.
2. An Efficient Funnel for Filtering Neutral Liquids, Especially of the Volatile Organic Solvents. T. B. Aldrich.
3. Studies on Pepsin. I. Chemical Changes in the Purification of Pepsin. Lewis Davis and Harvey M. Merker.
4. Pepsin *versus* Rennet in Cheese Making. Harvey M. Merker.
5. Digitalis Leaves—Effect on Activity of Temperature in Drying. H. C. Hamilton.
6. Scammony and Its Substitutes. W. L. Scoville.
7. Report of Committee on Analytical Methods.
8. Conference on War Time Changes in Medicinal Products, New Substances, New Methods, Etc.

PHYSICAL AND INORGANIC CHEMISTRY DIVISION

S. L. Bigelow, *Chairman* W. E. Henderson, *Secretary*

1. A Simple Interpretation of Osmotic Phenomena in Terms of the Phase Rule. A. S. McDaniel.
2. Two Papers on Chemical Actions Produced by Radium Emanations. (*a*) Part I. Combination of Hydrogen and Oxygen. (*b*) Part II. Chemical Action Produced by Recoil Atoms. S. C. Lind.
3. The Isotopism of Mesothorium and Radium. R. K. Strong.
4. Solubility Curves by an Application of Floating Equilibrium. W. E. Henderson.
5. The Reduction of Tungstic Oxide. C. W. Davis.
6. Several New Forms of Apparatus. (*a*) A New Type of Vacuum Distillation Flask. (*b*) A New Type of Fractionating Column for Vacuum Distillation. (*c*) A New Form of Dip Electrode for Conductivity Measurements and Substitute for Solid Platinum Electrodes. (Lantern.) H. C. P. Weber.
7. On the Separation of Germanium from Arsenic by the Distillation of the Chloride in the Presence of a Chromate. (Read by title.) Philip E. Browning and Sewell E. Scott.
8. The Potential of the Thallium Electrode. Grinnell Jones and Walter C. Schumb.
9. Ammono Nitrogen Trichloride; Probable Formation of Trichloroammonium Chloride. W. A. Noyes and A. B. Haw.
10. Crystalloluminescence and Triboluminescence. Harry B. Weiser.
11. The Absorption of Anions by Barium Sulfate. Harry B. Weiser and Jacob L. Sherrick.
12. Metallic Salts of Pyrrol, Indol and Carbazol. E. C. Franklin.
13. Sodium Pyrogallate Solution as an Absorbent for Oxygen. G. W. Jones and M. H. Meighan.

FERTILIZER CHEMISTRY DIVISION

J. E. Breckenridge, *Chairman* F. B. Carpenter, *Secretary*

1. Soil Acidity, the Resultant of Chemical Phenomena. (Lantern.) H. A. Noyes.
2. The Nature of the Recombined Potash in Cement Dust. Albert R. Merz.
3. Results of Further Cooperative Work on the Determination of Sulfur in Pyrite, Check Sample No. 4. H. C. Moore.
4. Report of Laboratory Work on the DeRoode Method for the Determination of Potash. J. E. Breckenridge.
5. A Study of the DeRoode Method for the Determination of Potash. T. E. Keitt.
6. A Study of Sources of Error Incident to the Lindo-Gladding Method for Determining Potash. T. E. Keitt.

Conference for general discussion on interesting phases of the fertilizer industry at the present time.

RUBBER SECTION

L. E. Weber, *Chairman* J. B. Tuttle, *Secretary*

1. The Determination of Lamp Black. A. H. Smith and S. W. Epstein.
2. Laboratory Methods for Determining the Degree of Vulcanization. Discussion opened by D. F. Cranor.
3. The Fruit Jar Ring Situation. Discussion opened by Chas. P. Fox.
4. Vulcanization of Rubber at Constant and by a Series of Increasing Temperatures. G. D. Kratz and Arthur H. Flower.
5. Report of the Committee on the Poisonous Nature of some Accelerators and Precautions Regarding their Use. Discussion opened by R. D. Earle.
6. Report of the Executive Committee. L. E. Weber, *Chairman*.

WATER, SEWAGE AND SANITATION DIVISION

R. S. Weston, *Chairman* W. W. Skinner, *Secretary*

1. Purification of Cleveland's Water Supply. Joseph W. Ellms.
2. Cleveland's Sewage Projects. George B. Gascoigne.
3. The Determination of Iodide in Mineral Waters and Brines. W. F. Baughman and W. W. Skinner.
4. A Study of Well Water. G. O. Higley.

COMMUNICATION FROM UNITED STATES SHIPPING BOARD

Washington, D. C.
August 1, 1918

American Chemical Society,
Washington, D. C.

Gentlemen:

I am going to call upon your organization for some teamwork.

The time has come for Americans everywhere to put themselves solidly behind American ships.

Our railroads must no longer stop at the ocean. We are building an American merchant fleet of 25,000,000 tons—3,000 ships. We are backing modern ships with modern port facilities, establishing our bunkering stations all over the globe, and will operate with American railroad efficiency. We will carry American cargoes at rates corresponding to our railroad rates—the cheapest in the world. Fast American passenger and cargo liners will run regularly to every port in Latin America, the Orient, Africa, Australia.

Are you taking steps to use these ships to increase your own prosperity? Do you realize that American products of factory, farm, and mine can be delivered to customers in foreign countries on terms which will build lasting trade?

Do you realize the possibilities for bringing back raw materials to extend your products and trade?

We must all take off our coats and work to bring these American ships home to the people of every American interest and community. The manufacturer must think of customers in Latin America as being as accessible as those in the next state.

The farmer must visualize ships carrying his wheat, cotton, breeding animals, dairy products, and fruit to new world markets. The American boy must think of ships and foreign countries when he chooses a calling.

Has your organization appointed a live Committee on Merchant Marine?

Is the chairman of this committee a man of international vision?

Are you applying the new world vision to the interests represented in your organization and learning what ships can do toward widening your markets?

These are *your* ships. It is your duty to bring them close, regard them as new railroads, spread knowledge about them through investigation, meetings, discussion.

Public neglect ruined our old merchant marine. Congress was not to blame—it simply reflected the indifference of the average American toward ships. Once more we have a real American merchant fleet under way, backed by far-reaching policies for efficient operation. We must dispel indifference and keep our flag on the trade routes of the world. We are going to take trade from no other nation. But we must serve our own customers and help other nations in their ocean transportation problems after the war.

I want to hear personally from your organization. These are precious days of opportunity. The nation is united for teamwork and service. Let us "Wake Up, America!"—which means waking up ourselves. I expect you to write me outlining your views and making any suggestions that you think will be helpful in our work.

With personal good wishes, I am

Yours very sincerely

EDWARD N. HURLEY, *Chairman*

COMMITTEE ON ORGANIC ACCELERATORS RUBBER SECTION, AMERICAN CHEMICAL SOCIETY

Members of the Rubber Section of the American Chemical Society:

In accordance with the resolution passed at the last meeting of the Rubber Section of the AMERICAN CHEMICAL SOCIETY held at Cambridge, September 12, 1917, the Committee on Organic Accelerators respectfully submits the following report:

Owing to the increasing use of certain organic compounds as accelerators in the vulcanizing of rubber goods, many of which are marketed under misleading trade names, it is desirable to call the attention of rubber manufacturers to the poisonous properties of some of these products and to the fact that disagreeable factory experience may result unless due precautions are taken.

The more common accelerators used to-day are aniline, hexamethylene tetramine, para-phenylene diamine, para-nitrosodimethylaniline, and thiocarbanilide.

ANILINE

SYMPTOMS OF POISONING—In small amounts, pallor, vertigo, and blueness of lips result. In large doses muscular weakness, strangulation, and death.

ANTIDOTES—Fresh air, change of clothing, artificial respiration. Use of milk in diet is recommended. Use of alcoholic stimulants predisposes to poisoning and is excessively injurious after poisoning has occurred.

HEXAMETHYLENE TETRAMINE

SYMPTOMS OF POISONING—Rash and inflammation of skin which has been in repeated contact with stock containing this material. In severe cases, blisters filled with watery fluid result.

ANTIDOTE—Cleanliness and care in regard to clothing are the best preventatives. Change of occupation will cause the rash to disappear, leaving no permanent effects.

PARA-PHENYLENE DIAMINE

SYMPTOMS OF POISONING—Inhalation of the dust gives the symptoms of a common cold with sneezing and extreme depression. In larger quantities, death with symptoms similar to those of ptomaine poisoning. This is probably the most poisonous of all the accelerators proposed up to date. All efforts should be made towards prevention of inhalation of dust, by means of suction hoods over the mixing mills.

PARA-NITROSODIMETHYLANILINE

SYMPTOMS OF POISONING—This causes a severe inflammation of the skin, increasing in severity according to the exposure.

ANTIDOTE—Change of occupation.

THIOCARBANILIDE

SYMPTOMS OF POISONING—This material decomposes when heated to vulcanizing temperatures with the formation of phenyl mustard oil, the fumes of which cause pallor, blueness of gums and lips. Probably the least poisonous of the common organic accelerators.

ANTIDOTE—Fresh air.

RECOMMENDATIONS

1—Cleanliness is essential. The hands should be washed before eating. Before leaving the factory a shower bath should be taken and a complete change of clothing made.

2—Mixing mills should be provided with adequate suction hoods, in which an efficient draft is maintained.

3—Ventilation of press rooms, especially if thiocarbanilide is used.

4—Immediate attention to early symptoms, and, if possible, temporary change of occupation in the factory.

5—Periodical medical examination of employees in mixing and compounding departments, and an educational campaign among employees in regard to use of alcohol and chewing tobacco while at work.

6—In the case of accelerators sold under trade names it is suggested that steps be taken to ascertain the nature of the material.

Respectfully submitted

RICHARD B. EARLE, *Chairman*

September 9, 1918

DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

MINUTES OF SESSIONS, 56TH MEETING A. C. S.

A symposium on the chemistry of dyestuffs was held on the afternoon of Tuesday, September 10, 1918, R. Norris Shreve presiding. All papers listed on the program were presented except those of Messrs. Crossley, Lewis, and Seydel. Those interested in the formation of a Dye Section were asked to leave their names and addresses with Mr. Shreve. The meeting seemed to think that the coöperation possible and the benefit to the industry would be such that the Council at its next meeting should be asked to form a Section on Dyes.

At the business meeting there were no reports from the Executive Committee or the Secretary. The Committee on Analysis of Oils and Fats made a further report, which was accepted and referred to Dr. Hillebrand's Supervisory Committee on Standard Methods of Analysis, and to the JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY for publication. There were no other reports.

The Nominating Committee, which consisted of Messrs. Paul Rudnick, E. F. Hicks, and C. P. Long, made the following recommendations: H. S. Miner, *Chairman;* H. D. Bachelor, *Vice Chairman;* H. E. Howe, *Secretary;* W. F. Hillebrand, S. W. Parr, A. W. Smith, David Wesson, J. G. Vail, and *ex officio*, Chas. H. Herty, *Executive Committee.*

All papers on the program were presented either in full or by abstract. The Potash Symposium brought out discussion by

Messrs. Grimwood, Herty, Wesson, Ashman, Jones, Cabot, Zerban, Parr, Mabery, Field, and Stockett.

Upon invitation, Dr. C. E. K. Mees spoke of the new work taken up by the Eastman Kodak Company which has as its object the supplying of chemicals needed for research which cannot be obtained in the market and are not capable of being made commercially by chemical firms. Large quantity production will not be undertaken now, but the making of small amounts of a great many compounds will be a specialty. In this work the coöperation of graduate students, research men, and industrial laboratories is required. Universities which can manufacture some of these chemicals will find a buyer in the Eastman Kodak Company, and the research man who would ordinarily make 100 grams will be asked to produce a kilo of any unusual substance he may make, with the expectation that the Company will buy, store, and later sell the material as it may be needed. Industrial men can help by calling attention to new materials, new sources of raw materials, etc. With our resources it may easily be possible to entirely supersede Kahlbaum and other foreign sources of this material.

All of this is the outcome of Dr. Roger Adams' work, and the plea of a professor who pointed out that unless someone began to make the unusual organic and inorganic chemicals here, we would all be forced after the war to return to German sources.

The Division approved the resolution of the Organic Division relative to nomenclature, and adjourned after discussing types of meetings and Dr. Herty's remarks on improving his Journal.

H. E. Howe
Acting Secretary

FALL MEETING, AMERICAN ELECTROCHEMICAL SOCIETY, SEPTEMBER 30–OCTOBER 2, 1918

The recent order of the Government (made public September 5) commandeering colleges, universities, and technical schools, rendered it inadvisable to attempt to hold the meeting at Princeton. The authorities of Princeton and the Princeton members felt constrained to withdraw their invitation, and asked the Society to visit them at a more convenient season and under more favorable circumstances.

The meeting was therefore held, on the dates announced, at Atlantic City, with headquarters at the Hotel Traymore. The meeting followed immediately after the Chemical Exposition at New York, permitting advantageous combination therewith. The Symposium on "Electrochemistry after the War" took both Tuesday sessions.

PROGRAM OF PAPERS

The Oscillatory Current Induction Furnace. E. F. Northrup.
Processes Within the Electrode which Accompany the Discharge of Hydrogen and Oxygen. D. P. Smith.
The Sign of Potential. O. P. Watts.
An Apparatus for the Separation of Radium Emanation and Its Determination Electroscopically. J. E. Underwood and H. Schlundt.
Notes on the Heterogeneous Equilibrium of Hydrogen and Oxygen Mixed with Radium Emanation. S. C. Lind.
Hardness of Soft Iron and Copper Compared. F. C. Kelley.
Nitrogen Fixation Furnaces. E. Kilburn Scott.
Relative Volatilities of Refractory Materials. W. R. Mott.
The Discharge Characteristics of a Common Type of 2½" by 6" Dry Cell C. A Gillingham.

Symposium on Electrochemistry After the War

The Electric Furnace After the War. F. A. J. FitzGerald.
The Future of Electric Steel. J. A. Mathew.
Electric Pig Iron After the War. R. Turnbull.
The Future of Electrolytic Chlorine. A. H. Hooker.
Commercial Uses of Chlorine. V. R. Kokatnur.
The Government and the Technical Man After the War. F. A. Lidbury
Tariff Problems in the Electrochemical Industries. Grinnell Jones.
The War and the Nitrogen Industry. W. L. Landis.
The Power Situation After the War. C. A. Winder.
Research After the War. W. D. Bancroft.

NOTES AND CORRESPONDENCE

PLATINUM REGULATIONS[1]

The following regulations are hereby promulgated under the provisions of the Act of October 6, 1917 (40 Stat. 385), as amended by the Act of July 1, 1918 (Public No. 181), authorizing the Director of the Bureau of Mines, under rules and regulations approved by the Secretary of the Interior, to limit during the period of the war, the sale, possession, and use of platinum, iridium, and palladium, and compounds thereof

Section I—The War Industries Board is hereby designated under Section 21 of the Act of October 6, 1917, and the President's proclamation of October 26, 1917, as the agent of the Director of the Bureau of Mines in the execution of the regulations as hereinafter indicated.

Section II—From and after the date of these regulations under the penalties prescribed by Section 19 of the Act of October 6, 1917,[2] no person[3] shall:

(A) Use any platinum or platinum scrap, iridium or iridium scrap, palladium or palladium scrap, and, or, compounds thereof, in the manufacture, alteration, or repair of any ornament or article of jewelry.

(B) Manufacture for use in dentistry any metal, metal parts, or alloys containing more than 20 per cent by weight of platinum, or 40 per cent by weight of platinum, iridium, and, or, palladium combined, or manufacture supplies therefrom.

Section III—From and after the date of these regulations, under the penalties prescribed by Section 19 of the Act of October 6, 1917, no person shall without a license:

(A) Purchase, sell, barter, or deal in unmanufactured platinum, iridium, or palladium, or compounds thereof (including crude, scrap, filings, polishings, or sweeps) except that sales may be made without a license to an authorized agent of the United States or to a licensee authorized to purchase the same; or possess for more than ninety days after the date of these regulations one ounce Troy, or more, of such unmanufactured platinum, iridium, palladium, or compounds thereof.

(B) Possess, use, sell, purchase, or barter, for purposes connected with his business, platinum, iridium, palladium, or compounds thereof (except that sales may be made without license to an authorized agent of the United States, or to a licensee authorized to purchase the same) if such person be engaged in:

1—Producing platinum, iridium, or palladium, or compounds thereof by mining.

2—Producing sulfuric acid, nitric acid, or other chemical products where platinum, iridium, palladium, or compounds thereof are used in such production.

3—Importing or exporting platinum, iridium, or palladium, or compounds thereof.

[1] Released October 1, 1918

[2] Section 19 of the Act of October 6, 1917, is as follows: "That any person violating any of the provisions of this Act, or any rules or regulations made thereunder, shall be guilty of misdemeanor, and shall be punished by a fine of not more than $5,000 or by imprisonment not more than one year or by both such fine and imprisonment."

[3] The word "person," for the purposes of these regulations, shall be construed in accordance with the definition contained in Section 4 of the Act of October 6, 1917, which is as follows: "That the word 'person' when used herein shall include States, Territories, the District of Columbia, Alaska, and other dependencies of the United States, and municipal subdivisions thereof, individual citizens, firms, associations, societies, and corporations of the United States and of other countries at peace with the United States."

4—Producing platinum, iridium, or palladium, or compounds thereof, either as a primary product or as a by-product of smelting or refining.

5—Manufacturing electrical appliances and, or, parts thereof containing platinum, iridium, or palladium or compounds thereof.

6—Manufacturing surgical appliances and X-Ray apparatus containing platinum, iridium, or palladium, or compounds thereof.

7—Manufacturing chemical apparatus and reagents of all kinds containing platinum, iridium, or palladium, or compounds thereof.

8—Conducting or operating chemical laboratories in which platinum, iridium, or palladium, or compounds thereof are used.

9—Manufacturing scientific instruments containing platinum, iridium, or palladium, or compounds thereof.

10—Manufacturing and, or, distributing dental supplies containing platinum, iridium, or palladium, or compounds thereof.

11—Manufacturing and, or, dealing in jewelry containing platinum, iridium, or palladium, or compounds thereof.

12—Manufacturing or producing any article or product not mentioned above where such business requires more than one ounce Troy per month of platinum, iridium, or palladium, or compounds thereof.

SECTION IV—Applications for licenses shall be made under oath to any licensing agent duly authorized under the Act of October 6, 1917, as provided in the regulations issued under this Act.

SECTION V—Every applicant for a license will be required to submit with his application a sworn inventory of all platinum, iridium, or palladium, or compounds thereof, in his possession or control; and every licensee will be required to submit at such times as may be designated by the War Industries Board a sworn inventory of his holdings of platinum, iridium, or palladium, or compounds thereof, in whatever form they may be.

The Director of the Bureau of Mines at the request of the War Industries Board may at any time require from any user or possessor a detailed sworn inventory of any and all materials held by him containing platinum, iridium, palladium, or compounds thereof, and such inventory must be furnished promptly upon receipt of such requirement.

SECTION VI—All licenses shall be issued in the name of the Director of the Bureau of Mines and countersigned by the War Industries Board, and shall be, and remain, subject to the following conditions:

(A) Each license shall contain such appropriate conditions as the Bureau of Mines through the War Industries Board may impose.

(B) The Bureau of Mines through the War Industries Board may change the conditions of the license from time to time, as it may deem necessary.

(C) Records shall be kept by each licensee of all his sales, purchases, and other transfers of platinum, iridium, or palladium, or compounds thereof, and of articles containing platinum, iridium, or palladium, or compounds thereof, with the names and addresses of the purchasers, sellers, and, or, transferees, and the quantities involved, which records shall be open at all reasonable times to the duly authorized representatives of the Director of the Bureau of Mines.

(D) Any and all platinum, iridium, or palladium, or compounds thereof, acquired under the authority of such license, shall be used strictly for the purposes and in the manner stated in such license.

(E) Upon request of the War Industries Board, the licensee shall report the prices at which sales of his products containing platinum, iridium, or palladium, or compounds thereof, are being made, and the right to prohibit further sale of such articles at prices deemed exorbitant by it is reserved to the War Industries Board.

SECTION VII—Any licenses issued hereunder may be revoked for violation of any of these regulations, or for violation of any of the conditions contained in such license, or if such revocation is deemed necessary or advisable for purposes of the National Security and Common Defense.

SECTION VIII—The War Industries Board will, upon request, furnish a list of Government agents or licensees authorized to purchase platinum, iridium, or compounds thereof. Neither the United States nor its representatives will assume any responsibility, financial or otherwise, where sales are made to licensees.

SECTION IX—The prices at which platinum, iridium, or palladium will be purchased by a duly authorized agent of the United States or by such licensee as may be authorized to purchase or sell platinum, iridium, or palladium, or compounds thereof, will be such prices as may be determined by the proper Governmental agency authorized to determine such prices.

SECTION X—Whenever such Government agents and such licensees as may be authorized to purchase platinum, iridium, or palladium, or compounds thereof, shall refuse to purchase the same from any person who is compelled by these regulations to sell the same, or is forbidden by these regulations to possess or use the same then such person shall promptly notify the Platinum Section, War Industries Board, Washington, D. C.

SECTION XI—These regulations shall not operate to relieve any person upon whom an order requisitioning platinum, iridium, or palladium, or compounds thereof, may have been or may hereafter be served, from any obligation imposed upon him by such order.

SECTION XII—These regulations are supplemental and amendatory to the regulations heretofore issued under the Explosives Act of October 6, 1917.

PLATINUM WANTED BY THE GOVERNMENT

Editor of the Journal of Industrial and Engineering Chemistry:

Replying to your letter of recent date I beg to advise you that the Government is desirous of procuring platinum and will receive deposits of that metal in any form and in any amount. Payment will be made at the rate of $105 per ounce after the value has been determined by melt and assay and nominal charges to cover the cost of determining the value of the deposits are deducted.

I have designated the United States Assay Office at New York as the Government institution to receive deposits of platinum. Packages should be sent to the following address: THE SUPERINTENDENT, UNITED STATES ASSAY OFFICE, NEW YORK, N. Y.

(Signed) R. T. BAKER
Director of the Mint

TWO LETTERS ON REPRODUCING BEILSTEIN'S HANDBUCH DER ORGANISCHEN CHEMIE

Editor of the Journal of Industrial and Engineering Chemistry:

I will be one of 1000 to pay not to exceed $50 for a copy of Beilstein. I believe you could readily procure sufficient subscribers to such an undertaking. Why ask anyone to donate $30,000?

S. J. MCGRATH

SOUTH BEND, INDIANA
September 12, 1918

.....

Editor of the Journal of Industrial and Engineering Chemistry:

I have noticed with much interest your editorial in the last number of the JOURNAL on the subject of reprinting Beilstein, and I might say that my patriotic sentiments are not entirely outraged by your suggestion, but I would go you one better and suggest the photographing and reprinting of Friedländer, or

Schultz-Huemann, or some other complete edition of the German chemical patents.

I happen to be one of the fortunate who have Beilstein, but I would like another copy for laboratory use.

My company is not one of the largest ones and therefore could not subscribe the $30,000, but we will take one copy at $100 instead of the $10, which you suggest. In fact, if it came down to the scratch you might induce us to pay twice that amount, and we would subscribe proportionally to the reproduction of any one of the editions giving the German patent specifications.

I think this is a splendid suggestion on your part. I hope you will push it with all possible speed, and as you say, let the Huns do the worrying about our patriotism. I do not think that this will be very cruel, because I think they will have other things to worry about which will case the pain caused by this slight offensive.

PEERLESS COLOR COMPANY
BOUND BROOK, N. J.
September 20, 1918

R. W. CORNELISON
President and *General Manager*

LIBRARY FOR EDGEWOOD ARSENAL LABORATORY

Editor of the Journal of Industrial and Engineering Chemistry:

Attached herewith is a copy of a letter which I recently addressed to our Commanding Officer, Colonel Wm. H. Walker. It is self-explanatory. Colonel Walker has approved my suggestion that I write to you. Since writing the above we have located a copy of Beilstein's *Organische Chemie, Metallurgical and Chemical Engineering, Transactions of the American Society of Testing Materials, Chemical Abstracts.*

The attached letter (copy) to Prof. V. H. Gottschalk, University of Missouri, is one which is also self-explanatory. Prof. Gottschalk's letter as well as others which we have received are full of splendid patriotism and scientific interest.

From what you saw here on your recent visit, you can readily appreciate our need of any files of the well-known chemical journals. Will you give us a lift? We dream of the *American Chemical Journal, Journal of the Chemical Society,* Liebig's *Annalen,* the *Berichte,* and others.

CHEMICAL LABORATORY
EDGEWOOD ARSENAL
September 20, 1918

(Signed) WM. LLOYD EVANS
Major, C.W.S., U. S. A.

Col. Wm. H. Walker,
Commanding Officer,
Baltimore, Md.

DEAR SIR:

As we are becoming more settled in our laboratory work, the need for the well-known handbooks and chemical journals becomes more apparent daily. We are badly in need of such works as Beilstein's *Organische Chemie,* Landolt-Börnstein *Tabellen, Journal of the American Chemical Society, Journal of Industrial and Engineering Chemistry, Metallurgical and Chemical Engineering, Journal of the Society of Chemical Industry, Transactions of the American Society of Testing Materials, Transactions of the American Electrochemical Society,* and many others that readily suggest themselves. Through the kindness of the duPont Company, of Wilmington, we have been able to locate the owners of a few of these desirable works, but as you can readily imagine they are very difficult to obtain. You will be happy to know that Dr. Ira Remsen has offered us his *Gmelin-Kraut* as a loan.

It has occurred to me that a notice placed in the *Journal of Industrial and Engineering Chemistry* and also in *Science,* explaining the needs of this laboratory, might bring forth loans of books we greatly desire. If the Commanding Officer, Edgewood Arsenal, concurs in this view, might I respectfully suggest that this notice be asked for, and that all communications in reference to the same be made to the Commanding Officer, Edgewood Arsenal?

(Signed) WM. LLOYD EVANS,
Major, C. W. S., U. S. A.

CHEMICAL LABORATORY
EDGEWOOD ARSENAL
August 31, 1918

AGREEMENT

The Edgewood Arsenal acknowledges the loan by Mr. V. H. Gottschalk of the books on chemistry and related subjects, listed below, and agrees to return them without damage at the end of the war. In case of damage or loss involving any or all of the books mentioned, the Edgewood Arsenal assumes liability therefor up to 150 per cent of the original price.

It is understood that the cost of packing and shipping the books to and from Edgewood Arsenal will be borne by the Government.

The following books are included in the above agreement:

Handbuch der anorganischen Chemie, Abegg, 6 Vols.

Handbuch der angewandten physikalischen Chemie, to date of last issue shipped to America.

Arendt's *Sammlung Chem. und Chem.-Tech. Vortrage,* Vols. 1–15.

Moissan, *Traité de Chimie Mineral.*

Zeitschrift für physikalische Chemie, Vols 42–70, Index 25–50.

Annalen der Physik (Drude), Vols. 1–36.

Winkelmann, *Handbuch der Physik* (Optik, Vols. 3, 4, 5, is loaned to Prof. Dean).

(Signed) WM. H. WALKER
Colonel, C.W.S., U. S. A.

CHEMICAL LABORATORY
EDGEWOOD ARSENAL
August 30, 1918

ORDNANCE DEPARTMENT, SCHOOL OF EXPLOSIVES MANUFACTURE, COLUMBIA UNIVERSITY

The Ordnance Department of the Army, particularly in the Production and Inspection Divisions, is in need of men with training in the manufacture of explosives and the related raw materials. The manufacture of explosives is developing out of proportion to the number of men in the country who have had training and experience in that work. To meet this condition the War Department Committee on Education and Special Training is establishing in the Department of Chemical Engineering at Columbia University in the City of New York an Ordnance Department School of Explosives Manufacture. The object of this School is to give men with proper preliminary qualifications the training necessary to fit them for use by the Ordnance Department as commissioned officers in the supervision of factory operation and inspection of the finished products in plants manufacturing explosives and raw materials for explosives.

The school will be only for enlisted men in the military service who are detailed for instruction in the school by the Ordnance Department. The ways in which students will be obtained are three:

1—Transfer of men already in the military service.

2—Induction of men of draft age who have not yet been called.

3—Volunteer enlistment of men not in draft age.

The minimum requirement as to technical training for admission will be graduation from a recognized college or university with a bachelor's degree in chemistry or chemical engineering, or factory experience of equivalent character.

The course of training will be of 12 weeks' length and will consist of:

1—Military drill and instruction
2—Class room and lecture instruction
3—Laboratory and plant work
4—Visits to plants

In the course of study the men will be made familiar with the methods of manufacture, of factory control, and of inspection of explosives such as smokeless gunpowder, trinitrotoluol, picric acid, ammonium nitrate, toluol, phenol, etc. The particular subjects on which emphasis is laid in the course will vary from period to period with the need for men trained for work in particular groups of plants.

While in the school each man will be rated both as to his technical performance and personal qualities exhibited. On the satisfactory completion of the course this rating will be made the basis of recommendation for a commission as second lieutenant in the Ordnance Department. The granting of commission will depend upon the number of commissions available and the varying needs of the Ordnance Department. While worthy graduates are expected to be commissioned, it is understood that commissions are not guaranteed. In any case the graduates of the school will be utilized in technical work by the Ordnance Department whether commissioned as officers or not.

The assignment of men for the first session has been completed. The second session will start about December 1 and arrangements for assignments to it should be made about one month earlier.

The general plan is to devote the morning hours to lectures and reading, and the afternoons to laboratory practice. During the course considerable time will be spent in plants actually manufacturing explosives or explosive raw materials. In common with the enlisted men, students in the other special army school at Columbia, students in this school will have the military drill of the post, amounting to about an hour and a half daily.

FIRST AND SECOND WEEKS

9–10 A.M. each day. Lectures on the general principles governing the manufacture of explosives and the tests for quality.
10–11 A.M. two days a week. Lectures on military regulations and relations.
1–5 P.M. Laboratory practice in testing acceptable and unacceptable samples of explosive raw materials such as benzol, toluol, nitric acid, etc.

THIRD AND FOURTH WEEKS

9–10 A.M. each day. Lectures on the methods of manufacture and of testing picric acid and ammonium picrate and the raw materials from which they are made.
10–11 A.M. two days a week. Military lectures continued.
1–5 P.M. Laboratory practice on picric acid, ammonium picrate and related materials.

Two days of the third week to be spent at a picric acid plant in New Jersey.

FIFTH WEEK

9–10 A.M. each day. Lectures on the methods of manufacture and testing of toluol, benzol, solvent naphtha and xylol.
10–11 A.M. two days a week. Military lectures continued.
1–5 P.M. Laboratory practice with hydrocarbons.

Two days at hydrocarbon plants in vicinity of New York City.

SIXTH AND SEVENTH WEEKS

9–10 A.M. each day. Lectures on the methods of manufacture and of testing trinitrotoluol.
10–11 A.M. two days a week. Military lectures continued.
1–5 P.M. Laboratory practice with trinitrotoluol.

Two days spent at the TNT plant at Kenville, N. J.

EIGHTH AND NINTH WEEKS

9–10 A.M. each day. Lectures on the methods of manufacture and testing of guncotton and smokeless gunpowder.
10–11 A.M. two days a week. Military lectures continued.
1–5 P.M. Laboratory practice with guncotton and smokeless gunpowder.

Two days spent at smokeless powder plant at Parlin, N. J.

TENTH WEEK

9–10 A.M. each day. Lectures on methods of manufacture and testing of ammonium nitrate, ammonium nitrate, TNT mixtures, and shell filling.
1–5 P.M. Laboratory practice with ammonium nitrate and ammonium nitrate mixtures.

One day at shell loading plant at Perth Amboy, N. J.

ELEVENTH WEEK

9–10 A.M. each day. Lectures on the methods of manufacture and testing of tetryl and tetranitraniline.
1–5 P.M. Laboratory practice with tetryl and tetranitraniline.

Two days at a tetryl or tetranitraniline plant.

TWELFTH WEEK

9–10 A.M. each day. Lectures on the methods of manufacture and testing of mercury fulminate, other detonators, and fuses.
1–5 P.M. Laboratory practice in connection with detonators and fuses.

One day at plant manufacturing or using detonators, Pompton Lakes, N. J.

It is understood that the field covered by the school will vary from period to period as the needs of the Ordnance Department for men trained for work in particular types of plants may vary.

CHEMISTRY FOR SOLDIERS IN TRAINING CAMPS

Editor of the Journal of Industrial and Engineering Chemistry:

It suggests itself to me that the Publicity Committee of the AMERICAN CHEMICAL SOCIETY should extend its activities into the training camps of the United States Army.

There is no question in anybody's mind but that the war is primarily a chemical war. It has been stated that the man with the most gas will win the war.

We are desirous, as a Society, to increase the influence of chemistry and chemists in the country and the best way that we can do it to-day is to take upon ourselves as a Society to supply elemental chemical information to the soldiers of our Army. All the men have had at least public school training, so that by primitive similes, it should be possible for a speaker to make chemistry, so far as it relates to the war, at least interesting to the men in the ranks. I feel that this is a golden opportunity for us, which has not as yet, to my knowledge, been taken care of.

J. W. BECKMAN

SAN FRANCISCO, CAL.
September 7, 1918

THE EMBLEM OF THE AMERICAN CHEMICAL SOCIETY

Editor of the Journal of Industrial and Engineering Chemistry:

Mr. Charles A. Doremus' letter in the August issue of THIS JOURNAL concerning the change of the emblem of the AMERICAN CHEMICAL SOCIETY must deserve due attention from the members of the Society. The Society's present emblem must be changed, not because it pictures an apparatus of German invention, but because the emblem does not represent chemical science in any way. Personally, I do not see how a CO_2 absorption bulb can express or convey any wide thought of chemical science and its practice. The emblem of the AMERICAN CHEMICAL SOCIETY should be of such a design that it would express the spirit and the scope of chemical science and should have a business-like and dignified appearance. I confess I do not wear the present emblem, for it is too superficial and has no scientific, technical, or business-like aspect. Something must be done to raise the standard of the Society's emblematical expression. For my part, as a member of the AMERICAN CHEMICAL SOCIETY, I suggest that Mendeléeff's periodic law be taken as the basis for designing a new, first-class emblem.

GREGORY TOROSSIAN

NATIONAL CARBON COMPANY
CLEVELAND, August 20, 1918

WASHINGTON LETTER

By Paul Wooton, Union Trust Building, Washington, D. C.

Only minor changes will be made in the War Minerals Bill in conference. While the conferees have not met as yet, Representative Foster, the Chairman of the Committee on Mines and Mining of the House of Representatives, is willing to accept the bill as re-written by Senator Henderson, the Chairman of the Committee on Mines and Mining of the Senate.

The Senate committee objected strenuously to the minimum price principle which was contained in the House bill. It feared that conditions easily could become such as to cause the Government to incur onerous obligations. The committee therefore elaborated the contract principle, which also had the approval of the House, which would lessen the Government's liability. The appropriation was increased from $10,000,000 to $50,000,000. The sum, however, is to be a revolving fund and probably will be returned to the Treasury when the emergency has passed. In addition, the bill carries $500,000 for administration expenses.

The Senate committee also disapproved of the licensing feature. After hearing from a large number of well-qualified witnesses, it appeared to be the consensus of opinion that the legislation could be administered successfully without the annoyance to the industries handling war minerals, which certainly would accompany a licensing plan such as that provided in the Lever Act or in the Explosives Act.

Phosphorus is the only mineral added to the list by the Senate. Sodium, however, was substituted for "sea salt." Phosphorus was added because of the greatly increased demand for its use in smoke screens. Senator Smoot made an ineffectual effort to amend the bill so as to take from under its jurisdiction chalk, fluorspar, fuller's earth, kaolin, and mica. Mr. Smoot insisted that those substances need not come under control at this time and that the bill should be restricted to the war minerals where the need of control is evident. He declared that the bill could be amended in a week at any time the War Industries Board would show cause for adding to the list. The bill, as passed, contains the following minerals: metallurgical products and their chemical compounds, antimony, arsenic, ball clay, bismuth, bromine, cerium, chalk, chromium, cobalt, corundum, emery, fluorspar, ferrosilicon, fuller's earth, graphite, grinding pebbles, iridium, kaolin, magnesite, manganese, mercury, mica, molybdenum, osmium, sodium, platinum, palladium, paper clay, phosphorus, potassium, pyrites, radium, sulfur, thorium, tin, titanium, tungsten, uranium, vanadium and zirconium.

The consideration of the War Minerals Bill occasioned debate for the greater part of two sessions, but the bill was not amended in important particulars. The committee accepted in advance such amendments as were adopted. The President has written Senator Henderson to assure him that he has done an important service in securing the passage of a bill which is apparently so workable.

Imports and exports of certain chemical materials, as reported by the Department of Commerce for July 1918, and the figures for July 1917, as finally revised, are as follows:

Exports	July 1917	July 1918
Acids		
Carbolic	$ 726,109	$ 101,883
Picric	1,943,632	1,257,864
Sulfuric	65,726	142,195
Dyes and dyestuffs	1,278,709	1,428,669
Glycerin	234,873	235,184
Medical preparations	637,809	979,078
Caustic soda	604,261	423,773
Soda ash	398,859	372,940
Total Chemicals	12,777,324	12,584,853

Imports	July 1917	July 1918
Arsenic	$ 18,231	$ 39,833
Creosote oil	121,240	23,953
Colors or dyes	105,372	211,721
Indigo	462,432	504,716
Total coal-tar distillates	754,220	797,101
Camphor, crude	211,440	142,686
Shellac	350,199	619,760
Nitrate of potash	238,299	21,365
Nitrate of soda	4,781,100	6,445,280
Total Chemicals	11,152,394	12,468,980

With the extension of the draft ages, the matter of industrial exemption, in the words of an officer in the Provost Marshal General's office, changes from an important to a vital question. It is regarded as so essential that officials are urging industries to take organized steps to acquaint district boards with their needs, so that the most intelligent action can be taken. It is pointed out that confusion is certain to result if each employer tries to take up the matter with the draft board himself. Each industry, it is suggested, would do well in selecting an individual or a committee to devote entire time to this very important matter. Experience has shown that systematic effort along such lines has been very helpful to industries and at the same time has made easier the task which confronts each district board.

The Provost Marshal General has made it very clear that the spirit of the regulations is to construe liberally the provisions regarding the deferment of necessary employees. The working of the new questionnaire makes possible a broader interpretation. It is quite generally understood that workmen necessary to the operation of a plant are to be given deferred classification but the same is not true of the administrative force, or of those engaged in selling and purchasing for necessary industries. The General Staff has outlined definitely what it regards as the essential occupation, so far as operatives are concerned, in the manufacture of sulfuric acid. That list includes: works manager; plant superintendents; chief chemist; trained chemists doing actual supervision of process work; chief engineer; electrical engineer; mechanical engineer; burner men for mechanical furnaces; chamber men; contact process men; power house engineer; concentrator operators; concentrator testers doing supervisory work; tank-car line supervisors; locomotive engineers, firemen, and yard masters (included only where factory includes an industrial standard gauge railroad); locomotive, mono-rail, bridge, and gantry crane operators; heads of clerical departments certified by the plant management as essential to continuous operation; maintenance engineer; master mechanic; foremen of skilled trades, including brick masons, boiler makers, carpenters, electricians, iron workers, machinists, pipe fitters; sufficient skilled men of each of above skilled trades as may be certified by the plant management as essential to continued operation; lead burners. Special police and truck drivers are regarded as necessary employees whom it would be difficult to replace by men over draft age. While the General Staff does not make mention of the necessary employees in the offices, it is obvious that they are to be given as careful consideration by district boards as are workers in the plants.

After much preliminary heralding, the War Industries Board made public on Sept. 9 its new preference list of industries. The list was made up after extended experience in meeting essential requirements and has met with very general approval. While Chairman Baruch is in receipt of numerous protests from industries which believe they should be included, the consensus of opinion apparently is that the list could not be expanded greatly and attain its object.

Under Class 1 are grouped those industries of exceptional importance in carrying on the war. The requirements of the industries in that group for fuel, electric energy, labor, and transportation will be satisfied fully before attention is paid to the wants of the remaining three classes. Among the other three classes, there is to be no absolute preference. Their requirements will be given preference over the industries which are not included in the list, but it does not mean that the requirements of Class 2 will be fully satisfied before providing any of the needs of Class 3. It may be necessary in many instances to keep an industry in Class 4 partially supplied at the expense of an industry in Class 2. The list does indicate, however, that the Class 2 industry is of relatively greater importance than a Class 3 or a Class 4 industry.

The text of the War Department's announcement advising of the suspension of work on the Muscle Shoals power plant is as follows:

> The Ordnance Department announces that the temporary suspension of work on the water power development at the Muscle Shoals nitrate plants will not in any way affect the production of nitrates at these or any of the other plants now engaged in their production.
>
> This action was taken upon the representation of the War Industries Board and affects only the erection of the huge water power plant being built on the Tennessee River, power from which was not anticipated for 4 or 5 years. The water power development was undertaken by the War Department in line with its established policy of utilizing these nitrate

plants for the benefit of agriculture after the war is over, when the water power plant would be available.

Work is progressing rapidly on the Muscle Shoals plants, one of which is about 60 per cent complete, and over 20,000 men are now employed there. Power for their operation is obtained from a steam-electric station erected on the Tennessee River, and also purchased from the Alabama Power Company. This power is adequate for the operation of the nitrate plants. The water power development was projected merely to obtain cheaper power in future years.

The nitrate division of the Ordnance Department has taken over the experimental ammonia plant and laboratory which has been conducted near Washington by the Department of Agriculture. The work is in charge of R. O. E. Davis and L. H. Greathouse.

Following experiments with lenses for air pilots' glasses, the Medical Research Board of the Division of Military Aeronautics announces that it has been able to effect the casting of certain substances in thin sheets which, while not glass, can be used as such and may afford a practical substitute for it in goggles. This substance has been on the market for some time but the company which makes it has not up to the present been able to cast it in the right strength and thickness suitable for goggles.

Under the direction of the Medical Research Board, thin sheets of the material have been produced which not only are of the proper texture and thickness but can be ground and polished. The substance is hard and non-inflammable and insures practically a non-shatterable lense for the protection of the pilot's eyes.

By order of the Secretary of War, the Training Camp for the Chemical Warfare Service, now under construction at Lakehurst, N. J., is designated as "Camp Kendrick."

This new camp is named in honor of Professor (Colonel, retired) Henry L. Kendrick, LL.D., who, after considerable service as a commissioned officer, served as professor of chemistry, mineralogy, and geology at the U. S. Military Academy from March 3, 1857, until his retirement from active service, December 13, 1880.

Henry L. Kendrick was appointed a cadet at the Military Academy from New Hampshire, Sept. 1, 1831; Second Brevet Lieutenant, Infantry, July 1, 1835; Second Lieutenant, April 1, 1836; First Lieutenant, June 20, 1837; Captain, June 18, 1846; Brevet Major of Volunteers, for gallantry and meritorious conduct in the defense of Pueblo, October 12, 1847; Professor, Military Academy, March 3, 1857; Brigadier General Volunteers (declined), Sept. 23, 1862; retired as Colonel, December 13, 1880, at his own request, having served 45 years as a commissioned officer and being over 62 years of age.

He received the degree of LL.D., March 3, 1857. He died in New York City May 24, 1891. He had no leave of absence from 1863 to 1880.

PERSONAL NOTES

Dr. Lucius P. Brown, who, following an investigation of the health department by the Hylan administration, New York City, was recently tried on charges of neglect of duty, acquitted, and unanimously reinstated as Director of the Bureau of Foods and Drugs of the New York Health Department, has now obtained a leave of absence for the duration of the war to accept a commission as captain in the food and nutrition division of the Sanitary Corps of the Surgeon-General's office.

Dr. J. Bishop Tingle, professor of chemistry at McMaster University, Toronto, has been elected a fellow of the Royal Society of Canada.

Mr. George C. Bunker, in charge of water purification, Canal Zone, has been engaged by the municipality of Lima, Peru, to investigate the water supplies now in use and those available for future use.

Mr. E. R. Meyer, formerly connected with the City of Toledo Water Department as chief chemist for seven years and for the past year connected with the Trommer Co., Fremont, O., is now with the Diamond Match Co., Oswego, N. Y., as assistant chemist.

Mr. Hamden Hill, research chemist of the Texas Oil Co., Bayonne, N. J., plant, died at St. Luke's hospital, New York City, on September 23, 1918, as the result of burns due to an explosion of gasoline vapors in the laboratory.

Dr. H. K. Benson, director of the Bureau of Industrial Research, University of Washington, has been commissioned captain in the nitrate division of the Army Ordnance Department. He will make investigations relative to the use of the arc process in nitrogen fixation. Until his entrance into the army, Dr. Benson acted as chief consultant for the American Nitrogen Products Co., Seattle, which is operating a commercial plant for the production of sodium nitrite at La Grande, Washington.

Mr. M. H. Barnes, formerly chemist for the Illinois Steel Co., Gary, Indiana, is now division inspector for the Aluminum Company of America, Maryville, Tenn.

Miss Irene DeMatty, for several years librarian of the Mellon Institute, Pittsburgh, and compiler of the New Publications column of THIS JOURNAL, was married in Greenville, Cal., on September 2, 1918, to Mr. Robert James Piersol.

Mr. Albert H. Carle, formerly instructor in chemistry at Union College, Schenectady, N. Y., is now employed in the chemical department of the Continental Can Co., Inc., Canonsburg, Pa.

Mr. W. Jesse Brown has resigned his position as division engineer for the Portland Cement Association to accept a commission as captain in the Ordnance Department, Nitrate Division; he will be stationed at U. S. Nitrate Plant No. 1, Sheffield, Ala.

Mr. Harold Ralph Wells, formerly graduate student and teacher in chemistry at the University of Michigan, after nearly a year's training in the Aviation Section of the Signal Reserve Corps, has been commissioned Second Lieutenant and is stationed at Park Field, Tenn., training fliers.

Mr. L. H. Goebel has resigned as superintendent of filtration and chief chemist of the Water Filtration Plant of the Union Stock Yard and Transit Co., Chicago, Ill., to become associated with the engineering staff of Wallace and Tiernan Co., manufacturers of chlorine control apparatus and sanitary engineering specialties.

Dr. Earl F. Farnau, formerly assistant professor of chemistry at New York University, has been appointed associate professor of organic chemistry at the University of Cincinnati.

Mr. Ross A. Baker, Chief Gas Officer, Camp Pike, Ark., has been made officer in charge of gas training for Chief Gas Officers, Army Gas School, Camp AA, Humphreys, Va. Mr. Baker was formerly assistant professor in chemistry at the University of Minnesota.

Mr. Arthur Lowenstein, a member of the Chicago Section of the AMERICAN CHEMICAL SOCIETY, has been elected vice president of Wilson and Company of Chicago.

Dr. Ralph E. Oesper, formerly assistant professor of chemistry at Smith College, has been appointed associate professor of analytical chemistry at the University of Cincinnati.

Dr. Clifford J. Rolle and Dr. Leonora Neuffer have been appointed instructors in chemistry at the University of Cincinnati.

Professor F. P. Treadwell of Zürich, Switzerland, died suddenly of heart disease on June 25, 1918. Chemists generally will feel his loss keenly as his excellent textbooks on analytical chemistry are widely used. Treadwell, American by birth, was born at Portsmouth, N. H., in 1857. In the early seventies he attended school at Heidelberg, and later at the university was lecture assistant from 1878 to 1881 under Bunsen. His subsequent professional service was at the Eidgenössiche Polytechnicum in Zürich.

Mr. J. Willard Hershey, who for six years has had charge of the physics and chemistry departments at Defiance College, has been appointed head of the chemistry department at McPherson College, McPherson, Kansas.

Mr. F. O. Sprague, formerly with the Cattaraugus Tanning Co. and Beardmore & Co., is now supervising the tanneries of the Transylvania Tanning Co., Brevard, N. C., the Toxaway Tanning Co., and the Rosman Tanning Extract Co., Rosman, N. C.

Dr. A. B. Coleman, formerly with the Federal Dyestuff and Chemical Corporation of Kingsport, Tenn., is now employed as research chemist for the Ault and Wiborg Co., Cincinnati, Ohio.

INDUSTRIAL NOTES

Coal land in West Virginia will be developed by the American Eagle Colliery Co., Charleston, incorporated with a capital of $600,000. The incorporators are George S. Crouch, V. L. Black, L. G. Summerfield, and others.

Cellulose Co., New York, financed by Vickers Co. and Nobel Co., London, will build the $10,000,000 Cumberland, Md., cellulose manufacturing plant which the War Department recently announced would be commenced. Until the war is won the cellulose products will be taken by the Government for airplanes; after that the Cellulose Company intends manufacturing acids, drugs, dyes, etc., from cellulose and other materials.

The Mississippi Wood Products Company has been incorporated, with $500,000 capital, by W. B. Burke and P. H. Starts of Charleston and G. E. Lamb of Clinton, Iowa. Output will be wood alcohol and acetone manufactured from the waste of the Lamb-Fish lumber mills.

A petition has been presented to the Secretary of Industry and Commerce, Mexico, for permission to develop petroleum deposits believed to exist in Lower California.

The Atlantic Potash Corporation has been incorporated at Dover, Del., with a capital of $1,000,000, to manufacture potash and chemicals.

A new chemical plant will be erected at a cost of $1,000,000 at Mechanicsville, N. Y. The plant will utilize the by-products from the West Virginia Pulp & Paper Company's plant in the manufacture of acetone for aeroplane wings.

The Castle Chemical & Color Co., Valley Stream, N. Y., has been incorporated with a capital of $300,000 by H. B. Knapp, I. J. Hartof, and E. Huneker.

The plant of the British-American Chemical Co., Ridgefield Park, N. J., manufacturing chemicals for war use, is to be increased by the erection of additions costing approximately $1,500,000.

The U. S. Nitrate Co., Tacoma, Wash., has been incorporated by J. E. Austin, J. E. Berkheimer, F. Campbell, and August Stein, with a capital stock of $1,000,000.

The wood chemical plant at Lyles, Tenn., which the Bon Air Coal and Iron Corporation of Nashville is building in accordance with contract to supply the Government with materials for explosives manufacturing, is expected to be ready for operation by December 1. Each day the completed factory will produce from 2,000 to 3,000 gal. of wood alcohol, 40,000 lbs. of acetate of lime, and 10,000 bushels of charcoal. All the alcohol and acetate of lime will be taken by the Government for the purpose of manufacturing explosives, while the output of charcoal will be burned in the Bon Air Coal and Iron Company's iron furnace.

Importation of vegetable oils and material for their production has trebled in value since the beginning of the war, and the United States, in common with other parts of the world, has greatly increased its consumption of food oils. With the demand for animal fats for the men in the trenches, people at home have turned to vegetable fats to take the place of the meats, butter, cheese, and condensed milk which they are sending to the battlefields. In addition to this, the war itself has made great demands upon the vegetable oils of the world, as a source of glycerin. A compilation by the National City Bank of New York shows that the United States alone, although the world's largest producers of cottonseed oil, imported in 1917 approximately $75,000,000 of food oils and material for their production, about one-fourth of this coming from the Philippine Islands.

With something like 110,000 acres of castor beans now being grown in the South under contract for the Government at a fixed price, the war-work authorities of the Government recently took the next step in providing an adequate supply of castor oil for the lubrication of the fleet of airships now being built. After nearly three months of investigation, study, and negotiation, carried on by cooperative efforts of the Signal Corps, the War Industries Board, and the Bureau of Plant Industry, of the United States Department of Agriculture, a contract has been let for the establishment of a plant in the South at which it is proposed to crush all the castor beans grown for the Government in Florida and adjoining States. This plant is to be located at Gainesville, Fla., and will be the largest castor-oil plant in the world.

Ricketts & Company, Inc., mining, metallurgical, and chemical engineers, have opened new laboratories at Room 590, 80 Maiden Lane, New York City, where they are equipped for assay and analytical work of all kinds, especially analyses of glycerin and manganese.

Copper and iron products for maritime purposes will be manufactured by the Curtis Bay, Md., Copper and Iron Works, incorporated with $1,000,000 capital by William F. Cochrane of South Baltimore, Md., M. C. Whitaker of Curtis Bay, Md., Patrick H. Loftus of New York, and others.

The Harrison Works of E. I. du Pont de Nemours & Company have opened a new Chicago office at 1542 McCormick Bldg., 332 S. Michigan Avenue. Under the direction of district salesmanager, W. H. Hasse, this office will be devoted exclusively to the sale of chemicals, pigments, and dry colors.

Messrs. A. E. S. Thompson & Company, handling large quantities of chemicals and dyes in the Oriental market, have established a San Francisco branch in the Merchants Exchange Building for the convenience of their clientele in America.

The plant of the La Salle Portland Cement Co., of La Salle, Ill. (known before the war as the German-American Portland Cement Co.), has been taken over by the Alien Property Custodian.

The Bureau of Markets has announced that 75,000 tons of nitrate of soda were bought in Chile through the War Industries Board and distributed to the farmers in this country at cost through the Department of Agriculture.

A process for making soap out of paraffin is announced by Dr. Bergman, at Leipzig. By the introduction of air the paraffin is oxidized while heated to about 130° in an iron boiler. The result is a brown ointment-like substance which, when treated with an alkali, produces a good lathery soap.

Phosphorus for war purposes may be manufactured at Tampa, Fla., by the Government; 26,000 kilowatts of electric power will be required. The War Department contemplates building the plant and Major Wm. G. Lockwood is now investigating as to the necessary facilities.

A $100,000 guncotton factory will be built by the Trinity Products Co., Dallas, Texas.

The Union Paint Co. of Manhattan has been incorporated with a capital of $1,000,000 by S. H. McIntosh, C. Mayer, and T. E. Byrnes, 120 Broadway, New York City.

The Southern Pine Tar and Oil Co., Savannah, Ga., has been incorporated with $200,000 capital by Henry Henken, W. W. Wilder, W. H. Proctor, and others. It will manufacture oil, tar, and various other products from southern pine timber.

A number of Swedish cellulose factories have combined to form a company for the production of alcohol from sulfite pulp. A number of sulfite spirit factories are ready and during this year nine new ones will be built and in 1919 five more are planned. Then a yearly production of 20,000,000 liters of alcohol will be attained.

The U. S. Geological Survey estimates a record-breaking outturn of copper for the current year. Even if the output has increased, the demand keeps up in like proportion, so that two records, one for consumption and another for production, may be established during 1918.

Members of the chemical trade in New York and vicinity, at the suggestion of the National League for Woman's Service, have raised $2566 to purchase and equip an ambulance to convey wounded soldiers to the base hospitals from the vessels arriving at Atlantic ports. This sum was made up as requested of individual contributions not exceeding $100 each.

A mysterious explosion occurred on August 19, 1918, at the Strausser Chemical Company's plant at Chauncey, N. Y., where a big Government order for acids used in manufacturing explosives was being filled. The explosion did not occur in any of the tanks of chemicals, but on the outside of the main building.

The Swedish dynamite industry is being seriously handicapped by the scarcity of glycerin, and difficulties are being encountered in providing the mining enterprises with sufficient quantities of explosive. Recent experiments in the use of liquid air as an explosive have resulted in several concerns procuring licenses for using German methods for compressing air. Machinery for these factories, which are regarded as war substitutes, has to be imported from Germany.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

PUBLIC HEALTH SERVICE

The following four articles make up Bulletin 112 of the Hygienic Laboratory. 52 pp. Paper, 10 cents.

(1) **Phenols as Preservatives of Antipneumococcic Serum, Pharmacological Study (with Bibliography).** Carl Voegtlin.

(2) **Nature of Contaminations of Biological Products.** I. A. Bengtson.

(3) **Studies in Preservatives of Biological Products, Effects of Certain Substances on Organisms Found in Biological Products.** M. H. Neill.

(4) **Effect of Ether on Tetanus Spores and on Certain Other Microörganisms.** H. B. Corbitt.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

The third annual report of the National Advisory Committee for Aeronautics includes the following reports that are of chemical interest. The full report covers 495 pages and is available from the Superintendent of Documents. Bound in paper, $1.50.

Report 13. Meteorology and Aeronautics. Part 1, Physical properties and dynamics of atmosphere; Part 2, Topographic and climatic factors in relation to aeronautics; Part 3, Current meteorology and its use. Prepared by William R. Blair. Submitted by Subcommittee on Relation of Atmosphere to Aeronautics.

Report 14. Experimental Research on Air Propellers. William F. Durand. Part 1, Aerodynamic laboratory at Leland Stanford Junior University and equipment installed, with special reference to tests on air propellers; Part 2, Tests on 48 model forms of air propellers, with analysis and discussion of results and presentation of same in graphic form; Part 3, Brief discussion of law of similitude as affecting relation between results derived from model forms and those to be anticipated from full-sized forms.

Report 22. Fabrics for Aeronautic Construction, Subcommittee on Standardization and Investigation of Materials. Part 1, Cotton airplane fabrics, E. D. Whalen; Part 2, Balloon fabrics, contributed by Bureau of Standards, Balloon Fabric Committee.

Report 23. Aeronautic Power Plant Investigations, Subcommittee on Power Plants. Part 1, Performance of aeronautic engines at high altitudes; Part 2, Radiator design; Part 3, Spark plugs, H. C. Dickinson.

GEOLOGICAL SURVEY

Bismuth in 1917. J. B. Umpleby. Separate from Mineral Resources of the United States, 1917, Part I. 3 pp. Published June 19.

The demand for bismuth, unlike that for most other metals, has not greatly increased during the war. There continue to be only two producers of bismuth in this country, so that the production may not be given, but it was very little in excess of that for 1916, and the wholesale price is understood to have been about 6 cents per lb. lower. The bismuth produced in this country is almost entirely a by-product obtained in the refining of lead bullion. Market conditions have not heretofore justified the recovery of bismuth at many plants where it could be obtained from flue dust or bullion, and as the cost of mining and delivery to these plants is charged against other constituents of the ore, it is doubtful whether ore that is primarily valuable for bismuth will ever command a ready market in this country unless the use of the metal is greatly extended.

The imports of bismuth in 1917 were somewhat less than in 1916, although greater than in 1915. Prior to the last decade the supply of bismuth in this country was almost entirely imported, but in recent years most of the imports have been displaced by the domestic product. The industry, however, is not a large one in this country, probably less than 250 short tons annually being sufficient to meet the demand.

Selenium in 1917. J. B. Umpleby. Separate from Mineral Resources of the United States, Part I. 1 p. Published June 19.

For the first time in recent years more than two companies reported a production of selenium in 1917, so that figures may now be given. The output in 1917 was 39,630 pounds, valued at $70,000.

Selenium, it is understood, was in demand in 1917, and the principal producing company reports that its output has been contracted for well into the future. This is in keeping with the fact that the value of imports for consumption of selenium and salts of selenium rose from $59 in 1915 and $302 in 1916 to $2,236 in 1917.

The shortage of imported manganese suitable for the glass industry has compelled the manufacturers of glass to seek a substitute, and it is reported that selenium has been found to be the most satisfactory.

Most of the selenium produced is a by-product in the electrolytic refining of copper. It is the opinion of metallurgists that if market conditions warranted, the domestic production would be greatly increased.

Prices at the refinery ranged from $1.29 to $3 per lb., but as usual the price for small lots was much higher and ranged between wide limits, depending largely on the quantity purchased.

Tellurium in 1917. J. B. Umpleby. Separate from Mineral Resources of the United States, 1917, Part I. 1 p. Published June 19.

There continues to be little market for tellurium and a correspondingly small production. Only two refiners, the Raritan Copper Works and the United States Smelting, Refining & Mining Co., reported a production in 1917.

Tellurium, like selenium, is a by-product from the electrolytic refining of copper. The domestic production is capable of large expansion if market conditions should warrant, as almost all blister copper contains recoverable quantities of tellurium. Much of this would be saved, if a demand existed, at prices of $1.50 to $2.50 per lb. In 1917 prices at the refinery averaged about $3 per lb., but a very small additional output would probably have flooded the market.

A Geologic Reconnaissance of the Uinta Mountains, Northern Utah, with Special Reference to Phosphate. A. R. Schultz. Bulletin 690–C. From Contributions to Economic Geology, 1918, Part I. 64 pp. Published May 10. No detailed work upon which to base a reliable estimate of tonnage has been done in this field. It is apparent, however, from the reconnaissance examination that a large amount of phosphate is present.

Geology and Oil Prospects of the Salinas Valley-Parkfield Area, California. W. A. ENGLISH. Bulletin 691–H. From Contributions to Economic Geology, 1918, Part II. 42 pp. Published June 18. Though by far the larger part of the area examined has little to recommend it for wild-cat drilling, certain areas appear to be well worth testing.

Oil Shale of the Uinta Basin, Northeastern Utah, and Results of Dry Distillation of Miscellaneous Shale Samples. D. E. WINCHESTER. Bulletin 691–B. From Contributions to Economic Geology, 1918, Part II. 29 pp. Published April 30. "The reconnaissance studies of the Uinta Basin have proved the existence along its entire southern margin of a bed or beds of oil shale of minable thickness and as rich or richer than those mined in Scotland at the present time. Previous examinations by members of the Geological Survey have revealed the fact that at practically all points along the north side of the basin, the Green River formation (containing the oil shale) is concealed beneath younger rocks which overlie the oil-shale beds unconformably, so that the area within the Uinta Basin underlain by oil shale cannot be determined without extensive prospecting with the drill. However, evidence at hand seems to indicate that the oil shale may be present beneath a great part of the basin, and it is estimated that the Utah portion of the basin alone contains sufficient shale to produce 42,800,000,000 barrels of crude shale oil, with perhaps 500,000,000 tons of ammonium sulfate as a by-product."

BUREAU OF FOREIGN AND DOMESTIC COMMERCE

Statistical Abstract of United States, 1917. 804 pp. Paper, 40 cents. This report presents in condensed form statements regarding commerce, productions, industries, population, finance, currency, indebtedness, and wealth of country, for series of years, compiled from more important statistical data collected by various Government departments; also condensed statement of commerce of principal foreign countries.

Standard Specifications and Tests for Portland Cement. Industrial Standards Serial, Publication No 1. 47 pp. Paper, 10 cents. The text of these specifications was adopted by the American Society for Testing Materials and by the United States Government. This is Revised 1917 Edition printed in Spanish and English. It was prepared with the cooperation of the Bureau of Standards.

COMMERCE REPORTS—JULY, 1918

The **turpentine** and **rosin industry** of India is increasing, though not yet able to supply the entire local demands. Methods of production are described in detail. (P. 7)

The Research Council of Ottawa has established a number of **research fellowships** in science, with special emphasis on industrial applications. "Studentships" of $750 per year and fellowships of $1000 to $1400 per year are open to graduate students in any Canadian universities. (P. 21)

The use of cardboard containers to replace **tin** in England has brought about not only a great saving in tin, but also in **steel**, of which it is estimated that 60,000 tons are thus saved annually. (P. 30)

New discoveries of **tungsten** ore in veins are reported near Swatow, China. (P. 79)

Cultivation of the castor bean in Malaga, Spain, is being encouraged to meet increased demands for **castor oil** for airplane lubrication. (P. 108)

Great difficulty is being experienced in Norway to obtain sufficient bark for **tanning material**, to replace former imports. Owing to the low tannin content of Norwegian bark, 400,000 tons will be required. The principal barks used are spruce, birch, oak, and willow, all cut from hewn trees and formerly wasted. That cut at sap time is superior to that cut in winter. A sulfite cellulose extract, known as "Norwego," is also used for tanning. (P. 148)

Manganese ore containing 40 per cent of manganese is now being shipped to the United States. P. 161

Peat fiber, also called "peat wool," is being used extensively in Sweden and Denmark for the manufacture of matting, carpet, feet soles in footwear, etc.; and by the addition of 30 to 40 per cent of wool, cloth can be produced. (P. 169)

The output of **manganese** ore from Panama is increasing, over 18,000 tons having been exported to the U. S. (P. 264)

Monazite sands discovered in Burma contain so low a percentage of thorium (only 0.18 per cent ThO_2), as to be of no commercial value. (P. 274)

A special scientific commission appointed to consider the best method of making **caustic soda** in Brazil has recommended the electrolytic process. (P. 292)

Exports of **camphor** from Japan have been restricted, owing to greatly increased domestic demands, especially for **celluloid**. (P. 299)

The **metal** output of Mexico in 1917, in kilos, was as follows: Gold, 5,788,972; silver, 648,684,365; copper, 141,528,966; lead, 29,769,455; zinc, 3,888,124; antimony, 2,140,590. (P. 325)

A detailed account is given of the application in England of the solvent extraction process for the **recovery of fats**, especially from "sud calce" (from the textile industry) and sewage sludge. The process is so successful that it now represents a profitable undertaking as well as a conservation of fat. (Pp. 357–366)

In a recent **fuel conservation** order in England, total fuel, including coal, gas, and electricity, used for heating or lighting is restricted according to the size of the house, etc. In order to encourage the manufacture and use of gas in those districts in which it can be economically made (and thus increase the supply of by-products), gas may be substituted for coal, at the rate of only 12,000 cu. ft. of gas per ton of coal in districts unfavorable for gas manufacture, and at the rate of 18,000 cu. ft. per ton in favorable districts. (Pp. 369–373)

Imports of **tin** into the United States in 1917–18 were the highest ever recorded. 13 per cent were imported in the form of Bolivian ore to be smelted in this country. (P. 412)

Large amounts of **iron oxide pigment** ("red oxides") are now exported from Malaga to the United States. The product is purified by levigation. The coloring power is not determined solely by the Fe_2O_3 content, since the Persian Gulf oxides, with lower Fe_2O_3 content, have higher coloring power than the Spanish oxides. (P. 412)

Extraction of **crude oil, acetic acid, ammonia, pitch,** and **gum spirit** from kauri peat gum swamps in New Zealand is becoming an important industry. (P. 415)

SPECIAL SUPPLEMENTS ISSUED IN JULY

SPAIN (P. 1[illegible]) CHINA (P. 52)
MEXICO (P. 329) BRITISH SOUTH AFRICA (P. 76)

EXPORTS TO THE UNITED STATES

VERA CRUZ (P. 390)
Indigo
Jalap root
Hides
Rubber
Silver
Alum
Cuticle
Saffron
Vanilla
Lead
Mica
Aniseed oil
Mercury

CHILE (P. 408)
Arsenic
Beeswax
Copper
Copper ore
Copper regulus
Glue
Hides
Mercury
Sodium nitrate
Quillay soap bark
Silver
Tartar

MALAGA (P. 351; Sup. 154)
Thymol
Essential oils
Almond oil
Olive oil
Iron ore
Iron oxide pigment
Licorice

MEXICO—Sup. 32b
Bones
Calcium citrate
Copra
Glue stock
Oil of limes
Sesame oil cake
Lead ore
Silver ore
Zinc ore

DURBAN SO. AFRICA—Sup. 76a
Asbestos
Mangrove bark
Wattle bark
Gum copal
Hides
Mica
Corundum

SHANGHAI, CHINA—Sup. 52c
Antimony
Alkanet
Camphor
Cantharides
Aniline dyes
Indigo
Gall nuts
Musk
Rhubarb
Sodium benzoate
Copper
Peanuts
Vegetable tallow
Hides
Bean oil
Castor oil
Cottonseed oil
Peanut oil
Rape oil
Wood oil

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Alcohol: Its Composition and Preparation. CENTRAL CONTROL BOARD OF ENGLAND. 133 pp. Price, $0.60. Longmans, Green & Co., New York.

Analysis: Aids to the Analysis of Food and Drugs. C. G. MOOR AND W. PARTRIDGE. 4th Ed. 12mo. Price, 4s. Baillière, London.

Chemical Analysis of Iron. A. A. BLAIR. 8th Ed. 8vo. 318 pp. Price, $5.00. J. B. Lippincott, Philadelphia.

Chemistry: Essentials of Modern Chemistry. C. E. DULL. 12mo. 458 pp. Price, $1.40. Henry Holt & Co., New York.

Chemistry: An Intermediate Textbook of Physiological Chemistry. C. J. V. PETTIBONE. 8vo. 328 pp. Price, $2.50. C. V. Mosby Co., St. Louis.

Chemistry: Principles of Chemistry. J. H. HILDEBRAND. 12mo. 313 pp. Price, $1.75. The Macmillan Co., New York.

Chemistry: Textbook of Physical Chemistry. A. T. LINCOLN. 12mo. 547 pp. Price, $3.50. D. C. Heath & Co., New York.

Chemistry for Engineers and Manufacturers. B. BLOUNT AND A. G. BLOXAM. 2nd Ed. 8vo. 404 pp. Price, 14s. Chas. Griffin & Co., London.

Chemistry of Essential Oils and Artificial Perfumers. Vol. 1. E. J. PARRY. 3rd Ed. 8vo. 532 pp. Price, 25s. Scott, Greenwood & Co., London.

Concrete Stone Manufacture. H. M. WHIPPLE. 2nd Ed. 12mo. 318 pp. Price, $1.50. Concrete-Cement Age Pub., Detroit, Mich.

Food: Its Composition and Preparation. M. T. DOWD AND J. D. JAMESON. 12mo. 173 pp. Price, $1.25. John Wiley & Sons, Inc., New York.

Hindu Achievements in Exact Science. A Study in the History of Scientific Development. VINAYA-KUMARA SARKAR. 12mo. 82 pp. Price, $1.00. Longmans, Green & Co., New York.

Hydraulic and Placer Mining. E. B. WILSON. 3rd Ed. 12mo. 425 pp. Price, $3.00. John Wiley & Sons, Inc., New York.

International Mining Law. T. F. VAN WAGENEN. 12mo. 342 pp. Price, $3.50. McGraw-Hill Co., New York.

Minerals, Prospecting for. S. H. COX. 7th Ed. 8vo. 271 pp. Price, 5s. Charles Griffin & Co., London.

Mining Geology: A Textbook of Mining Geology. JAMES PARK. 8vo. 354 pp. Price, 9s. Charles Griffin & Co., London.

Popular Oil Geology. VICTOR ZIEGLER. 12mo. 149 pp. Price, $2.50. John Wiley & Sons, Inc., New York.

Soap Makers Directory, 1918. 21st Ed. 8vo. 97 pp. Price, 2s 6d. Simpkin, Marshall & Co., London.

Stoichiometry. SYDNEY YOUNG. 2nd Ed. 8vo. 363 pp. Price, $3.75. Longmans, Green & Co., New York.

Studies on Solution in Its Relation to Light-Absorption, Conductivity, Viscosity, and Hydrolysis. P. B. DAVIS AND OTHERS. 8vo. 144 pp. Price, $2.00. Carnegie Institute of Washington, Washington, D. C.

Water Rights Determination from an Engineering Standpoint. J. M. WHITHAM. 8vo. 204 pp. Price, $2.50. John Wiley & Sons, Inc., New York.

RECENT JOURNAL ARTICLES

Aluminum and Its Light Alloys. P. D. MERICA. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 4, pp. 200–202.

Analysis of Ferrozirconium and Zirconium in Steel. J. D. FERGUSON. *Engineering and Mining Journal*, Vol. 106 (1918), No. 8, p. 356.

Bisulfite Liquor and Its Constituents. JAMES BEVERIDGE. *Paper*, Vol. 22 (1918), No. 23, pp. 11–15.

Carbocoal Fuel Process Perfected. C. T. MALCOMSON. *Iron Trade Review*, Vol. 63 (1918), No. 9, pp. 496–497.

Chromite. J. C. WILLIAMS. *Mining and Scientific Press*, Vol 117 (1918), No. 9, pp. 281–282.

Coal: Aspects of the Low Temperature Carbonization of Coal. E. C. EVANS. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 14, pp. 212*t*–219*t*.

Coal: Danger to Equipment from Impure Coal. W. S. GOULD *Iron Trade Review*, Vol 63 (1918), No. 9, p. 501.

Coke: Some Characteristics of American Coke in By-Product Coking Practice. F. W. SPERR, JR. *Journal of the Franklin Institute*, Vol. 186 (1918), No. 2, pp. 133–164.

Coke: The Wastage of Coke By-Products. FREDERICK MCCOY. *Engineering and Mining Journal*, Vol. 106 (1918), No. 6, pp. 254–255.

Colloidal Chemistry in Papermaking. W. M. BOVARD. *Pulp and Paper Magazine*, Vol 16 (1918), No. 33, pp. 729–731.

Combustion Train for Carbon Determination; Apparatus Giving Results in Six Minutes and Meeting Color Test Inaccuracies Arising from Varying Heat Treatment of Samples. J. B. SHEESER AND R. H. NORTON *Iron Age*, Vol. 102 (1918), No. 8, pp. 443–445.

Concrete: Failures in Reinforced Concrete. H. J. CREIGHTON. *Pulp and Paper Magazine*, Vol 16 (1918), No. 35, pp. 771–773.

Cutting Steel Ingots with Oxy-Hydrogen. W. B. PERDER. *Iron Trade Review*, Vol. 63 (1918), No. 9, pp. 504–505.

Development of Electric Melting Furnaces. H. W. GILLETT AND A. E. RHOADS. *The Metal Industry*, Vol. 16 (1918), No. 8, pp. 355–358.

Die Blocks: Correct Heat Treatment of Die Blocks. GUSTAF PETERSON. *The American Drop Forger*, Vol. 4 (1918), No. 8, pp. 295–297.

Dyestuffs. L. J. MATOS. *Journal of the Franklin Institute*, Vol. 186 (1918), No. 2, pp. 187–210.

Fertilizer: The General Fertilizer Situation. C. G. WILSON. *The American Fertilizer*, Vol. 49 (1918), No. 3, pp. 128–138.

Filtered Water for Industrial Use. Large Savings are Effected by the Purification of Water Used for Steam Generation and Cooling Purposes. H. C. STEVENS. *Iron Trade Review*, Vol. 63 (1918), No. 9, pp. 491–494.

Forging: Fuel Analysis of a Drop Forge Plant. Part 2. B. K. READ. *American Drop Forger*, Vol. 4 (1918), No. 8, pp. 307–312.

Forging: Possibilities of the Forging Machine. E. R. HAGEN. *American Drop Forger*, Vol. 4 (1918), No. 8, pp. 304–305.

Fuel: Application of Efficiency Principles in Burning Fuel Under Boilers. JOSEPH HARRINGTON. *Journal of the Cleveland Engineering Society*. Vol. 11 (1918), No. 1, pp. 45–56.

Fuel: Maximum Fuel Production with Minimum Fuel Waste. D. M. MYERS. *Industrial Management*, Vol. 56 (1918), No. 2, p. 104.

Galvanizing: Modern Practice in Galvanizing Sheets. Methods of Constructing and Operating Galvanizing Pots. C. F. POPPLETON. *Iron Age*, Vol. 102 (1918), No. 8, pp. 433–436.

Gasoline-Driven Diamond-Drill Outfit. J. M. LONGYEAR. *Engineering and Mining Journal*, Vol. 106 (1918), No. 8, pp. 343–345.

Hammer Foundations: Question of Correct Hammer Foundations. TERREL CROFT. *American Drop Forger*, Vol. 4 (1918), No. 8, pp. 300–304.

Industrial Research: Developments in Industrial Research. C. L. REESE. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 4, pp. 197–199.

Japanese Steel: Future of the Japanese Steel Industry. J. P. SUZUKI. *Iron Trade Review*, Vol. 63 (1918), No. 7, pp. 389–390.

Liquid Crystals: Studies in Liquid Crystals. T. C. CHAUDHARI. *Chemical News*, Vol. 117 (1918), No. 3054, pp. 269–272.

Lubrication: Methods of Conducting Tests of Lubricants on Internal Combustion Engines. S. F. LENTZ. *Lubrication*, Vol. 5 (1918), No. 9, pp. 4–9.

Magnetic Permeability of Steel. F. P. FAHY. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 5, pp. 247–250.

Manufacture of Ferro-Alloys in Colorado. R. M. KEENEY. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, pp. 405–409.

Manufacture of Tin and Lead Foil. L. J. KROM. *Metal Industry*, Vol. 16 (1918), No. 8, pp. 352–354.

Metallurgical Treatment of Radium Ores. R. B. MOORE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, pp. 410–412.

Mining in the Telluride District of Colorado. H. J. WOLF. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, pp. 395–399.

Molybdenite Operations at Climax, Colorado. D. F. HALEY. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, p. 394.

Nitrate Deposits of Southeastern Oregon. I. A. WILLIAMS. *Mining and Scientific Press*, Vol. 117 (1918), No. 9, pp. 285–289.

Potash: The Recovery of Potash as a By-Product in the Manufacture of Portland Cement. J. J. PORTER. *Chemical Engineer*, Vol. 26 (1918), No. 8, pp. 289–290.

Radium Ore Deposits. R. B. MOORE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, pp. 392–393.

Refrigeration and Ice Making. C. L. HUBBARD. *Industrial Management*, Vol. 56 (1918), No. 2, pp. 105–109.

Remelting of Aluminum Pig in the Electric Furnace. D. D. MILLER. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 5, pp. 251–254.

Roaster: The New American Spirtlet Roaster. F. J. HARLOW. *Engineering and Mining Journal*, Vol. 106 (1918), No. 7, pp. 293–299.

Roasting of Sulfotelluride Ores for Amalgamating and Cyaniding. A. L. BLOOMFIELD AND J. M. TROTT. *Engineering and Mining Journal*, Vol. 106 (1918), No. 9, pp. 400–404.

Soap and Its Textile Use. W. H. BUTLER. *Textile World Journal*, Vol. 54 (1918), No. 9, p. 33.

Sulfite Coal. R. W. STREHLENERT. *Pulp and Paper Magazine*, Vol. 16 (1918), No. 32, pp. 709–710.

Sulfite Pulp Manufacture, Chemistry of the Process and Details of the Various Operations. R. E. COOPER. *Paper*, Vol. 22 (1918), No. 25, pp. 11–13.

Sulfur and Pyrites Situation in Relation to the Fertilizer Industry. A. D. LEDOUX. *American Fertilizer*, Vol. 49 (1918), No. 3, pp. 113–123.

Sulfur in Natural Gas. J. P. PHILLIPS. *Bessemer Monthly*, 1918, No. 18, pp. 2–4.

Sulfuric Acid: The Production of Sulfuric Acid. W. D. HUNTINGTON. *American Fertilizer*, Vol. 49 (1918), No. 3, pp. 123–125.

MARKET REPORT—SEPTEMBER, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON SEPTEMBER 10, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal		
Alum, ammonia, lump	100 Lbs.	7.00		
Aluminum Sulfate, (iron free)	Lb.	4	@	5
Ammonium Carbonate, domestic	Lb.	nominal		
Ammonium Chloride, white	Lb.	19	@	20
Aqua Ammonia, 26°, drums	Lb.	nominal		
Arsenic, white	Lb.	9¾	@	17
Barium Chloride	Ton	75.00	@	90.00
Barium Nitrate	Lb.	12	@	14
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent	Lb.	4	@	5
Blue Vitriol	Lb.	9¼	@	9¾
Borax, crystals, in bags	Lb.	7¾	@	10¼
Boric Acid, powdered crystals	Lb.	7¾	@	8¼
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused	Ton	20.00	@	22.00
Caustic Soda, 76 per cent	100 Lbs.	4.25	@	4.50
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	20.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	2.00	@	3.00
Green Vitriol, bulk	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial	Lb.	C. P. nominal		
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	18
Lead Nitrate	Lb.	C. P. 85		
Litharge, American	Lb.	14	@	15
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	30
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	7¾		
Nitric Acid, 42°	Lb.	8¼		
Phosphoric Acid, 48/50%	Lb.	7½	@	9
Phosphorus, yellow	Lb.	1.10	@	1.15
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate	Lb.	44	@	46
Potassium Bromide, granular	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%	Lb.	35	@	
Potassium Chlorate, crystals, spot	Lb.	40	@	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	60	@	70
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.	Lb.	1.85	@	2.00
Quicksilver, flask	75 Lbs.	130.00	@	135.00
Red Lead, American, dry	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'	Ton	22.00	@	25.00
Silver Nitrate	Oz.	63½	@	65
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.50	@	2.60
Sodium Acetate, broken lump	Lb.	20	@	21
Sodium Bicarbonate, domestic	100 Lbs.	3¼	@	3½
Sodium Bichromate	Lb.	23	@	24
Sodium Chlorate	Lb.	25	@	25½
Sodium Cyanide	Lb.	32	@	35
Sodium Fluoride, commercial	Lb.	17	@	18
Sodium Hyposulfite	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.42½	@	5.00
Sodium Silicate, liquid, 40° Bé		2¼	@	2¾
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal		
Sodium Bisulfite, powdered		12	@	14
Strontium Nitrate	Lb.	25	@	30
Sulfur	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé	Ton	18.00		
Sulfuric Acid, oleum (fuming)	Ton	32.00		
Talc, American white	Ton	15.00		
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	28	@	30
Tin Oxide	Lb.	90	@	1.00
White Lead, American, dry	Lb.	10	@	10¼
Zinc Carbonate	Lb.	18	@	20
Zinc Chloride, commercial	Lb.	15	@	15½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	70	@	72
Acetic Acid, 56 per cent, in bbls	Lb.	10.76	@	10.77
Acetic Acid, glacial, 99½%	Lb.	19.50	@	19.70
Acetone, drums	Lb.	25½	@	
Alcohol, denatured, 180 proof	Gal.	68	@	69
Alcohol, sugar cane, 188 proof	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined	Gal.	91½	@	92
Amyl Acetate	Gal.	5.30	@	5.35
Aniline Oil, drums extra	Lb.	28½	@	30
Benzoic Acid, ex-toluol	Lb.	2.65	@	2.85
Benzol, pure	Gal.	23	@	28
Camphor, refined in bulk, bbls	Lb.	1.24½	@	1.25
Carbolic Acid, U. S. P., crystals, drums	Lb.	42	@	45
Carbon Bisulfide	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals	Lb.	nominal		
Chloroform	Lb.	70	@	75
Citric Acid, domestic, crystals	Lb.	82	@	83
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	20	@	22
Dextrine, corn (carloads, bags)	Lb.	8	@	9
Dextrine, imported potato	Lb.	nominal		
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	16¼	@	18
Glycerine, dynamite, drums extra	Lb.	60	@	62
Oxalic Acid, in casks	Lb.	41	@	43
Pyrogallic Acid, resublimed, bulk	Lb.	3.25	@	3.50
Salicylic Acid, U. S. P.	Lb.	85	@	95
Starch, corn (carloads, bags) pearl	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese	Lb.	13	@	14
Starch, rice	Lb.	12½	@	13
Starch, sago flour	Lb.	9¾	@	10¼
Starch, wheat	Lb.	nominal		
Tannic Acid, commercial	Lb.	65	@	80
Tartaric Acid, crystals	Lb.	82	@	85

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63	@	63
Black Mineral Oil, 29 gravity	Gal.	24	@	25
Castor Oil, No. 3	Lb.	30	@	32
Ceresin, yellow	Lb.	17	@	18
Corn Oil, crude	100 Lbs.	17.75	@	18.00
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	21.00	@	22.00
Menhaden Oil, crude (southern)	Gal.	1.15	@	1.25
Neat's-foot Oil, 20°	Gal.	3.45	@	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	9¾	@	10
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	15.10	@	15.20
Rosin Oil, first run	Gal.	75	@	76
Shellac, T. N.	Lb.	68	@	70
Spermaceti, cake	Lb.	31	@	33
Sperm Oil, bleached winter, 38°	Gal.	2.23	@	2.25
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	36	@	38
Turpentine, spirits of	Gal.	65	@	66½

METALS

Aluminum, No. 1, ingots	Lb.	33	@	34
Antimony, ordinary	Lb.	13¾	@	14
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	26	@	
Copper, lake	Lb.	26	@	
Lead, N. Y.	Lb.	8.05		
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	1.01¼		
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	20.00	@	24.00
Zinc, N. Y.		9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	8.00	@	9.00
Blood, dried, f. o. b. Chicago	Unit	6.95		
Bone, 3 and 50, ground, raw	Ton	38.00	@	40.00
Calcium Cyanamide	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.25	and	20c
Phosphate, acid, 16 per cent	Ton	16.50	@	17.50
Phosphate rock, f. o. b. mine:	Ton	nominal		
Florida land pebble, 68 per cent	Ton	5.00	@	6.00
Tennessee, 78–80 per cent	Ton	7.00	@	8.00
Potassium "muriate," basis 80 per cent	Ton	290.00	@	300.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.75	@	6.80

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | NOVEMBER 1, 1918 | No. 11

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD H. K. BENSON F. K. CAMERON B. C. HESSE A. D. LITTLE A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized July 13, 1918.

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY EASTON, PA

TABLE OF CONTENTS

EDITORIALS:
- Preparation for After the War.... 878
- Developments in Ceramics.... 878
- Commissions for Baseball Players.... 879
- A Record of Achievement.... 879
- Conservation Begins at Home.... 879
- Another Idol Shattered.... 880
- Pernicious Activity.... 880

OUR PREPARATION FOR AFTER THE WAR. Bernhard C. Hesse.... 881

CHEMICAL MARKETS IN THE UNION OF SOUTH AFRICA. O. P. Hopkins.... 887

ORIGINAL PAPERS:
- Examination of Organic Developing Agents. H. T. Clarke.... 891
- A Summary of the Literature on the Solubility of Systems Related to Niter Cake. H. W. Foote.... 896
- The Recrystallization of Niter Cake. Blair Saxton.... 897
- The Formation of Aromatic Hydrocarbons from Natural Gas Condensate. J. G. Davidson.... 901

LABORATORY AND PLANT:
- Methods of Analysis Used in the Coal-Tar Industry. III—Heavy and Middle Oils. J. M. Weiss 911
- The Polariscope Situation and the Need of an International Saccharimetric Scale. C. A. Browne.... 916

ADDRESSES:
- The Potash Situation. A. W. Stockett.... 918
- Russia's Production of Platinum. Albert R. Merz.... 920
- The Preparation of Several Useful Substances from Corn Cobs. F. B. LaForge and C. S. Hudson 925
- Statistics of Garbage Collection and Garbage Grease Recovery in American Cities. Raymond Pearl 927
- Cotton Oil Industry in the War. David Wesson 930

THE BUREAU OF FOREIGN AND DOMESTIC COMMERCE—ITS RELATIONS TO AMERICAN CHEMICAL INDUSTRY:
- Government Trade-Building Information. C. D. Snow 931
- Our Publications and Their Bearing on the Chemical Industry. O. P. Hopkins 933
- The Method of Preparation of the Census of Chemical Imports. E. R. Pickrell 936

CURRENT INDUSTRIAL NEWS:
- Analysis of White Metal, Lubricating Oil, Venezuelan Trade Inquiries, Potash Salts in Chile, New Concrete Mixer; Combustion of Coal, Batik Dyeing Process; Lamp Tests; New Radio-Active Element Rubber Seed Oil; The Schoop Metal-Spray Process; Catalytic Processes in Germany; Cadmium in Brass; Acid Resisting Ferro-Silicons; New Norwegian Industries; Newfoundland Cod Liver Oil; National Metal and Chemical Bank; Discoloration of White Paint; Gas in Glass Industry; Heating in a Liquid; Sources of Ore; Bolivian Wolfram Industry; Gas and Petrol Engines; Antifriction Metals; Hydrosulfites; Metallic Liquids; Starting Rheostats; Air Raid Signals; Oxidation of Ammonia; Synthetic Rubber; Corrosion of Brass Tubes; Tool Steels; Compression Strength of Glass and Quartz; Fats and Oils in Germany; Damascene Steel; Chinese Pencil Factory; Japanese-Chilean Nitrate Enterprise; Drying Ovens; Riveting Recorder; Platinum Substitute; New South-African Industries; Aeroplane Construction; New Steam Motor; A New Plastic Compound; Iron and Steel Trade of Aden.... 937

SCIENTIFIC SOCIETIES:
- Resolution Concerning Organic Nomenclature; Fall Meeting, American Electrochemical Society—Atlantic City, September 30 to October 2, 1918, The Milwaukee Meeting of the American Institute of Mining Engineers; Report of the Committee on Research and Analytical Methods, Fertilizer Division, American Chemical Society.... 944

NOTES AND CORRESPONDENCE:
- The Census of Chemists; Deferred Classification and Furloughs for Government and State Chemists; Chemical Industry in the Netherlands, Portrait of Charles M. Hall for the Chemists' Club; Coöperation Requested by the Alien Property Custodian; An Alinement Chart for the Evaluation of Coal Correction; Personnel, Research Division, Chemical Warfare Service—Correction.... 946

WASHINGTON LETTER.... 948

PERSONAL NOTES.... 949

INDUSTRIAL NOTES.... 951

GOVERNMENT PUBLICATIONS.... 954

BOOK REVIEWS:
- Sulfuric Acid Handbook; Treatise on Applied Analytical Chemistry, Cellulose—An Outline of the Chemistry of the Structural Elements of Plants, The Chemist's Pocket Manual, Chemical French, The Science and Practice of Photography, The American Fertilizer Hand Book for 1918, Van Nostrand's Chemical Annual; Sir Wm. Ramsay as a Scientist and Man 960

NEW PUBLICATIONS.... 963

MARKET REPORT.... 964

EDITORIALS

PREPARATION FOR AFTER THE WAR

The beginning of the end is at hand. A bitter four-year struggle has sufficed to indicate clearly the peal: of potency of that great military machine which was shot through with the conviction that *might* must triumph. Little did the leaders of the Teutonic hordes realize what possibilities of resistance lay in the spirit of free men. Strengthened now with the ever increasing impetuous hosts of Americans the armies of the Entente Allies are steadily driving back the enemy, giving no time for recovery of strength, no opportunity for such concentration of forces as might prove an effective resistance. Filled with the conviction that only "Unconditional Surrender" will satisfy those who have been eye-witnesses of the many crimes against humanity, our men are hastening their steps toward Berlin. Doubtless many obstacles will be thrown in the path of that mighty advance; it may be retarded from time to time but it cannot be stopped. How long this final stage will last no one can predict, but no one doubts its finality.

With the advent of peace new adjustments of our present abnormal life will be immediately required. Especially will this be true for chemists whose entire activities have been so directly centered on war problems. During this war period chemistry has come into its own in this country, and the responsibilities are thereby increased as to the wise solution of those large problems which will confront us during the early days of the peace period.

With characteristic foresightedness Dr. B. C. Hesse, a member of the Committee Advisory to the President and a councilor-at-large, prepared an address on this subject which was to have been delivered before the Philadelphia Section. Unfortunately the ravages of the prevailing epidemic have made impossible the holding of the meeting at which the address was to have been read. We are glad to be able to print the address as the special feature of this issue, and would urge its careful and thoughtful reading by every member of the AMERICAN CHEMICAL SOCIETY.

In this address Dr. Hesse has dared "to think out loud," regardless of whether or not his thoughts may be sound, an example well worthy of imitation if progress is to be made. Without seeking to divert in the slightest the minds of chemists from those problems directly connected with the winning of the war, he points out that

> In the tense industrial, commercial, and financial world-wide struggle that is bound to ensue directly after the close of hostilities, success will in all probability fall in a greater measure to those who have, in advance, prepared a comprehensive workable plan adapted for immediate development and operation, and sufficiently elastic to allow of effective adaptation to changing or unforeseen conditions, than to those who have not so prepared themselves.

In the preparation of such a plan it is urged that the councilors in consultation with the members of their respective local sections prepare lists of suggestions for future activities and comment in a spirit of constructive criticism upon the suggestions made by others. Often during the past few months members have commented upon the difficulty in securing speakers for the meetings of the coming winter. Might it not be well to vary these programs and occasionally to do without speakers, devoting the time instead to informal discussion of after-war problems?

The councilors of the Philadelphia Section were so much impressed by the spirit of Dr. Hesse's address that they have already started action. A letter from Dr. J. Howard Graham, the Secretary of that Section, informs us that the following plan has been adopted:

> That a letter be printed and sent to all chairmen and secretaries of the 54 sections, calling attention to preprints mailed under separate cover, and especial attention to pages 3 and 14 of the same, and urging that the preprints be sent immediately to all councilors, and that suggestions for plans for "Preparation for After the War," be sent through the secretaries to me so that our council might boil them down, eliminate duplicates, and forward them in bound form to the general council for their consideration. A personal and typewritten letter is also to be sent to the 54 secretaries urging their coöperation to the utmost of their time, and calling attention to the fact that the Philadelphia Section, realizing the importance of the movement, has simply agreed to act as a clearing-house for the many suggestions that we believe it possible to make.

This action of the Philadelphia Section provides the machinery for a thorough interchange of opinion, and for a compilation of suggestions which should prove of inestimable value to those who may be charged, perhaps suddenly, with the responsibility of presenting the views of chemists upon after-war problems, and of formulating those measures which will lead truly to greater usefulness of our science to our country, a peace service just as obligatory upon us as is the splendid war service now being given.

In no whit, however, is it intended that these discussions of after-war problems should interfere with that concentrated effort needed to furnish an abundance of those products of the chemist's skill which, at the least sacrifice of the lives of our men, will wring from the enemy the only words which will satisfy our people—"Unconditional Surrender!"

DEVELOPMENTS IN CERAMICS

The clothes became too small for the growing body, hence the American Ceramic Society decided to discard the annual volume of "Transactions" with which it formerly was content and to issue instead a monthly periodical, *The Journal of the American Ceramic Society*.

The editor is Dr. George H. Brown of Rutgers College, New Brunswick, N. J., and associated with him is the Committee on Publications: Drs. L. E. Barringer, *chairman*, A. V. Bleininger, H. Ries, and E. W. Tillotson.

In spite of the restrictions placed upon the ceramic industry by the Fuel Administrator, abundant signs exist of unusual activities in this field which give rich promise for its future. Outward evidences of this activity are noted in the creation of the School of

Ceramics, with its special building, at the University of Illinois, under the leadership of Dr. E. W. Washburn; the segregation of the ceramics exhibits at the recent Exposition; the resignation of Dr. Arthur L. Day from the directorship of the Geophysical Laboratory in order to undertake research for one of the great glass companies, already markedly successful in its efforts to render America independent in glassware.

The mention of the names of Drs. Day and Washburn in connection with this industry emphasizes again the increasing call of the industries for physical chemists in industrial research, and this in turn brings us back to the responsibility resting upon universities to lay stress upon physical chemistry in the curriculum for the chemists of the future.

COMMISSIONS FOR BASEBALL PLAYERS

Many letters have been received containing unfavorable comments on the appointment of well known baseball players to commissioned offices in the Chemical Warfare Service. Complaint is made that this tends to lower the dignity of the chemical profession and to work an injustice to men who have spent years in chemical training, yet who still rank as privates or non-commissioned officers.

We must confess to an inability to sympathize with these criticisms, and do not believe that this is in any wise due to a natural predilection for baseball players. The Service in question is not a Chemical Service, but a Chemical Warfare Service. Its personnel numbers approximately thirty thousand. As there are only some sixteen thousand chemists recorded in the country, and as many of these are still connected with the industries, it is evident that a considerable majority of the members of the Chemical Warfare Service are not chemists.

Furthermore, while the work of the chemist is the all-important foundation of this division of the War Department, there is also the important function of applying the results of the chemists' work most forcefully to the enemy in the offensive and to our own soldiers in the defensive. For this work natural leaders are desired, men of proved personality, of fine physique and undoubted personal courage.

In the light of the requirements we congratulate the Chemical Warfare Service on the appointments, confident that these officers will command the respect of the men in the field, will hold their nerve at every critical moment, and will contribute their full measure of terror to the enemy as he increases his backward pace through the liberated lands of France and Belgium.

No, let's not worry about that matter. A much larger and far more important problem remains unsolved, namely, the most efficient utilization of the service (we mean service and are not thinking about the matter of commissions) of the chemists already in uniform. We met one last week, known to us for years, who is doing mere clerical work which could be done by any man of average intelligence without the slightest knowledge of chemistry; two others were unloading box cars at a well-known arsenal. Still other men, of marked attainments, while nominally engaged in chemical work, are really put at tasks which the tyro could perform just as well.

It has been stated that the government requirements for next year call for two thousand additional chemists. A systematic search for these should begin within the ranks of all branches of the service. We believe that a good "shaking down" would reveal many such men qualified for the work in mind, now engaged in less important tasks. We have preached efficiency; we must practice it.

A RECORD OF ACHIEVEMENT

The dyestuff census compiled for the Bureau of Foreign and Domestic Commerce by Dr. Thomas H. Norton in 1916 gave for the first time, and with reasonable accuracy, an itemized statement of our importation of coal-tar dyes. It was a sketch in detail of our dependency, and has proved a valuable guide in the development of the new American industry.

The "Census of Dyes and Coal-Tar Chemicals, 1917," just issued by the U. S. Tariff Commission as Tariff Information Series—No. 6, is a record of achievement during the intervening time, of which all Americans may be proud.

In planning for the future of the industry, opinion may be replaced by facts, carefully collected and clearly presented in this new census. The formidable list of one hundred and ninety manufacturers shows how widespread is the activity in this line.

Every chemist, whether or not connected with the industry, will find interest in Part II, a concise and accurate twelve-page "History of the Dye Industry in the United States Since the Beginning of the European War."

While we are waiting to learn the character of the report the Tariff Commission will make to the Ways and Means Committee as a result of this study, will not someone inform us as to what is a "dyestuff," particularly as differentiated from a dye? We confess to very loose practice in the indiscriminate use of the two words, chiefly because we have been unable to find two authorities who agree.

CONSERVATION BEGINS AT HOME

The little girl had been almost worrying the life out of us to secure every particle of tin foil in the cigarette boxes. The enthusiasm of the six-year-old conservationist was due to the fact that "the Government wanted tin and asked everybody to save it." The twofold source of the request changed the worry into pleasure and we reached the office feeling just a bit a better citizen. There on the desk was a pile of editorial preprints, three pages each, and held together at one corner by an effective though scarcely visible tin-coated clip. On the other side of the desk was the morning mail, the top letter of which was a three-page communication, a form letter, from a government bureau in Washington. Almost dazzling to the eye

was the huge tin-coated fastener which held the three sheets together. It was a complicated affair, but we were interested not so much in its ingenuity and complexity as in the unusual and unnecessary bulk. The habits of the laboratory returned, and the two clips were weighed, with the following result:

Weight of preprint clip = 0.020 gram
Weight of government bureau clip = 6.6435 grams

To make sure, the matter was followed a step further and the little clip and a portion of the huge one were each dissolved in hydrochloric acid (it was good to get hold of a test tube again), and the solutions tested qualitatively for tin. The one showed a slight amount, the other an abundance. Quantitative tests were not necessary as the preprint clip was round, the other flat, therefore the 300 per cent ratio was sure to be increased, and it was bad enough as it was. The only way we could help the situation immediately was to buy another package of cigarettes and save the tin foil for the little girl, but we did gather a clearer idea of what a friend meant when he said: "I don't care how much they tax me for carrying on this war, if the funds are applied efficiently toward winning the war."

ANOTHER IDOL SHATTERED

The fetish of Teutonic superchemistry is receiving some hard blows nowadays. In laboratories and in plants results are being achieved which will act as pincers, forcing German retirement just as truly and as effectively as the successive blows of our armed forces are to-day by a similar process bringing near the day of complete victory.

The debt of Germany to other countries for the basic ideas on which its chemical industry is founded is being constantly illuminated by many recently published articles. Someone familiar with all the facts should write an article on Germany's debt to the American chemical industry, legally and illegally incurred, as a result of the tour of German chemists through the plants of this country immediately after the Eighth International Congress of Applied Chemistry in New York City in 1912.

While waiting for that story it may be well to record in the chemical literature another instance of German inspiration drawn from American environment and example. In 1914 the U. S. Bureau of Foreign and Domestic Commerce published a monograph, Special Agents Series No. 78, entitled "Commercial Organizations in Germany," by Archibald J. Wolfe. From page 50 of that publication the following is reproduced, the italics being ours:

VEREIN ZUR WAHRUNG DER INTERESSEN DER CHEMISCHEN INDUSTRIE DEUTSCHLANDS. The chemical industry is one of the best organized in Germany. The interests of all the chemical trades are served by this one central organization, with headquarters at Berlin. Closely allied to it are the Association of Fertilizer Manufacturers, at Hamburg; the Syndicate of Soda Manufacturers, at Bernburg; and the Association of Lead Paint Manufacturers, at Cologne. It has 290 active members (manufacturing concerns) and 138 personal members, who are heads of manufacturing establishments. The annual income of the association is about 60,000 marks ($14,280), of which 14,000 marks ($3,330) are expended on the official organ of the organization, *Die Chemische Industrie*, and 24,000 marks ($5,710) on the administration. Its official organ is one of the high-grade, well-edited German trade publications.

The impetus to the formation of this association was given at the Philadelphia Exposition [1876] when several representatives of the German chemical industry met at the banquet given by the AMERICAN CHEMICAL SOCIETY *to their foreign colleagues.* It was decided at that informal meeting to form an association for the protection of the common interests of the chemical industry in customs and taxation matters. The scientific interests of the industry had been well served up to that time by the German Chemical Society, but it was only in later years that the German chemists effected a closer alliance between the scientific laboratory and the manufacturing establishment. A convention of all manufacturers and scientists interested in the chemical industry was called at Frankfort-on-the-Main in 1877, in order to found an association for the protection of the interests of that industry, particularly as at that time the entire economic legislation of Germany was undergoing a change. This association has been active, and successfully so, in representing the interests of the chemical industry in the matter of customs tariffs, taxation of industries, negotiation of commercial treaties, classification of chemicals for freight rates, patent and trade-mark laws, and in labor legislation and labor difficulties. The organization is remarkable for the liberal treatment extended to foreigners. Foreign scientists and other foreigners having an interest in the technical phases of the chemical industry are admitted as members, and may attend the session of the Association, but have no right to vote. Permanent commissions for matters requiring special study are organized under the auspices of the society, among them commissions for patents and trade-marks, for customs tariffs, for the investigation of complaints of individual manufacturers against acts of local authorities, etc.

The membership fee in the association has been increased from time to time, and is based on the annual pay roll of each concern. The minimum is 25 marks ($5.95) and the maximum 500 marks ($119) per annum. It has organized an important employees' insurance association for the chemical trade. Its statistical bureau tabulates in the most detailed manner not only the production in the chemical industry, but also the wage scales. It publishes an accurate directory of the chemical industry.

An AMERICAN CHEMICAL SOCIETY banquet is capable of producing almost anything, but we did not know that it was in such a genial and at that time friendly atmosphere that the "Verein zur Wahrung, etc.," had its birth.

Even at that date, the initial year of existence of the AMERICAN CHEMICAL SOCIETY, the Manufacturing Chemists' Association of the United States had already passed some eight or ten years of useful life.

Travel is a great educator!

PERNICIOUS ACTIVITY

In the midst of these strenuous abnormal times even our printer's devil had to run amuck. After we had approved a correct setting of the heading to the Exposition section of the October issue he slipped one over on us, too late for correction, and made the heading read "Fourth National Exposition of Chemical *Engineers*."

That none of our readers have called attention to the slip we take as an evidence of good-will, or perhaps as an indication that chemists, unlike newspaper readers in general, pay no attention to headlines.

After all, the little imp may have had the serious purpose of upsetting convention and giving credit to those to whom credit is due, for it was only through the work of chemical engineers that the Exposition was possible.

OUR PREPARATION FOR AFTER THE WAR

Address prepared by BERNHARD C. HESSE for the Philadelphia Section of the AMERICAN CHEMICAL SOCIETY, October 17, 1918

The AMERICAN CHEMICAL SOCIETY has long since completed its preparations for active assistance in our war; its participation is in full swing and operation and is capable of all needful expansion. The real business now in hand is for each of us to contribute all that we can to every effort to bring the war quickly to a successful issue.

However, all the belligerent countries, including our own, have been engaged for some time past, and in more or less official manner, in tentatively considering after-the-war conditions and how best to provide for them. Some of these tentative conclusions have found their way into print. Due to this necessary tentativeness all these discussions leave a feeling of confusion on a great many points, yet in them there clearly stands forth the unanimous decision that hereafter *each* nation must be as independent of all other nations as its resources in men, minds, and materials will enable it to become.

Our own Government has not yet, so far as I am aware, given out any statement as to what it may or may not be thinking of for after the war. In view of the greatly increased public appreciation of and wholesome interest in chemical endeavor as a factor in our national life, it seems highly improbable that the chemical requirements of our nation will not be thoroughly considered in any such plans. Further, it is not inconceivable that the AMERICAN CHEMICAL SOCIETY with its more than 12,000 members, meeting in 54 local sections in 33 states of the union, may be called upon for assistance, not only in the making of such plans, but also in their execution.

Whether so called upon or not, it is clear that in consequence of the very great changes and gigantic readjustments that will then surely take place in the economic life of practically the entire world, the AMERICAN CHEMICAL SOCIETY and all its members will find ready to hand many problems of varying scope that must be solved by us, and solved right and fairly promptly, and which are not connected with Government functions in any way, if we wish to live up to the proper and just demands of loyal citizenship and of professional responsibility. No doubt there will be many who will then believe in close affiliation with or even in actual control by the Federal Government of many matters which others will regard and have heretofore regarded as belonging to non-governmental agencies solely.

In the tense industrial, commercial, and financial world-wide struggle that is bound to ensue directly after the close of hostilities, success will in all probability fall in a greater measure to those who have, in advance, prepared a comprehensive workable plan adapted for immediate development and operation, and sufficiently elastic to allow of effective adaptation to changing or unforeseen conditions, than to those who have not so prepared themselves.

When that time comes, neither the AMERICAN CHEMICAL SOCIETY nor the American chemical profession should be found among the unprepared. But it would be an entirely mistaken policy for us to become so intent upon after-the-war preparedness that we were thereby and in any way to neglect, overlook, or omit even a single win-the-war activity. I am convinced that there is much of such preparation that we can do without taking any of our attention from the paramount business before us. Necessarily, some of these preparations are now in nebulous outline only, but they can undoubtedly be made sufficiently concrete for effective treatment if we seriously take counsel among ourselves betimes.

RESPONSIBILITY RECIPROCAL

It is clear that when time comes for action on behalf of the AMERICAN CHEMICAL SOCIETY such action will have to be determined and taken, and perhaps taken promptly, by a relatively small number of persons; they can act the more intelligently for the Society the better informed they are of the thought of our members on such subjects. There is therefore a reciprocal responsibility. Our Society officers must get the views of the members and the members must get their views to their officers. What individuals will have to act for the Society at such time is now unknown. Hence, members should proceed now or with as little delay as possible to formulate as well as they can what they want done and get it in such shape that it can be revised from time to time and promptly handed over in as concrete shape as possible to those who will have to carry the burden, when that time comes.

To do this calls in the first instance, at least, for no new machinery nor committees nor appointments. Our splendid Society organization is admirably adapted to take on that load. Our Council is an advisory body to our Directors and to our executive officers. Each of our local sections has a councilor for every 100 of its members or fraction of 100 members. In addition, we have 12 councilors-at-large. This machinery ought to enable us to get something concrete together in a relatively short space of time.

PROPOSED GENERAL PLAN OF ACTION

As I see it, if the councilors of each Local Section will get the views of the members of their respective sections and will put them into one document with a separate and consecutively numbered paragraph for each recommendation, these 54 documents can then be thrown into one document of numbered paragraphs, and this single document can go back to the local councilors for additions, if need be. In that way we will have compressed into a small space the ideas of all our individual members and make them, therefore, promptly available for comprehensive analysis and treatment. Even so, we must not look for a complete job at the first trial, and while reasonable care should be taken at this first attempt yet the work

should not be held up merely because it is not a polished job in all respects. Before a job like this is finished there will have to be a lot of "ironing out" of rough places. Yet it can be done. It has been done, but of course on a much smaller scale, by the New York Section in respect of the three symposiums held by it on the relations between universities and the industries.[1] That résumé does not pretend to offer a complete solution but it nevertheless is an accurate and workable summary of the papers there treated. This is the same kind of a job, only *very* much larger. With such a document before them our executive or other officers acting for us at that time can proceed with greater confidence, than they otherwise could, that they are acting in reasonable accord with the best obtainable judgment of our members and our members could then look forward to such action, assured that their proposals had all been given consideration.

With me personally this is not wholly an academic or supposititious matter. If the time for action comes before January 1, 1920, I, as a member of the Advisory Committee to the President of the AMERICAN CHEMICAL SOCIETY, will, no doubt, have to bear my proper share of responsibility for decisions reached and actions taken on behalf of our Society. There is ample room for errors both of commission and omission. Whenever I consider the large number of new and strange problems that may come up at such a time I confess I become somewhat uneasy. On some subjects I have very definite convictions, on others I am less certain of myself, and on still others I have neither information nor opinion. Withal there is the uncertainty arising from the question that applies to each problem: "What do the members think about this?" And, again, there is the vexing question: "Have I overlooked anything vital?" With a document obtained as above outlined before me there is no doubt in my mind that I could and would act, with far greater confidence than otherwise, that I was properly considering the best judgment of the membership and that I was acting in the light of the best and most comprehensive information and help obtainable from our members. Beyond question such a document would be of great help to me personally and I cannot imagine that it could fail to be so for all those who will have to act in a similar capacity, although I am in no wise speaking for them nor any of them but myself.

MEMBERS INDIVIDUALLY RESPONSIBLE

These are extraordinary times and call for extraordinary measures. The membership must take extraordinary steps to get its views on these topics before those upon whom the burden of wise decision and effective execution must fall. Any member who has ideas on these subjects and fails to get them before his councilors is not "toting fair." Each of us must regard himself as a Committee of One to do this job and do it promptly. We owe this to our country, to our profession, and to ourselves.

I am making this suggestion to the membership as a whole, because I am thoroughly convinced that if I did not do so I would fall far short of dealing fair with the members who have honored me with their confidence by placing me among the councilors-at-large and upon the Advisory Committee to our Society's president.

When time for action comes we will be standing upon the threshold of a new order of things. We must leave nothing undone that can be done to make sure that those who are to carry our burdens for us have then been given every help that it is within our power to give. Coöperative effort the world over will take on new impetus and we must not fall behind the new standards of efficiency and coöperation that the world will then begin to set. Our aim should be to lead in this effort and not to trail after anyone. We cannot then afford to experiment very much; we should get things right the very first time.

Of course, those who will have to make the decision will have the advantage of being guided by events as they then stand, whereas any attempt now to reach a decision as to desirable or needful policies will be disadvantaged by the absence of the event. Nevertheless, there must be certain fundamental policies that will have to be settled regardless of the specific event and as to which there is legitimate present difference of opinion. These we should decide as far in advance as possible so that we will have much of our talking out of the way and permit our getting down to action along these predetermined lines and to meeting new problems as they arise.

In order to visualize and to make as concrete as I now can what in general and in part is in my mind I will proceed to illustrate, with as little detail as may be, some of the problems that have presented themselves to me.

Broadly, these divide themselves into two classes: internal and external, and under each are the two subheads, with or without co-action with our Government, Federal or otherwise; some are of a mixed nature. I shall not now attempt to arrange this material in any rigidly logical or connected order for I regard that at present more a hindrance than a help.

DIRECTED GROWTH OF CHEMICAL KNOWLEDGE

Our Society was organized in 1876 for the "advancement of chemistry and the promotion of chemical research." Through its general meetings, the meetings of its Local Sections, and the publication of three separate journals, much has been done toward disseminating chemical knowledge among American chemists and providing efficient vehicles of scientific record and communication. This is no small accomplishment. But that is now out of the way and is running itself. Can we not now do something new that is just as necessary as the above was in 1876, and just as nebulous and difficult as the problems then tackled? Shall we continue merely to be a recording agency and a means of communication? Can we not take an active and effective part in determining, at least in some degree, how and in what directions and to what extent chemistry shall advance and chemical research shall be promoted? Are we to-day engaged

[1] THIS JOURNAL, 8 (1916), 658.

in the kind of pioneer work that the founders of our Society did in 1876? I am inclined to think that the answer must be "No!" that is, we are not breaking new ground, although we are very effectively cultivating old ground. Ought we not do more? I think the present war has taught us that we should and must.

Certainly, the creative part of research, in its truest sense, we cannot expect to control or guide. Nevertheless, it is of importance to the country and to our science, once a general reaction or property has been discovered, say, by Mr. A, that the full details and scope thereof shall become known and recorded with the least delay. Why should not Mr. A (or Miss A, for that matter) be placed in a position where, through the coöperation of others, those details can be promptly worked out carefully and under good supervision? There is no insuperable obstacle to giving A credit for the reaction and B, C, D, and so on, credit for the details that they may determine and fix, but it is not an easy thing to do. If that could be done it would relieve those who do not have a sufficient number of coöperating students to enable them rapidly to work out the large amount of requisite detail, from such detail work, and would permit them freely and without the restraining thought of not having completed that other work, to engage in new work in which they could use their creative and constructive ability to better advantage.

POOLING MEN, MINDS, AND MATERIALS

But, to take this subject out of the field of clashing priority and similar claims, let us consider another phase. There are gaps a-plenty in our knowledge of theoretically foreseeable preparations, inorganic and organic alike. Why not have these gaps charted and the work of filling them in by our colleges and universities coördinated, directed, and, if need be, *supported* by our Society? To be sure, we would have to feel our way very carefully at first, but the fact that it has not been done is, in this case, no reason why it should not be attempted. Not the smallest good from such a work would be closer acquaintance between our various instructional and investigational laboratories and encouragement to investigation by students, but fields abandoned by their original workers would be kept in mind and further developed when opportunity offered; continued and balanced growth of our store of fact-knowledge would result. Further, there must be any number of reactions for identification and differentiation, modes of separation, and the like, which are awaiting discovery and recording. Can it be that it is impracticable for the laboratories of this country to "pool" their resources in students, instructors, and facilities, and systematically to work out these fact-details? I am convinced that it can be done and I believe that our Society is the proper agency to effect such "mobilizing," to use a war-time expression, of our country's resources in men, minds, and materials. It will not do to say, "it can't be done." It is proportionately not as difficult as the job the founders of our Society tackled in 1876. I am convinced that the AMERICAN CHEMICAL SOCIETY has become so strong and so large that it is under obligation to the country to do everything that can be done once and for all for the benefit of all the chemists of the country. This particular job of getting a line on the unworked and abandoned chemical fields, lining up our country's resources in institutions and personnel, distributing the work to be accomplished, publishing the results, attending to it that the "moppers-up" follow as close on the heels of investigators as circumstances will permit, and keeping the whole work in proper alinement is peculiarly one that our Society should undertake.

GOVERNMENT CONTROL OF CHEMICAL RESEARCH

If we do not do it, it is not unreasonable to expect that our Federal Government will, sooner or later; perhaps that may be a good thing, but I am inclined to think not. If we chemists *cannot* efficiently direct the new growth of chemical knowledge, the Federal Government also probably cannot; if we *will not* then our Government would be perfectly justified in taking a hand, an event already foreshadowed in proposed legislation of the Sixty-fourth Congress. We must be prepared to find that hereafter those governments that are spending large sums on chemical research are going to view the field as a whole and are going to determine in large measure what is to be investigated and to what extent and, further, that they will not be over-communicative on such matters as may affect national interests, external or internal. In that event, our country will be disadvantaged. On the other hand, if we so order our affairs that our resources are "pooled" or "integrated," as the latest stylish legal expression has it, and our efforts are directed as a unit and the other countries do not, we will not be at any disadvantage at any rate. The choice, therefore, as I see it is: if we do we will surely *not* be hurt; if we do not, we *may* be hurt. The answer is not in doubt: The Boards of Editors of our "Journal," of our "Chemical Abstracts," and of our "Journal of Industrial and Engineering Chemistry," will serve as an excellent starting point. The final answer lies with us, as members, and with no one else.

AMERICAN HANDBOOKS ESSENTIAL

In 1801 seven of the European languages were spoken by 161,800,000 people. Arranged in the order of the size of their percentage participation, these languages are:

French	19.4
Russian	19.0
German	18.7
Spanish	16.2
English	12.7
Italian	9.3
Portuguese	4.7

In 1911, 585,000,000 people spoke these seven languages; arranged in the order of their percentage participation they are:

English	27.3
German	22.2
Russian	17.1
French	11.9
Italian	8.6
Spanish	8.6
Portuguese	4.3

If now we divide the 1911 percentages by the 1801 percentages, we will get the "growth-rate" for each of these seven European languages; the result is

	Per cent
English	215
German	119
Russian	90
French	61
Italian	92
Spanish	54
Portuguese	91

That is, English and German were the only languages that really grew and English grew 181 per cent as fast as German.

To-day our Society publishes three chemical journals, each in its field the equal of anything published in any language; this was not true 50 years ago nor even 30 years ago. This progress is highly gratifying and augurs well for the future.

But how about those storehouses of the sum total of our chemical fact-knowledge and references to the original sources which are the indispensable tools for research? Has not the time come when for very good and practical reasons, we should have our own handbooks? Why should we be compelled to go to Beilstein for fundamental information in organic chemistry, to Gmelin-Kraut for inorganic, and to Stohmann and Kerl for industrial information? Or to Morely and Muir of England or Thorpe of England? Or to Wurtz of France or Fremy of France? We have made ourselves independent of the *Centralblatt;* why can we not go the whole length? Why should not the leading publications of this kind be in the world's leading and most rapidly growing language? It is clear from European experience that the only way to keep publications of this sort up to date is by putting them under the control of organizations like our Society, which provide continuous editorship and can expand it if need be, and we all know such need. These are only a few of the things that can be done once and for all for the benefit of all American chemists and I earnestly propose that the AMERICAN CHEMICAL SOCIETY do them. Of course, we cannot hope to do all these things or substitutes for them at once, but if we members will set down in black and white all the things we are convinced our Society should do and keep that list of "Wants" up to date, our responsible officers can plan more wisely than they otherwise could, what things shall be undertaken, and how and to what extent. The initiative lies with us as members and not elsewhere. Without a complete picture of the enterprises to be undertaken our officers cannot as safely proceed as they otherwise could.

If our Society will undertake these new enterprises or some of them, then we will be "advancing chemistry and promoting chemical research" more nearly in the sense our founders had in mind in 1876, than if we refrain from so doing.

IT HAS BEEN DONE BEFORE

The physicians, the medical societies, and the medical colleges of this country about 100 years ago and after almost 5 years of cooperative labor published the first U. S. Pharmacopoeia (which has been revised decennially ever since and latterly in cooperation with pharmacists, pharmaceutical colleges and societies and several of the United States Government services) and have produced a work which for decades has been the premier publication of its kind in the world. It simply cannot be that we chemists cannot do equally well by the fact-material of pure and applied chemistry, inorganic, organic, physical, and theoretical. The procedure involved in effecting these proposals is not at all new for this country, the only novel feature is the materials upon which it is proposed to operate: the critical, painstaking research and sifting inseparable from the Pharmacopoeia would not be so prominent a part of these proposals where close reading and full, accurate recording, based upon systems already in existence or to be created, are the prime essentials. Other like successful cooperative American efforts are, no doubt, known to each of you.

If we undertake the work now under discussion there will still be gaps between revisions during which it might be desirable or even necessary to publish supplemental volumes or independent systematic records of *interim* progress like one or the other of the yearbooks that have been published abroad in the past, or on the general plan of the annual progress reports which, for a short time, our Society published, or of those published by the American Pharmaceutical Association for so many years.

OUR JOURNALS AND OUR GOVERNMENT

There is probably no government that is so lavish in publishing, in good readable form, matter from all parts of the world for the benefit of its citizens as the Government of the United States. It is probably true that there is no people that is so indifferent to the efforts of its Government to enlighten it as the people of the United States and that includes us chemists. Apart from a very limited number of our trade publications, our chemical journals have not made any sustained or systematic effort to go through the valuable material so made accessible, *digest* it for their respective readers so that we could with any degree of confidence go to the volume for any one year and find, for example, the important features of the world's and our own development along lines of chemical industry and its specific trends and particularly the extent and nature of our dependence upon foreign countries in this regard.

It took this war to wake us up to this matter and our Directors have recently set aside a fund to enable *The Journal of Industrial and Engineering Chemistry* to try to supply that feature, and our first efforts in that direction are to be found in its September 1918 issue. To be sure, this is a new venture and it would be unreasonable to expect that we had scored a "bull's-eye." We are doing the best we can in this, to us, new field; we are feeling our way; you may want to call it "groping" and perhaps you are right. If any of our members have suggestions for betterment they can rest assured that those suggestions will be welcomed by those who have charge of that field. This work is couched in modes of expression and proceeds from points of view that are unfamiliar to most of us; to grasp its message in all its bearings we will be compelled, in effect, to acquire a new language and a new mode of thought. But that is *our* job.

If and when we get our bearings in this branch of Government publications, we will try to extend our

work to other suitable branches. It is not too much to hope that in the course of a few years we will have developed this work to such an extent that THIS JOURNAL will annually contain a bird's-eye view of international trade and production, by countries, of chemicals, chemical products, and materials of and for chemical industry practically the world over. There is so very much room for varied elucidative presentation and treatment of matters of this kind that it is earnestly to be hoped that other chemical publications in this country will enter this field each with an eye to the main requirements and viewpoints of its own readers. The more angles we can get from which to view these matters the better for our country and our profession. Among the benefits of this work that I look forward to is not only that of giving us of the present day a bird's-eye view of the chemical industry of the world and more particularly of this country, that is, a view of the thing as a whole, but further, the opportunity it will afford for the oncoming chemists of to-morrow gradually to absorb this viewpoint by specific instruction or otherwise on their way through college or other courses of learning with the result that when they take their places in our profession and our business, comprehensive view and understanding of *their* function in the industrial and economic fabric as a whole will come almost as second nature to them.

The proposals I have so far made call primarily for no extraordinary help from our Federal Government, though it is no doubt true that as we progress in those fields we will be able to make practical and practicable suggestions for betterment or expansion of such Governmental publications and activities.

OUR CHEMICAL DEPENDENCE

There are, however, matters in which special Governmental work is necessary. As an example, take the matter of the nature and extent of our dependence on foreign countries for chemicals, chemical products, and materials of and for chemical industry. The material published prior to 1914 was not adapted to giving effective answer to that question. There was not enough detail. The first step in this direction was taken when the Bureau of Foreign and Domestic Commerce late in 1916, under the direction of Dr. Thomas H. Norton, published what has since come to be known in general usage as the "Norton Dye Census." Early in 1917, as the direct result of a suggestion made by Dr. Norton in THIS JOURNAL, arrangements were initiated by our Society with the Bureau of Foreign and Domestic Commerce for similar treatment of imports in 1913–14 of all chemicals, chemical products, and products of and for chemical industry other than dyes, and along the general and composite lines followed in a number of foreign countries and our own country. It took considerably over a year to get all those details straightened out and then it took several months to locate a chemist to supervise the work and then some considerable time to get the necessary invoices and working staff together. But all that, happily, is now behind us and we can look forward to a list of about 4000 items for which the Bureau of Foreign and Domestic Commerce will give us the amounts and values of each item and the countries of origin of our imports for that period, the last peace-year before the war. Now that we are practically "out of the woods" on this phase of the work, it seems incredible that we should have had to spend so much time getting where we now are. The reason is *not* Government "red-tape"—not by any means. Very little of that was encountered. The answer is not simple: in the first place it took a long time to analyze the problem into its elements because we chemists did not know exactly what we wanted and of course the Government officials could not guess what we wanted. I haunted many offices in Washington and in New York trying to find out what we needed and to get it into workable shape. In the second place, when we got things boiled down the only available way looked to be such a tremendously rocky road that we spent quite some time looking for "short-cuts" but to no use. There was nothing for it but to arrange with the Treasury Department to have each of the approximately 100 ports of entry segregate from a total of over 500,000 invoices those invoices containing the desired material. To pick out this material from Table 9 of the Bureau of Foreign and Domestic Commerce did not take long, once I had made up my mind that I could not get any substantial help in that direction from the membership-at-large of our Society, although certain few Sections did give me great help. I am perfectly fair when I say that the greatest single cause of delay was due to my attempts to hear from our membership, an effort of great magnitude consuming practically eight months. The reason behind that is no doubt our own inexperience in these matters, and I am very sure that it was not due to unwillingness in any degree. However, that is behind us. When that publication appears, as I hope it may in February 1919, I am sure that the Committee on Import Statistics of our Society appointed last month at our Cleveland meeting will have the benefit of every constructive criticism our membership can make. It is too much to expect that our first effort is perfect, but we do hope for "better luck" next time.

This publication, then, in connection with the Norton Dye Census, will be the best information we can get as to the nature, extent, and scope of our chemical dependence upon foreign countries in 1914. Excepting dyes for the moment, which seem to need no further help from our Society, and turning to the other materials, there is one thing that can be done once and for all for American chemists and which should be done and is being done by the AMERICAN CHEMICAL SOCIETY; that is, to translate all manufactured and semi-manufactured products into needful raw materials and their amounts and to classify these as of mineral, animal, or vegetable origin as well as that can be done.

Unless present tentative plans go wrong the Geological Survey and the Department of Agriculture will tell us in suitable publications where those raw materials come from and which of them can be (and perhaps those which ultimately shall be) obtained in the United States, the object of these being to enable us more speedily and more certainly than otherwise to

give full force and effect to our Declaration of Chemical Independence towards which we now have such magnificent results to our credit, and whose advantages we should never relinquish but, on the contrary, should unremittingly protect and energetically develop. I hope that when we similarly record the imports for the first peace-year there will be only 2000 items of imports with big reductions each succeeding year until we have brought our chemical dependence to its irreducible minimum. In order that this result may be further hastened the Tariff Commission may tell us in a suitable publication about the industrial uses of each of these entries.

PROMPT SPECIFIC RESPONSE ESSENTIAL

I have dwelt upon this particular enterprise of our Society at this length not only because it is important as such but also because it shows to what extent a coöperative effort can be blocked through oversight. If more of our Sections than did had notified me promptly that they could not be of service, the work would have been pushed ahead faster in some other direction; but, without seeming arbitrary or high-handed, I could not, in fairness, do otherwise than I did, and I therefore hope that in all future coöperative efforts Sections will understand, and act accordingly, that time limits set must be observed and that before the expiration of that time limit they will definitely express themselves either by giving help or by stating that they need not be waited for, as one Section did to my great comfort. Then those who have to do our work know where they stand and can act accordingly.

With this piece of work, the result of coöperation between at least six Government Bureaus, Departments, or Commissions and our Society, completed, it is not too much to expect that in the future when we will have time to look more closely into the status and possibilities for development of our industries or the betterment of our national research, educational, or other facilities, ways and means of further effective coöperation with Government agencies, Federal or otherwise, will readily be found.

DUTY-FREE CHEMICALS AND APPARATUS

If the reports, spread both by word of mouth and through the press, to the effect that our college and other chemical laboratories have been greatly hampered since the beginning of the war for lack of certain supplies, both apparatus and chemicals, which formerly came to us from abroad have actual foundation in fact, should we not carefully study that question, come to our conclusion as to the remedy, if any, and forcefully present it in such quarters as may be needful to prevent recurrence? Have we not been too complaisant, both in college and out, as to this dependence upon foreign supply sources? Have we not perhaps too actively helped along the idea that foreign laboratory chemicals, foreign filter paper, foreign test tubes, foreign microscopes, foreign porcelain, foreign glassware, and foreign-almost-everything were the real and only things to use? Have we really encouraged domestic makers of related materials to supply these things from domestic sources and manufacture? What percentage of our laboratories in 1913 were of all-American equipment? Have not our colleges contributed a great deal to that state of affairs by using foreign-made goods so extensively in their equipment of those laboratories where most of us received our introduction to materials of this kind? I presume we will all agree that it is of vital national importance that our colleges, universities, and the like be kept at all times at top-notch ability and that measures should be taken to prevent their being crippled at any time. Would it help matters any to abolish our practice of many years' standing; namely, duty-free importation of materials of these kinds for scientific, philosophical, and educational purposes? Perhaps not, but should we not know what our opinion on that point is and should we not now and thoroughly go into it again with the events of the past four years clearly in mind? I will not attempt to give a categorical answer, but will merely ask: If it be proper to tax dyes to the end that we may have a domestic dye industry for the ultimate purpose that large domestic dependent industrial interests may never again be placed in jeopardy, may it not also be proper to tax foreign-made educational and scientific materials to the end that these be made here and for the ultimate purpose that our educational and scientific undertakings dependent thereon may never again be placed in jeopardy? This is a question that requires a great deal of thought and one that cannot be settled off-hand; furthermore, it is a question that may require Federal legislative or other action.

CHEMICAL COMMERCIAL AGENTS

If chemistry and chemical industry be really so essential to national welfare as they are now quite generally accepted as being, should there not be more and effective chemical talent embraced in our foreign consular and similar services than there has been? Should not the AMERICAN CHEMICAL SOCIETY get at the facts, form an opinion, and be prepared to express and follow up that opinion? This may involve added Federal administrative action.

These problems are some of the very many that have been in my mind in a more or less general way and are probably fairly typical of all the rest. But there is just one other big and very handsome thing I should like to see done, and I believe the AMERICAN CHEMICAL SOCIETY really ought to do it. It is not truly a war measure, although its utilitarian side was made more readily discernible by the war. It has considerable utilitarian or sentimental possibilities, as you prefer, through the encouragement the beginner or even an "old timer" in chemistry can get from it when things look very "blue" and the world is "all wrong," quite apart from the new ideas that it may help engender.

AMERICA'S CONTRIBUTION TO CHEMISTRY

What I have in mind is that the contribution of America's chemists to the science and industry of chemistry is not as well known as it should be nor is it a matter that could be readily ascertained, at any rate

not before 1914. Professor Edgar F. Smith, by his books "Chemistry in America" (published in 1914) and "The Life of Robert Hare" (published in 1917) has most auspiciously inaugurated the work of worthily presenting the labors and triumphs of America's chemists. Could the Fiftieth Anniversary of the AMERICAN CHEMICAL SOCIETY, which comes in 1926, be more fittingly marked and celebrated than by a Jubilee Volume, which contains as compact and complete an account as could then be made of what American chemists have done? From 1768, the date of the earliest known American chemical research, to 1926 makes a span of 158 years. Just think of the tradition, concrete and tangible, crammed to the bursting point with the triumphs and trials of *Americans*, that would be contained in such a volume. Could any one appraise in dollars and cents or otherwise the value of the stimulation to and the enthusiasm for more and better work on the part of America's then chemists, from beginner to old-timer, that such a volume would create? Could we give the Nation a better or more dependable means of appraising the value of chemistry in its affairs? Incorrect knowledge of national achievements and capabilities is a national weakness; correct knowledge is a national strength.

I know that our Society has many burdens to face in the near future, but could we not find time and opportunity for this work also?

OUR MEMBERS IN THE SERVICE

It may safely be taken for granted that those of our members in Service, both at home and abroad, are acquiring new points of view as to what the future course of action of America's chemists should be and that they are formulating more or less definite lines of action for the AMERICAN CHEMICAL SOCIETY. When they come triumphantly home they will expect to find our Society prepared to receive, consider, and to act upon their suggestions. No doubt, at meetings of our newest Section, "for the entire territory of France," this subject will be threshed out more or less formally and conclusively. Should we not then be able to match their plans with something we have planned so that we can compare the two programs and act upon the result with the least delay? Would any other course be fair to them?

CONCLUSION

I am fully aware that in proposing pre-peace preparedness a task of very great dimensions is being opened up. But can we, in good conscience, do less? Our faces are set toward a future filled with perplexing problems; much effort will have to be put forth, not all of it can succeed. Many or even all of my suggestions may be impracticable or impractical, my present view to the contrary notwithstanding; that is something we must each and all individually be prepared to face; that should not and must not, in these extraordinary times, deter any of us from making all suggestions that to us seem proper. An imperfect suggestion may well contain the germ of a valuable plan. Neither personal pride nor fear of chagrin must in these times make us shrink from contributing whatever we can; fear of personal failure must resolutely be put to one side. We must accustom ourselves to "thinking out loud;" not all thoughts bear fruit, but that is no reason whatever why we should not now "think out loud."

25 BROAD STREET
NEW YORK CITY

CHEMICAL MARKETS IN THE UNION OF SOUTH AFRICA

By O. P. HOPKINS, Washington, D. C.

The Union of South Africa is a self-governing British dominion comprising the Cape, Natal, Orange Free State, and Transvaal provinces, the total area of which is 473,075 sq. mi. with a population of 5,973,394, of which 1,276,242 are whites. Mining and agriculture are the chief industries, but the output of gold and diamonds easily exceeds in value all other products. The principal mineral products in 1914 were gold, $173,560,000; diamonds, $26,703,000; coal, $10,847,000; copper, $3,369,000; tin, $1,515,000.

Manufacturing is still in a backward state despite the war stimulation and recent earnest discussion of plans for promoting industrial development. The manufacture of wattle-bark extract for export, in place of the bark formerly taken largely by Germany, is a war industry, and there has also been a marked increase in sugar production. The diamond and ostrich-feather industries, on the other hand, have been very adversely affected by the war. As a whole, the Union has had its share of war prosperity, the fly in the ointment being the high prices of necessities, which, as in other countries, have counteracted to a large extent the high wages received by the poorer classes.

The per capita purchases of heavy and fine chemicals are high, so that the Union is a more attractive field for the sale of such products than many of the more thickly settled countries that receive more attention from our manufacturers. The principal difficulty lies in the fact that the mother country does the bulk of the business and in all likelihood will continue to do so. American products are well and favorably known, however, and a steady expansion of the business should be possible, especially in view of the fact that there are certain German lines to replace, although it should be recognized at the start that this is one of the markets that Teuton chemical products did not dominate.

An idea of the extent of the market for chemicals and allied materials and products can be gained from the following table, which shows imports by principal classes for the calendar years 1914, 1916 and 1917. It should be borne in mind that there was a dislocation of trade during the latter part of 1914, wherefore that year should not be considered normal. The total imports of all classes of goods into the Union in 1914 fell about 20 per cent below the total for 1913; in value, the imports for 1916 correspond very nearly to normal.

SUMMARY OF IMPORTS OF CHEMICALS AND ALLIED LINES

CLASSES	1914	1916	1917
Chemicals	$6,226,000	$7,806,000	$7,392,000
Drugs, medicines, perfumery, etc.	2,089,000	2,760,000	2,595,000
Dyes and tanning materials	28,000	132,000	137,000
Explosives	1,189,000	1,646,000	1,201,000
Fertilizers	880,000	617,000	219,000
Oils, fats, and waxes	5,215,000	8,216,000	9,614,000
Paints, varnishes, etc.	831,000	1,304,000	951,000
Metals and miscellaneous materials	1,527,000	3,041,000	2,260,000
Miscellaneous products	5,264,000	6,754,000	6,169,000
TOTAL	23,249,000	32,036,000	30,538,000

An idea of the relative importance of the principal chemicals and allied products that enter the import trade may be gained from the following arrangement, in which the articles are divided into two convenient classes and arranged according to their importance in 1917, only such lines being included as exceeded $400,000 in value during one or more of the three years considered. It will be seen that the three most important items under the heading "Chemicals, drugs, etc." have to do with mining, the principal industry of the country; that is, they are materials for the manufacture of explosives for breaking rock, or materials for the reduction of the ore. Large quantities of explosives, however, are now being manufactured for war purposes. These classes are followed by the finer chemicals included under the headings perfumery, medicines, and pharmaceutical supplies, the per capita consumption of which, considering the limited white population, is rather high. The only important item imported for agricultural purposes is superphosphates, the last on the list. The most imposing totals for the allied products are mineral oils, in which the United States has a large share, paper, paraffin wax, and vegetable oils.

RELATIVE IMPORTANCE OF VARIOUS LINES IMPORTED

ARTICLES	1914	1916	1917
CHEMICALS, DRUGS, ETC.:			
Glycerin	$2,101,000	$1,826,000	$1,910,000
Industrial nitrates	1,073,000	1,357,000	1,579,000
Sodium cyanide	1,812,000	2,167,000	1,703,000
Perfumery	398,000	668,000	677,000
Medicinal preparations	514,000	648,000	595,000
Pharmaceutical supplies	722,000	620,000	375,000
Superphosphates	429,000	437,000	148,000
ALLIED MATERIALS AND PRODUCTS:			
Mineral oil	3,196,000	4,105,000	5,565,000
Paper	1,267,000	3,031,000	2,595,000
Paraffin wax	626,000	1,461,000	1,812,000
Vegetable oil	872,000	1,608,000	1,295,000
Zinc	683,000	1,898,000	1,191,000
Glass	903,000	1,651,000	974,000
Sugar	1,315,000	245,000	821,000
Fuse	463,000	888,000	752,000
Detonators	201,000	568,000	302,000

CHEMICALS

The following table shows the extent to which the various articles that may be classed as chemicals are imported into the Union of South Africa and the extent to which the principal competing countries share in the market. The glycerin is imported chiefly from the mother country, but there has recently been an acute shortage and great efforts are being made to stimulate the domestic output and at the same time to produce mine explosives that do not require glycerin.

The sodium cyanide was supplied by Great Britain and Germany before the war and now comes exclusively from the former country. The United States has no share in the trade. The sodium nitrate is imported directly from Chile.

IMPORTS OF CHEMICALS

ARTICLES	1914	1916	1917
Acids:			
Acetic	$ 1,290	$ 5,086	$ 2,370
United Kingdom	1,192	3,854	1,630
United States	19	895	419
Nitric	1,698	2,866	2,837
United Kingdom	1,552	2,253	2,453
United States	.....	613	384
Sulfuric	6,823	3,489	3,815
United Kingdom	6,546	2,711	2,793
United States	.....	779	1,022
Tannic	550	3,708	2,331
Germany	448	.....	.....
United Kingdom	.....	297	.....
United States	.....	3,236	2,331
Tartaric	25,190	41,794	39,024
Germany	12,818	.....	.....
Italy	706	24,284	18,396
United Kingdom	10,628	14,634	17,841
United States	.....	934	268
Ammonia:			
For re-making	25,856	31,439	43,638
Australia	10,701	10,692	15,461
United Kingdom	7,680	9,227	16,478
United States	7,266	11,519	11,699
Carbonate	3,460	7,583	8,186
United Kingdom	3,460	7,568	8,186
United States	.....	15	.....
Nitrate	34,431	42,923	574
Belgium	14,800	.....	.....
Germany	6,536	.....	.....
Norway	11,879	42,923	.....
United States	.....	.....	.....
Borax	60,850	120,553	57,965
United Kingdom	60,019	120,081	57,274
United States	550	443	15
Calcium carbide	256,865	257,564	140,356
Canada	111,161	149,071	111,477
Norway	105,273	64,924	14,809
United States	12,994	14,590	2,304
Carbonic acid gas	6,833	5,646	4,989
Germany	4,794	34	.....
United Kingdom	1,187	4,375	4,989
United States	.....	54	.....
Chloride of lime	11,290	31,625	19,675
United Kingdom	11,144	28,552	18,566
United States	5	2,068	258
Creosote	2,769	8,444	2,384
United Kingdom	2,769	8,424	2,384
United States	.....	20	.....
Disinfectants and germicides	226,560	393,948	396,090
United Kingdom	213,464	363,659	363,216
United States	4,531	20,220	24,464
Glycerin, industrial:			
Crude	2,100,927	486,188	598,526
United Kingdom	1,177,173	409,531	514,424
United States	258	.....	111
Other	(a)	1,340,205	1,311,128
United Kingdom	.....	1,332,275	1,255,465
United States	.....	2,930	19,282
Nitrates for manufacturing purposes	1,073,117	1,356,980	1,829,357
Chile	1,044,682	1,348,751	1,746,626
United States	.....	92	.....
Potash:			
Cyanide	9,184	1,343	184,670
United Kingdom	3,299	1,265	184,670
United States	.....	.....	.....
Saltpeter	6,575	15,588	15,860
United Kingdom	3,991	15,364	14,463
United States	.....	15	1,397
Compounds of, n. o. d.[1]	69,815	117,195	67,411
United Kingdom	16,878	86,271	46,188
Germany	16,328	1,849	.....
United States	633	8,123	11,281
Sheep and cattle dip	215,250	321,642	259,414
United Kingdom	192,552	264,684	186,718
United States	18,284	56,851	62,685
Soda:			
Carbonate	.....	24,878	45,896
United Kingdom	.....	24,863	42,480
United States	.....	15	1,976
Caustic	107,005	346,476	248,817
United Kingdom	101,278	268,772	160,045
United States	4,701	76,899	124,743
Cyanide	1,812,431	2,167,287	1,703,241
Germany	739,990	7,548	.....
United Kingdom	1,064,153	2,159,739	1,703,241
United States	.....	.....	.....
Compounds of, n. o. d.[1]	69,815	78,935	49,239
United Kingdom	63,157	70,730	46,013
United States	5	6,994	1,796
Sulfur			
Rock, including iron pyrites	58,340	205,897	310,079
Italy	55,883	80,307	29,569
Japan	.....	.....	89,787
Spain	.....	80,755	35,229
United States	2,414	44,836	152,025
Flowers of	38,874	146,701	43,657
Italy	22,639	124,807	7,597
Japan	.....	5	10,166
United Kingdom	13,582	15,948	745
United States	1,436	5,588	25,160

[a] No classification of glycerin attempted in 1914.
[1] Not otherwise distinguished.

Sheep and cattle dips, germicides, and disinfectants together form a considerable total, of which Great Britain has almost a monopoly. According to the Weekly Bulletin of the Canadian Department

of Trade and Commerce, there will be a steadily increasing demand for ammonia for ice-making, as the refrigerating industry is bound to grow.

To those who have pondered the German success in other countries, the insignificant part that German chemicals have played in this market, as shown in the preceding table, will come as a surprise.

DRUGS, MEDICINES, PHARMACEUTICAL SUPPLIES

In medicinal supplies and perfumeries the United States has a very fair share of the South African trade, the United Kingdom alone having a larger business, and Germany being nowhere. In pharmaceutical supplies English goods predominate, although American lines are sold in some quantity. German manufacturers did twice as much business as their American competitors in this line in 1914. In estimating the effect the war has had on the trade, the rise in prices should be kept in mind when comparing the import values for the different years. The South African market for drugs, medicines, etc., can be estimated from the following table:

IMPORTS OF DRUGS, MEDICINES, ETC.

ARTICLES	1914	1916	1917
Bacteriological products, including vaccine virus, etc.	$22,765	$17,938	$14,400
United Kingdom	14,390	10,390	5,373
United States	7,154	6,780	8,522
Bromine, litharge, and manganese dioxide	25,992	65,051	24,338
United Kingdom	23,534	62,588	19,228
United States	1,061	822	73
Magnesium sulfate	10,147	29,133	19,043
United Kingdom	9,617	23,982	16,449
United States	...	243	1,484
Medicinal preparations:			
Spirituous	70,827	127,108	108,596
United Kingdom	39,837	82,804	68,477
United States	25,832	41,584	36,416
Non-spirituous	442,897	520,721	486,456
United Kingdom	339,380	417,707	362,326
United States	77,023	83,724	98,070
Opium	2,934	6,818	7,660
Turkish Empire	2,389	3,353	560
United States	...	...	...
Perfumery and perfumed spirits:			
Perfumery	311,442	527,178	517,411
United Kingdom	149,873	237,733	227,815
United States	111,204	205,298	232,118
Perfumed spirits	84,001	140,476	159,538
Germany	26,231	...	...
United Kingdom	46,310	123,712	147,304
United States	988	1,981	3,076
Pharmaceutical supplies	721,541	620,216	375,256
Germany	98,498	759	73
United Kingdom	515,966	460,955	266,762
United States	42,304	61,337	42,188
Saccharine	910	3,319	1,518
United Kingdom	857	3,314	1,060
United States	53	5	24
Spirits, non-potable:			
Alcohol	117	526	229
Methylated	224	117	5
Other plain spirits	...	...	555
Tartar, cream of	36,100	49,088	48,105
France	22,225	28,698	32,683
Germany	7,947	...	...
United Kingdom	5,792	3,051	7,354
United States	...	12,594	4,102
Tinctures	1,475	3,908	1,178
United Kingdom	1,012	3,076	535
United States	297	822	642
All other[1]	358,613	648,501	831,568
Germany	73,991	1,382	1,426
United Kingdom	233,565	517,718	576,748
United States	23,758	73,032	109,462

[1] Includes all other drugs, chemicals, and pharmaceutical products.

DYES AND TANNING MATERIALS

The items included under this head in the following table are those shown in the official statistics. The only articles of any importance are evidently included under the "All other" head, which itself is comparatively insignificant:

IMPORTS OF DYES AND TANNING MATERIALS

ARTICLES	1914	1916	1917
Bark	$ 107	$ 9,179	$ 3,275
Cutch	307	944	1,981
Gambier	866	886	1,236
Logwood	170	788	3,854
Myrobalans	331	7,057	4,536
Sumac	428	1,178	5,169
All other, n. o. d.	25,394	111,477	116,981
United Kingdom	10,273	60,121	57,338
United States	5,359	42,971	46,403

FERTILIZERS

The only important fertilizer imported into the Union of South Africa is superphosphate, the bulk of which came from the Netherlands before the war. In 1916 England was the most important source of supply, with Japan, a newcomer, second. In 1917 Japan had the field to herself, although unable to satisfy demands. Details of the fertilizer trade are shown in the following table:

IMPORTS OF FERTILIZERS

ARTICLES	1914	1916	1917
Ammonium sulfate	$11,719	$ 3,859	$ 3,903
Basic slag	67,090	100,318	12,191
United Kingdom	29,374	100,318	12,191
United States	...	...	...
Bone manures	89,023	4,404	10,069
India	24,498	...	8,527
United Kingdom	25,691	4,205	297
United States	5	...	...
Guano	24,171	448	7,140
Nitrate of soda	1,105	73	...
Phosphates, raw	5,767	...	...
Potash	30,080	...	...
Superphosphates	428,753	437,133	148,063
Japan	...	139,352	130,914
Netherlands	290,633	...	...
United Kingdom	87,986	289,187	17,135
United States	...	8,595	15
All other	222,604	70,584	38,013
Netherlands	78,341	...	...
United Kingdom	138,510	60,077	12,395
United States	...	3,509	17,953

COLORS, PAINTS, AND PAINTERS' GOODS

In this line the United States has a monopoly of the trade in turpentine and a goodly share of the business in water paints, distempers, and ocher. The mother country dominates the important "All other" class. Details of the trade are as follows:

IMPORTS OF PAINTS, COLORS, AND PAINTERS' GOODS

ARTICLES	1914	1916	1917
Ocher	$35,998	$47,897	$44,909
United Kingdom	35,852	47,858	44,826
United States	...	...	...
Turpentine and substitutes	71,654	93,632	88,225
United States	69,498	87,627	83,281
Varnish	107,535	184,811	128,787
United Kingdom	93,569	163,758	110,664
United States	9,412	17,792	15,817
Water paints and distempers	59,673	81,582	57,065
United Kingdom	24,756	30,927	23,753
United States	33,963	48,147	31,481
All other kinds	556,075	895,601	632,193
United Kingdom	484,689	819,922	495,770
United States	43,005	45,127	95,287

EXPLOSIVES

A glance at the next table will show that the mining industry has not depended upon foreign manufacturers to any great extent for explosives, although reliance seems to be placed upon outside sources for such accessories as fuses and detonators. As already mentioned, the shortage of glycerin has worked a hardship on the domestic explosive industry, but the manufacturers have been producing an explosive called sengite to take the place of gelignite, the new preparation not calling for glycerin. Nevertheless the Chairman of the Scientific and Technical Committee, in a report published by the Department of Mines and Industries and dated January 1918, states:

The mining industry is dependent upon an adequate supply of explosives, in the manufacture of which glycerin forms an

essential ingredient, and, unless the requisite quantity of this latter chemical is obtained, the supply of gold to the United Kingdom, the revenue of the Union, the livelihood of many persons directly or indirectly dependent upon the mining industry, and the market for South African produce, must be seriously curtailed.

IMPORTS OF EXPLOSIVES

ARTICLES	1914	1916	1917
Blasting compounds:			
Collodion and guncotton	$245,247	$ ...	$ ...
Germany	65,173	...	...
United Kingdom	180,074	...	...
United States	...	...	...
Dynamite and other compounds	58,739	7,587	...
United Kingdom	58,695	7,582	...
United States	...	...	...
Caps, percussion	633	336	638
Cartridges, loaded	183,560	155,208	125,045
Germany	76,508	83	...
United Kingdom	103,801	102,499	62,111
United States	6,803	52,339	62,311
Detonators	200,670	568,212	301,621
United Kingdom	195,580	279,849	243,510
United States	...	288,365	58,111
Fuse	463,116	887,981	752,346
Germany	75,495	...	...
United Kingdom	379,772	570,121	718,695
United States	1,986	308,074	33,409
Gunpowder, including powder contained in cartridges	37,263	26,956	21,052
United Kingdom	30,280	21,549	13,870
United States	676	5,183	6,419

OILS, FATS, AND WAXES

Mineral oils form by far the largest item in this group of imports, and the United States dominates the trade, especially in lubricating and illuminating oils. The Dutch East Indies are a formidable competitor in the trade in the lighter distillates. American producers have some share in the edible-oil trade, but considering the vegetable-oil business as a whole the United States is not an important factor. American exporters had about half the business in paraffin wax before the war, but are second now to the exporters of India, although sales have increased greatly in value. The imports of "anti-friction grease" were divided rather evenly between Great Britain and the United States before the war, but our exporters have increased their share since hostilities started. Details of the imports of these lines are shown in the table that follows:

IMPORTS OF OILS, FATS, AND WAXES

ARTICLES	1914	1916	1917
Oils, animal:			
Fish	$ 2,005	$ 9,154	$ 9,548
Lard	4,950	9,825	7,320
Whale	38,685	131	83
Other animal	2,205	3,796	2,633
Oils, mineral:			
Lubricating	726,637	926,343	1,110,326
United States	627,667	844,937	1,041,431
Motor spirit, including benzene and naphtha	1,164,301	1,760,413	2,661,328
Dutch East India Islands	557,837	869,507	1,055,807
United States	600,872	884,613	1,601,566
Paraffin	1,384,581	1,225,629	1,485,383
United States	1,385,150	1,225,369	1,485,383
Other mineral	20,902	192,831	308,123
Oils, vegetable:			
Castor	80,808	130,364	205,541
India	26,572	39,268	106,820
United Kingdom	48,787	86,921	96,858
United States	774	190	200
Cocoa butter	10,843	8,838	6,132
United Kingdom	8,276	5,184	4,759
United States	...	3,629	1,178
Coconut	83,524	165,991	145,285
Australia	29,068	...	...
India	25,253	27,078	38,353
Mauritius	16,576	88,366	24,703
Zanzibar	...	29,311	43,112
United States	83	...	5,558
Colza and rape	4,785	15,023	13,310
Cottonseed, industrial	99,462	105,146	90,833
China	11,824	77,684	81,655
United Kingdom	77,986	19,505	117
United States	2,136	6,696	9,062
Linseed	189,828	323,891	254,031
United Kingdom	189,161	320,722	208,753
United States	2,136	6,696	9,719

[1] Kerosene.

IMPORTS OF OILS, FATS AND WAXES (Concluded)

ARTICLES	1914	1916	1917
Oils, vegetable (concluded):			
Palm and palm kernel	$ 76,755	$ 431,284	$ 125,546
British West Africa	13,128	347,167	297
Nigeria	62,393	76,030	120,787
United States	...	...	...
Salad:			
Cottonseed	149,696	150,501	83,719
United States	123,819	133,927	79,708
Other salad oils	126,738	261,385	315,675
India	3,037	75,056	137,566
United Kingdom	43,745	66,448	77,032
United States	48,865	82,658	51,298
Other vegetable	50,077	46,313	54,715
Anti-friction grease	214,953	331,764	315,992
United Kingdom	113,005	132,890	124,539
United States	97,427	198,529	191,186
Margarin and other butter substitutes	107,521	152,268	32,980
Netherlands	52,592	65,820	5,159
United Kingdom	50,378	84,069	22,259
United States	1,509	652	2,623
Wax			
Beeswax	1,976	7,193	10,030
Paraffin	626,163	1,461,118	1,811,671
India	148,852	259,531	914,547
United Kingdom	122,310	66,326	98,425
United States	317,608	1,113,922	770,620
Stearin	148,219	118,227	145,266
United Kingdom	61,970	110,454	134,340
United States	9,052	7,626	10,925
Oil-bearing materials			
Copra	...	253,903	299,937
Zanzibar	...	196,938	280,176
United States	...	...	...
Palm kernels	...	76,181	...
British West Africa	...	76,181	...
United States	...	...	...
All other	...	78,575	118,952

MISCELLANEOUS PRODUCTS

The United States has never enjoyed the lion's share of the trade in any of the articles included in this group except baking powder, yet a study of the following table should reveal possibilities for future opportunities that will be well worth while. The demand for some of these lines will grow steadily once the war is over and it is unlikely that certain of the old sources of supply will be relied upon again for some years to come.

IMPORTS OF MISCELLANEOUS PRODUCTS

ARTICLES	1914	1916	1917
Baking powder	$ 228,726	$ 243,174	$ 409,803
United Kingdom	14,429	31,914	15,632
United States	211,372	211,051	394,152
Blacking and shoe polish	241,129	254,941	240,275
United Kingdom	234,872	241,968	226,132
United States	3,796	12,886	13,758
Blue	63,864	70,043	114,636
United Kingdom	63,494	68,580	114,582
United States	...	151	24
Candles	22,858	10,774	4,628
United Kingdom	19,982	10,186	4,531
United States	433	10	78
Extracts and essences:			
Food	123,576	130,086	68,219
United Kingdom	120,582	125,623	62,520
United States	618	2,526	4,370
Flavoring, spirituous	83,879	110,571	89,145
France	14,829	26,708	28,061
United Kingdom	67,124	83,130	60,627
United States	185	779	268
Flavoring, non-spirituous	9,942	12,556	5,918
United Kingdom	7,889	8,162	2,132
United States	219	419	355
Glass:			
Bottles and jars	499,848	894,356	509,703
Germany	78,443	13,456	1,304
Japan	...	63,469	61,907
Sweden	75,022	245,686	76,721
United Kingdom	267,468	261,351	284,564
United States	46,860	286,288	57,211
Plate	115,662	182,394	137,245
Belgium	32,523	4,069	151
Canada	80,891	2,847	...
United Kingdom	...	160,195	133,966
United States	15	15,364	5,056
Window	97,287	206,057	142,827
Belgium	44,575	10,798	17,174
United Kingdom	44,388	98,912	90,814
United States	44	85,456	26,375
Glassware, n. o. d.	190,719	368,302	183,964
Belgium	46,870	86,904	18,658
Germany	82,395	900	209
Japan	920	76,803	59,503
United Kingdom	56,106	92,729	48,816
United States	12,994	83,437	40,548
Glue	19,155	50,616	46,870
United Kingdom	12,984	33,559	33,648
United States	1,343	2,861	1,436
Matches	17,048	8,609	3,981
Sweden	15,714	8,098	3,830
United States	5	...	...

IMPORTS OF MISCELLANEOUS PRODUCTS (*Concluded*)

ARTICLES	1914	1916	1917
Paper:			
Printing	$ 960,346	$1,903,503	$1,754,617
Canada	288,394	312,634	365,810
Germany	73,295	895	.....
Norway	30,133	116,675	113,200
Sweden	110,898	228,044	382,346
United Kingdom	439,567	996,095	606,142
United States	45,235	213,654	225,095
Wrapping	306,765	1,127,320	840,634
Canada	2,540	288,365	168,113
Germany	35,117	209	.....
Norway	57,070	177,175	50,514
Sweden	110,898	348,101	251,866
United Kingdom	80,847	288,282	278,627
United States	5,290	79,752	50,646
Photographic material[1]	240,177	292,569	295,353
Germany	15,418	122	.....
United Kingdom	132,491	168,434	178,849
United States	87,845	120,383	108,396
Soap:			
Common, brown, etc.	184,467	172,002	130,208
Australia	150,862	77,013	82,293
United Kingdom	7,539	30,211	23,924
United States	28,455	63,834	19,432
Toilet	155,101	263,000	207,011
United Kingdom	102,757	174,284	151,597
United States	39,905	85,203	50,495
Extracts and powders	11,996	26,333	21,408
United Kingdom	11,315	25,895	21,198
United States	428	389	107
Sugar, molasses, etc.:			
Glucose	58,899	69,012	111,930
United States	54,627	67,771	100,664
Golden sirup	312,750	107,443	27,968
United Kingdom	312,493	106,937	24,990
United States	88	165	1,645
Molasses and treacle	3,650	3,158	808
Saccharum	1,197	1,523	545
Sugar	1,314,889	245,495	821,339
Mauritius	588,384	14,999	43,608
Portuguese East Africa	586,170	186,056	724,052
United States	7,898	34,523	49,843

[1] Sensitized goods not stated separately.

MISCELLANEOUS MATERIALS

Zinc is the only item of outstanding importance in this group and it is now imported almost exclusively from the United States. Previous to the war Germany was a serious rival. The extent to which the various items are imported is shown in the following table:

IMPORTS OF MISCELLANEOUS MATERIALS

ARTICLES	1914	1916	1918
METALS:			
Copper, bar, ingot, rod	$ 24,747	$ 39,959	$ 23,126
Iron, pig and ingot	20,770	36,903	56,617
Lead, bar, pig, and sheet	80,419	119,190	58,734
Quicksilver	134,817	192,003	188,664
Tin, bar, block, ingot	50,096	81,616	170,688
Zinc, unmanufactured	683,251	1,898,485	1,191,217
Belgium	68,112	.....	.....
Germany	245,086	92	24
United States	340,052	1,810,684	1,079,818
OTHER MATERIALS:			
Asphalt and bitumen	17,729	14,230	20,863
Cement	340,169	227,475	105,389
Emery	12,195	25,185	23,987
India rubber and gutta-percha	(*a*)	105,720	141,840
Lime	12,502	9,519	1,479
Mica	2,097	2,900	2,599
Pitch	8,210	3,314	4,015
Plumbago	3,528	6,152	4,730
Plaster	5,305	11,422	8,098
Resin and rosin	45,132	129,206	115,653
Tar and substitutes	86,088	137,887	142,224

(*a*) Not stated separately in 1914.

ORIGINAL PAPERS

EXAMINATION OF ORGANIC DEVELOPING AGENTS

By H. T. CLARKE

Received July 20, 1918

From the time that the European war cut off the supply of foreign organic chemicals to this country, two distinct activities have been apparent in the photographic developing agent trade; on the one hand, the efforts of manufacturing concerns to produce the most necessary substances, like hydroquinone and salts of *p*-aminophenol, and, on the other, the less commendable manipulations of the purveyors of bogus and adulterated developing agents. For the control of both of these activities chemists are necessary—to check the purity of the genuine products and expose the composition of the false. Moreover, in many cases developing agents are submitted under fancy names and it is necessary to identify the substances they contain.

The work of the analyst thus falls into three classes: the separation and identification of genuine developing agents; the quantitative determination of such substances; and the identification of the materials employed for adulteration or substitution.

The following scheme for the identification of the commoner developing agents is drawn up to meet the first; a few suggestions for quantitative work follow; but owing to the enormous number and variety of adulterants, no attempt can be made to indicate all of the methods employed for their detection and estimation, which in any case are subject to the methods of routine analysis.

QUALITATIVE METHODS

GROUP TESTS

Taking 0.1 g. of sample:

I—Insoluble in 5 cc. of cold water:
- *p*-Hydroxylphenyl glycine

II—Soluble in 5 cc. of ether:
- Hydroquinone
- Chlorohydroquinone
- Catechol
- Pyrogallol

III—Soluble in 5 cc. of alcohol:
- *p*-Aminophenol base
- *p*-Aminophenol hydrochloride
- 5-Amino-2-cresol hydrochloride
- 2,4-Diaminophenol hydrochloride
- *p*-Dimethylaminophenol oxalate

III*a*—Insoluble in alcohol:
- *p*-Aminophenol sulfate
- 5-Amino-2-cresol sulfate
- *p*-Methylaminophenol sulfate
- *p*-Dimethylaminophenol sulfate
- *o*-Methylaminophenol sulfate
- *p*-Phenylenediamine hydrochloride

DISTINGUISHING TESTS

(A) Test aqueous solutions with litmus: Neutral or only faintly acid with Group II; Groups III and III*a* give markedly acid solutions (with the exception of pure *p*-aminophenol base). Test aqueous solutions for chlorides, sulfate, oxalate, and other common anions.

(B) Treat 0.1 g. in 1 cc. hot water with one or two drops of 10 per cent sodium carbonate solution, and let mixture stand a few minutes to cool.

GROUP I. *p-Hydroxyphenylglycine*—Dissolves with effervescence; very little change on standing.

GROUP II. *Hydroquinone, Chlorohydroquinone, and Catechol*—No effervescence; solution darkens slowly on standing.

Pyrogallol—No effervescence, solution darkens rapidly on standing.

GROUPS III AND IIIa. All cause effervescence except pure *p-aminophenol* base.

Crystalline precipitates formed on cooling: Salts of *p-aminophenol, 5-amino-2-cresol* and *o-methylaminophenol.*

No precipitate on cooling: Salts of *2,4-diaminophenol, p-methylaminophenol, p-dimethylaminophenol,* and *p-phenylenediamine.*

(C) To 0.1 g. of sample in 2 cc. of water add a few drops of 10 per cent ferric chloride solution.

GROUP I—*p-Hydroxyphenylglycine* gives no color reaction in the cold; odor of quinone on boiling.

GROUP II—*Hydroquinone* gives dark greenish precipitate of quinhydrone in the cold; strong odor of quinone on boiling.

Chlorohydroquinone gives reddish brown coloration in the cold, odor resembling that of quinone on boiling.

Catechol gives a green coloration with one drop of ferric chloride; with excess a nearly black precipitate is formed; no odor is produced on boiling.

Pyrogallol gives intense reddish brown coloration in the cold; no odor on boiling.

GROUPS III AND IIIa—Salts of *p-aminophenol* and *5-amino-2-cresol* give purple colorations in the cold; odors of quinones on boiling; the purple colors are not destroyed.

p-Methylaminophenol sulfate behaves similarly, except that the purple coloration is developed more slowly.

Salts of *p-dimethylaminophenol* give no color in the cold; the solution darkens on boiling, with formation of quinone odor.

With *2,4-diaminophenol hydrochloride* an intense red color is developed in the cold; no odor is produced on boiling.

With *o-methylaminophenol sulfate* a dark purple color is produced, turning to red-brown on standing or more rapidly on warming. No odor is produced on boiling.

With *p-phenylenediamine hydrochloride* a deep green color is developed, followed immediately by a dull purple; on boiling, the color changes to a dull reddish brown, and the odor of quinone is produced.

(D) To 0.1 g. of sample in 1 cc. of water add 2 cc. of 5 per cent silver nitrate solution.

GROUP I—*p-Hydroxyphenylglycine* in suspension causes a black deposit in the cold which, on boiling, instantly becomes light brown, while the liquid rapidly acquires a purple color.

GROUP II—*Hydroquinone* gives a silky white precipitate in the cold; the odor of quinone is developed on boiling.

Chlorohydroquinone scarcely reduces silver nitrate in the cold, but rapidly on boiling.

Catechol slowly reduces the reagent in the cold; no characteristic color or odor developed in boiling.

Pyrogallol causes instant reduction in the cold, giving a brown precipitate; no odor produced on boiling.

GROUPS III AND IIIa. Salts of *p-aminophenol, p-methylaminophenol* and *5-amino-2-cresol* give purple colorations, with quinone-like odors on boiling.

Salts of *p-dimethylaminophenol* give no color in the cold; on boiling, a brownish red color and the odor of quinone are developed.

2,4-Diaminophenol hydrochloride yields an intense red color; no odor on boiling.

o-Methylaminophenol sulfate gives a yellowish brown color in the cold, becoming reddish brown on heating; no odor developed on boiling.

p-Phenylenediamine hydrochloride yields in the cold a transitory pale green color, followed instantly by a deep purple; no color change and no odor on boiling.

SPECIFIC TESTS

Two reactions which should be performed with every developing agent are acetylation and benzoylation.

In acetylation the substance is mixed with about three times its weight of acetic anhydride, together, if the developing agent be a salt of a base, with an equal weight of anhydrous sodium acetate, and the mixture gently boiled for a few instants over a flame. After the mass has cooled, about ten volumes of water are added and the separated solid filtered off and recrystallized from alcohol or similar solvent.

In benzoylation (Schotten-Baumann process) the substance is mixed with about four times its weight of benzoyl chloride, and an excess of 10 per cent caustic soda solution added, whereupon the mixture is vigorously shaken in a stoppered tube, cooling if necessary, and occasionally releasing any excess pressure by opening the stopper. Shaking must be continued until the irritating odor of the benzoyl chloride has disappeared. Care must be taken that an excess of alkali is present at the end of the reaction. The separated solid is then filtered off, washed with water, and recrystallized from acetone or other suitable solvent.

The derivatives thus produced possess characteristic melting points, so that any identification can be definitely established by their aid.

GROUP I—*p-Hydroxyphenylglycine* dissolves readily in dilute sodium carbonate, sodium hydroxide, sodium sulfite, or ammonia; also in dilute mineral acids, but not in dilute acetic acid. When pure it crystallizes in colorless leaflets, melting indistinctly with decomposition above 200°.

GROUP II—The four substances described in this group all form bright yellow, water-soluble compounds with sulfurous acid (or sodium bisulfite and dilute acid).

Hydroquinone crystallizes readily from water in colorless needles melting at 169°. It boils at 285°. The vapor is almost odorless. It is insoluble in benzene. Quinhydrone, precipitated by a cold acid solution of ferric chloride, or of potassium bichromate, melts at 171°. Quinone, formed by the action of an excess of acid bichromate, melts at 116°. The diacetyl derivative melts at 123°; the dibenzoyl derivative melts at 199°.

Chlorohydroquinone is too soluble in water to crystallize from aqueous solution. It dissolves readily in warm benzene. It melts at 106° and boils at 263°. The vapor has a distinct phenolic odor. The diacetyl derivative melts at 99°. Chloroquinone, produced by oxidizing with acid bichromate, melts at 57°.

Catechol forms feathery needles which melt at 104° and boil at 245° and are extremely soluble in water. It is readily soluble in hot benzene, sparingly in cold. It possesses an odor resembling that of pyrogallol. On treatment with bromine in carbon tetrachloride solution, hydrogen bromide is evolved, and a tetrabromo derivative melting at 192° is produced. The diacetyl derivative melts at 63°; the dibenzoyl derivative melts at 84°.

Pyrogallol is extremely soluble in water. It is slightly soluble in hot benzene, almost insoluble in cold. It melts at 133° and boils at 293°. It possesses a peculiar and characteristic odor. Its aqueous solution gives a blue precipitate with ferrous

sulfate. The triacetyl derivative melts at 161°; the tribenzoyl derivative melts at 89°.

GROUPS III AND IIIa. *p-Aminophenol and Its Salts*—The free base crystallizes from water in leaflets, melting with decomposition at 184°, soluble in about 100 parts of cold water. It is moderately soluble in hot alcohol, sparingly in ether. The hydrochloride crystallizes in prisms, and is sparingly soluble in concentrated hydrochloric acid. The sulfate, crystallizing in fine needles, is less soluble in cold water than the hydrochloride, but the hydrochloride is precipitated from an aqueous solution of the sulfate on adding concentrated hydrochloric acid. On adding to a cold, slightly acid solution an excess of sodium acetate and then a few drops of benzaldehyde, the pale yellow benzylidene derivative is soon precipitated, which crystallizes from methyl alcohol in needles melting at 183°. The diacetyl derivative melts at 150°; the dibenzoyl derivative melts at 234°.

5-Amino-2-cresol and its salts resemble *p*-aminophenol and its corresponding salts very closely in solubility and chemical behavior. The free base crystallizes from water in flat needles melting with decomposition at 176°. The hydrochloride crystallizes either in needles, or, less frequently, in leaflets. The sulfate crystallizes in fine needles. On oxidation with acid bichromate it yields toluquinone melting at 68°. The benzylidene derivative is markedly less soluble than benzylidene-*p*-aminophenol in methyl alcohol, from which it crystallizes in leaflets melting at 208°. The diacetyl derivative melts at 103°; on gentle hydrolysis with alkali it yields the monoacetyl derivative melting at 179°. The dibenzoyl derivative melts at 194°.

2,4-Diaminophenol is met with only as the hydrochloride. The free base is not precipitated from solution on addition of sodium carbonate; the neutralized solution darkens very rapidly in air. The hydrochloride is sparingly soluble in concentrated hydrochloric acid. Attempts to prepare a benzylidene derivative led to a smeary yellow product. The triacetyl derivative melts at 180°; the tribenzoyl derivative melts at 231°.

p-Methylaminophenol is met with only as the sulfate, which crystallizes in fine needles. The free base is fairly readily soluble in cold water, but is precipitated on neutralizing a cold saturated solution of the sulfate with sodium carbonate; it melts at 85° and is extremely soluble in ether. On allowing a solution in an excess of sodium hydroxide to stand in air, a dark color rapidly develops, accompanied by a characteristic odor not unlike that of a trace of pyridine. On adding sodium nitrite solution in slight excess to a solution acidified with sulfuric acid, the sparingly soluble nitroso derivative separates in colorless needles melting at 136°. The perfectly pure monomethyl compound yields no benzylidene derivative on treatment with sodium acetate and benzaldehyde, but technical samples are rarely entirely free from salts of *p*-aminophenol, which is converted by benzaldehyde into the insoluble benzylidene *p*-aminophenol. A good technical sample should be completely soluble in three parts of concentrated hydrochloric acid. The diacetyl derivative is insoluble in cold water and melts at 97°; on gentle hydrolysis by warming with dilute alkali this is converted in the monoacetyl compound (soluble in alkali and precipitated by acid) which melts at 240°. The dibenzoyl derivative melts at 173°.

p-Dimethylaminophenol—The sulfate crystallizes in hexagonal tablets which are extremely soluble in water. The oxalate is moderately soluble in water and alcohol; it melts at 187° to 191°. The free base is fairly readily soluble in cold water; it melts at 75° and is extremely soluble in ether. On allowing a solution in sodium hydroxide to stand in air, the same dark color and pyridine-like odor are developed as with the monomethyl compound. On adding sodium nitrite to a solution in dilute acid, a reddish brown coloration is formed, with evolution of gas. On adding a saturated solution of potassium ferrocyanide to a fairly concentrated solution in dilute sulfuric acid, a white crystalline precipitate of the acid ferrocyanide soon separates. It forms an acetyl derivative melting at 78°, and a benzoyl derivative (soluble in dilute acid) which melts at 158°.

o-Methylaminophenol—The sulfate crystallizes in stout needles which are extremely soluble in water; the free base, which is slightly soluble in cold water but readily so in hot water, crystallizes in leaflets melting at 96°. It dissolves in alkali, forming a solution which slowly darkens to a dull green color on standing in air, giving a pyridine-like odor, but more slowly than the para compound. The free base and its sulfate are completely soluble in three parts of concentrated hydrochloric acid. On adding sodium nitrite to a solution in dilute acid, the nitrous compound is precipitated in colorless leaflets which melt with decomposition about 130° after darkening from 120° onwards (the melting point is rather indistinct and depends upon the rapidity with which the bath is heated). The derivative obtained on acetylation is a liquid which dissolves in cold water; on gentle hydrolysis by warming with dilute alkali it yields the monoacetyl compound (soluble in alkali and precipitated by acid) which melts at 150°. The dibenzoyl derivative melts at 113°.

p-Phenylenediamine—The hydrochloride crystallizes in leaflets which are readily soluble in water. The free base, melting at 140°, is moderately soluble in cold water and sparingly in ether. On adding to a cold dilute solution an excess of sodium acetate and then a few drops of benzaldehyde, the pale yellow dibenzylidene derivative is precipitated; this crystallizes from methyl alcohol, in which it forms a bright yellow solution, in thin leaflets, melting at 138°. Both the diacetyl and dibenzoyl derivatives melt at temperatures too high for convenient measurement.

QUANTITATIVE METHODS

It frequently happens that photographic developers placed upon the market consist of mixtures of developing agents or of impure simple substances, so that it may be necessary to separate and estimate the constituents of a mixture or to determine the purity of a sample of a single substance.

GROUP I—No direct method for determining the purity of a sample of *p*-hydroxyphenylglycine is available. An ash determination should be made, and the amount of matter insoluble in dilute sodium carbonate estimated. If a sulfite be present the sulfurous acid liberated by mineral acid should be determined by the method indicated below.

GROUP II—All the substances in this group should leave no ash on ignition; if there be any, it should be estimated. Likewise, all should dissolve in water and, in ether without residue, and should leave no considerable residue when the main constituent is volatilized under atmospheric or reduced pressure.

The melting point forms a fairly satisfactory criterion of the purity when the sample is found to be completely soluble in ether.

The proportion of hydroquinone in a sample of chlorohydroquinone may be estimated by isolating and weighing the matter insoluble in warm benzene.

GROUPS III AND IIIa—Water-insoluble material and ash should be estimated; in Group III the amount of matter insoluble in alcohol should also be determined. The proportion of chloride, sulfate, sulfite, etc., should be determined; and in certain cases it may be well to estimate the total nitrogen by the Kjeldahl method, making certain, of course, that free ammonium salts are absent.

It is important in all cases to determine the amount of salts of *p*-aminophenol or aminocresol present, both in samples consisting principally of one of these compounds and in samples of methylated derivatives. The procedure is as follows:

Ten grams of the sample are dissolved in about 150 cc. of cold water (or, in the case of the free base, dilute hydrochloric acid). Heating must be avoided, since this may cause impurities to enter into solution which do not again separate on cooling. A slight excess of sodium acetate is then added, and to the cold solution about 10 cc. of benzaldehyde are run in. When the sample contains a relatively small proportion of aminophenol, as in samples of *p*-methylaminophenol sulfate, the amount of benzaldehyde should be considerably reduced. After standing over night the mixture, which should still contain excess of benzaldehyde, is filtered by suction, the solid well washed with water, dried in the steam oven, and weighed. A Gooch crucible answers satisfactorily.

The following factors are applied for expressing the result:

As *p*-aminophenol hydrochloride	0.738
As *p*-aminophenol sulfate	0.802
As *p*-aminophenol base	0.554
As 5-amino-2-cresol hydrochloride	0.756
As 5-amino-2-cresol sulfate	0.815
As 5-amino-2-cresol base	0.584

For the remaining substances in this group the simple though non-specific total nitrogen content must be determined and the assumption made that all the nitrogen is in the form of the pure substance.

INORGANIC RADICLES—When an ash has been found and shown to consist of a salt of an alkali metal, a weighed sample of the substance should be ignited in a platinum crucible and the residue repeatedly evaporated to dryness and heated to redness after adding a few drops of 20 per cent sulfuric acid; in this way the metal is completely converted into the sulfate.

Chlorides and bromides should be determined by the Volhard method. Direct estimation of alkali carbonate is difficult or even impossible in some instances, and may have to be effected by difference.

Sulfites are best estimated by distilling an acidified solution of the sample into alkali and titrating the distillate against standard iodine solution, running the sulfite into the iodine. A regular Kjeldahl distillation apparatus answers well for the purpose.

TYPICAL ANALYSES

For obvious reasons the sources of the material used for these typical analyses are not indicated; they represent a selection from a very large number performed in the years 1916–1918.

"MQ" DEVELOPER TUBE (APRIL 1916)—The total weight of material in the compartment containing the developing agent was 0.6276 g. This was placed on a filter and well washed with ether; the ethereal solution, on evaporation, left pure hydroquinone; the insoluble residue, when dried at 100°, weighed 0.1241 g. and was found to consist of pure *p*-methylaminophenol sulfate. The hydroquinone was not weighed, but estimated by difference.

"MQ" DEVELOPER TUBE (APRIL 1916)—A similar analysis on another tube showed total weight 0.5713 g.; ether-soluble material consisted of pure hydroquinone; ether-insoluble material weighed 0.1120 g. and consisted of technically pure *p*-aminophenol hydrochloride.

DEVELOPING AGENT (MARCH 1916)—The material was a light brown powder of rather moist appearance. It contained no substance soluble in ether, but dissolved partially in alcohol, the alcoholic extract depositing *p*-aminophenol hydrochloride on evaporation. 2.000 g. were boiled with alcohol and filtered on a weighed Gooch crucible. The insoluble residue was well washed with hot alcohol and dried to constant weight *in vacuo* over sulfuric acid. It weighed 0.728 g. and consisted of pure starch. The filtrate was evaporated to dryness and the residue dried at 115°; it weighed 0.998 g. Another 2.000 g. sample were heated in the oven at 115° to constant weight; it lost 0.308 g.

The material thus consisted of

	Per cent
p-Aminophenol hydrochloride	49.9
Starch	36.4
Moisture	15.4
	101.7

"METOL" (APRIL 1918)—This consisted of technical *p*-aminophenol hydrochloride, without a trace of methylated product.

"METOL" (APRIL 1918)—The label claimed the contents to be "Hydrochloride of methyl-*p*-amino-*m*-cresol guaranteed 96.3 per cent pure." The material consisted entirely of 5-amino-2-cresol hydrochloride, without a trace of methylated product.

"METOL SUBSTITUTE" (APRIL 1916)—The material was first extracted with ether, and the filtrate found to contain only pure hydroquinone. 2.7654 g. gave 0.5122 g. of hydroquinone, or 18.5 per cent. The residue showed the presence of sulfite and sulfate as the only acid radicles; on ignition, a residue consisting of sodium salts was left. *p*-Methylaminophenol was found by the usual methods, and the behavior of the material led to the suspicion that cane sugar was present. This was confirmed by boiling with strong hydrochloric acid, when the characteristic brown color and odor of caramel were developed. Further examination failed to show the presence of other substances.

The portion insoluble in ether was dissolved in water and diluted to 50 cc.; this solution in a 20 cm. tube gave a rotation of 2.90°, using mercury green light, corresponding to 0.932 g. cane sugar in the sample, or 33.7 per cent.

Another portion of the original sample was ignited in a platinum crucible and the residue converted into sodium sulfate; 1.3604 g. gave 0.5319 g. of sodium sulfate, corresponding to 34.7 per cent of sodium sulfite. (The sulfurous acid content was not determined as a check.)

For estimating the *p*-methylaminophenol sulfate, a portion was digested with sulfuric acid and the nitrogen determined by the Kjeldahl process; 1.4880 g. required 8.6 cc. of *N*/10 acid, corresponding to 0.148 g. *p*-methylaminophenol sulfate, or 10 per cent.

The material thus contained:

	Per cent
Hydroquinone	18.5
Cane sugar	33.7
Sodium sulfite	34.7
p-Methylaminophenol sulfate	10.0
	96.9

"METOL SUBSTITUTE" (JUNE 1916)—The material on treatment with ether yielded a soluble constituent which was identified as pyrogallol; the residue, which contained no nitrogenous matter, consisted entirely of sodium sulfite; the ethereal extract from 5.1215 g. gave, on evaporation, 1.3050 g. of pyrogallol or 25.5 per cent; the residue was acidified and the sulfurous acid distilled into alkali, which was then diluted to 200 cc. Of this solution 15.9 cc. were required by 60 cc. of standard iodine solution, equivalent to 50.0 g. sodium sulfite per liter, corresponding to a total of 3.773 g. sodium sulfite, or 73.8 per cent. Another sample was ignited with sulfuric acid: 1.2730 g. gave 1.0455 g. sodium sulfate, corresponding to 0.9280 g. sodium sulfite or 72.9 per cent.

The material thus consisted of:

	Per cent
Pyrogallol	25.5
Sodium sulfite	73.4
	98.9

DEVELOPING AGENT (JULY 1916)—Ether dissolved out a small amount of dark smeary material, which was not further investigated. The residue, on further examination, was found to consist of impure *p*-aminophenol hydrochloride mixed with lead chloride and a small amount of lead sulfate. The lead was determined by ignition with sulfuric acid: 1.7130 g. gave 1.1270 g. of lead sulfate, or 0.429 equivalent of lead per 100 g. of sample. In another sample chlorine and nitrogen were determined by collecting in alkali the gases evolved on heating with sulfuric acid in the Kjeldahl process: 1.6070 g. were heated with 25 cc. of sulfuric acid, the gases evolved during the early stages of digestion being absorbed in 25 cc. of 10 per cent alkali. This was diluted to 100 cc. 10 cc. of the solution required 22.6 cc. of *N*/20 silver nitrate after deducting the blank test, corresponding to 0.710 equivalent of chlorine per 100 g. of sample. The ammonia required 46.4 cc. of *N*/10 acid, corresponding to 0.289 equivalent per 100 g. of sample. Deducting this leaves 0.421 equivalent of chlorine combined as lead chloride; again deducting, there remains 0.008 equivalent of lead sulfate.

Composition of 100 g. of sample:

		Per cent
Impure *p*-aminophenol hydrochloride	0.289 equivalent or	42.1
Lead chloride	0.421 equivalent or	58.5
Lead sulfate	0.008 equivalent or	1.2
		101.8

The above analysis is of course accurate only to about 1 or 2 per cent, especially in the figure for *p*-aminophenol since all nitrogenous matter has been calculated as *p*-aminophenol hydrochloride.

DEVELOPING AGENT (SEPTEMBER 1916)—This material was stated by its label to be "Identical to Metol." On treatment with ether a considerable quantity entered into solution; the ethereal extract, on evaporation, left hydroquinone: 1.2140 g. gave 0.6300 g. or 52.0 per cent of hydroquinone. The insoluble portion was found to contain sulfite, sulfate, carbonate, iodide, sodium, potassium, and a salt of *p*-methylaminophenol.

Iodine estimation: 0.8996 g. gave 0.0613 g. AgI. Expressed as potassium iodide, 0.0487 g., or 5.4 per cent.

Sulfite estimation: 1.2140 g. required 36.0 cc. of standard iodine solution (1 liter corresponding to 50.0 g. of anhydrous sodium sulfite) corresponding to 0.179 g. or 14.7 per cent sodium sulfite.

Alkali metals: 0.2135 g. gave 0.0512 g. mixed sodium and potassium sulfates. This corresponds to 5.4 per cent potassium iodide plus 14.7 per cent sodium sulfite plus 3.7 per cent sodium carbonate.

Nitrogen estimation (Kjeldahl): 0.6030 g. required 11.5 cc. of *N*/10 acid, corresponding to 0.198 g., or 32.8 per cent of *p*-methylaminophenol sulfate.

Composition:

	Per cent
Hydroquinone	52.0
p-Methylaminophenol sulfate	32.8
Sodium sulfite	14.7
Potassium iodide	5.4
Sodium carbonate	3.7
	108.6

METOL SUBSTITUTE (JUNE 1918)—The material was extracted with ether, which, on evaporation, left no residue. Methyl alcohol dissolved a considerable proportion; the filtrate, on evaporation, left a residue consisting of pure ammonium *p*-toluenesulfonate, which was identified by the preparation of the corresponding sulfonic chloride and sulfonamide, both of which had the correct melting points. Further examination showed the presence of a salt of *p*-methylaminophenol and a small amount of some sodium salt. Sulfate was found to be present.

As ammonium *p*-toluene sulfonate has no developing action, the principal interest lay in the proportion of *p*-methylaminophenol present. A weighed quantity was accordingly dissolved in water and heated to boiling. To the boiling solution an excess of sodium carbonate solution containing a small amount of sodium sulfite was added, and the mixture boiled until every trace of ammonia was expelled. The residue was then immediately acidified with dilute sulfuric acid, and the nitrogen determined by the Kjeldahl method: 0.1200 g. required 8.5 cc. of *N*/10 acid corresponding to 0.146 g., or 12.0 per cent of methylaminophenol sulfate. The material thus contained 12.0 per cent *p*-methylaminophenol sulfate, the remainder consisting of ammonium *p*-toluenesulfonate together with a small proportion of sodium salts.

ADULTERANTS—These are of such diverse nature that it is impossible to suggest any general lines of examination. Among the adulterants and useless substitutes the following have been encountered:

Starch	Potassium bromide	Sodium carbonate
Cane sugar	Potassium iodide	Ammonium chloride
Citric acid	Potassium nitrate	Ammonium sulfate
Sodium formate	Sodium chloride	Calcium sulfate
Potassium oxalate	Sodium sulfate	Magnesium sulfate
Rochelle salt	Sodium sulfite	Lead chloride
Potassium ferrocyanide	Sodium bisulfite	Lead sulfate
Boracic acid	Sodium sulfide	
Borax	Sodium hydroxide	

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
ROCHESTER, N. Y.

A SUMMARY OF THE LITERATURE ON THE SOLUBILITY OF SYSTEMS RELATED TO NITER CAKE[1]

By H. W. Foote

Received July 24, 1918

In a recent article[2] Johnston has pointed out that "the best mode of using a solution of niter cake for any particular purpose could be ascertained from the appropriate solubility data." He has called attention, in particular, to the importance of such data for the three-component system Na_2SO_4–H_2SO_4–H_2O, and of four-component systems like Na_2SO_4–$FeSO_4$–H_2SO_4–H_2O. No system of the latter type has been investigated. There are 4 three-component systems which lead up to it of which only the following three have any importance:

(1) Na_2SO_4–H_2SO_4–H_2O
(2) Na_2SO_4–RSO_4–H_2O
(3) RSO_4–H_2SO_4–H_2O

Another system which may prove to be of some importance in connection with the utilization of niter cake is that consisting of Na_2SO_4–$(NH_4)_2SO_4$–H_2O.

I propose to review briefly the literature relating to the solubility of these systems, omitting older data obtained before the solubility relations in three-component systems were well understood. In some of the very recent publications, I have not been able to consult the original articles and in these cases the reference to *Chemical Abstracts* has been added.

Na_2SO_4–H_2SO_4–H_2O

This system has been investigated by D'Ans[3] and very recently by Pascal.[4] A few data are also given by Herz.[5] The results obtained by D'Ans were chiefly at 25°. The writer has recently repeated a number of his determinations and in general obtained excellent agreement. Pascal investigated the system under a wide range of temperature but only a summary of his results, expressed in a diagram without numerical data, has been published up to the present. The diagram is inaccurate in at least one respect, as it represents the solubility of the salt $Na_2SO_4.10H_2O$ far above its transition temperature, where it can no longer exist. The results at 25° taken from his diagram do not agree closely with those of D'Ans.

This system is not as simple as it might appear, for besides the decahydrate and the anhydrous salt, a series of four acid sulfates was found by D'Ans, each salt existing in contact with solutions of varying acid concentration between limits set by the formation of other solid phases. A transition temperature exists at 16.67°, at which temperature the three solid phases $Na_2SO_4.10H_2O$, Na_2SO_4, and $Na_3H(SO_4)_2.H_2O$ exist in equilibrium with solution and vapor. Below this temperature, the anhydrous salt cannot exist in stable equilibrium with acid solutions, and with increasing acidity the decahydrate is followed directly by an acid salt.

The solubility results in this system are important on account of the possibility of separating niter cake into its components by direct crystallization or leaching. This possibility is considered in detail by Saxton in the following article and no further mention is necessary here.

Na_2SO_4–RSO_4–H_2O

The first system of this type to be thoroughly investigated was that with magnesium sulfate.[1] Later, similar systems were investigated by Koppel[2] for R = Cu, Fe″, Co, Ni, Zn, Cd, Mn. Very recently, Schreinemaker and Prooye[3] have again investigated the system containing manganese as the bivalent metal, Massink[4] that containing copper, and LeChatelier and Bogitch[5] that with ferrous iron. Cameron and Seidell[6] have determined the solubility at 25° of calcium sulfate in solutions of sodium sulfate and in connection with the formation of salt deposits, van't Hoff[7] and others have investigated the same system. It is evident, therefore, that systems of this type have been investigated thoroughly. In many cases, the data are given for a considerable range of temperature. Excepting calcium sulfate, all the systems form double salts of the 1:1 type with either 2 or 4 molecules of water. Unlike most double salts, they are formed from the single salts by raising the temperature. The transition temperatures, at which the two single salts, double salt, solution, and vapor are in equilibrium, were determined in all systems investigated by Koppel. They all fall between the limits 8.7° and 22°. Below the transition temperature only the single salts crystallize. Beginning at temperatures slightly above the transition points, the double salts can be recrystallized from water without decomposition.

RSO_4–H_2SO_4–H_2O

The following systems of this type have been investigated, usually at 25°: R = Fe″,[8] R = Cu,[9] R = Ba,[10] R = Ca,[11] R = Be.[12] Very incomplete data for R = Zn are given by Hoffman[13] who describes an acid sulfate.

For copper and ferrous sulfates, and probably for all similar sulfates, the type of solubility with increasing concentration of sulfuric acid, is similar, the concentration of the sulfate decreasing with increasing acidity. Ferrous sulfate and zinc sulfate form acid salts from strongly acid solutions, while copper sulfate does not, giving ultimately the anhydrous sulfate.

[1] Published at the request of the Division of Chemistry and Chemical Technology of the National Research Council.

[2] This Journal, **10** (1918), 468.

[3] *Ber.*, **39** (1906), 1534; *Z. anorg. Chem.*, **49** (1906), 356; **61** (1909), 91.

[4] *Compt. rend.*, **164** (1917), 628.

[5] *Z. anorg. Chem.*, **73** (1912), 274.

[1] Van't Hoff and van Deventer, *Z. physik. Chem.*, **1** (1887), 170; Roozeboom, *Ibid.*, **2** (1888), 513.

[2] *Ibid.*, **42** (1902), 1; **52** (1905), 385.

[3] *Proc. Akad. Wetenschappen*, **15**, 1326; *Chem. Abs.*, **8**, 1068.

[4] *Z. physik. Chem.*, **92** (1917), 351; *Chem. Abs.*, **11**, 3184.

[5] *Rev. Metall.*, **12** (1915), 949; *Chem. Abs.*, **10**, 2460.

[6] *J. Phys. Chem.*, **5** (1901), 649.

[7] A summary of this work is found in *Z. anorg. Chem.*, **47** (1905), 244.

[8] Kenwick, *J. Phys. Chim.*, **12** (1908), 693; Wirth, *Z. anorg. Chem.*, **79** (1913), 360. Data are also given for ferric and aluminum sulfates. Florentin, *Bull. Soc. Chim.*, **13** (1913), 362.

[9] Bell and Taber, *J. Phys. Chem.*, **12** (1908), 171; Foote, *J. Am. Chem. Soc.*, **37** (1915), 288.

[10] Volkhonskii, *J. Russ. Phys.-Chem. Soc.*, **41**, 1763; *Chem. Abs.*, **5** (1911), 617.

[11] Cameron and Breazeale, *J. Phys. Chem.*, **7** (1903), 571.

[12] Wirth, *Z. anorg. Chem.*, **79** (1913), 357.

[13] *Z. angew. Chem.*, **23** (1910), 1672.

Barium sulfate becomes more soluble in strong sulfuric acid, as is well known, and an acid sulfate forms from strongly acid solutions.

Na_2SO_4-$(NH_4)_2SO_4$–H_2O

This system has recently been well investigated by Matignon and Meyer[1] through a considerable range of temperature. The work is of importance at present because of the possibility of using niter cake to absorb ammonia and produce ammonium sulfate. The attempts which have been made to do this have been summarized by Johnston.[2] They appear not to have been very successful thus far and the results obtained have been irregular. With the data which have now been published, it is possible to calculate exactly what can be done in this direction.

A double salt, $Na_2SO_4.(NH_4)_2SO_4.2H_2O$, forms, with a transition temperature at 59°. Above this temperature, only the single salts are deposited from solution.

Na_2SO_4–RSO_4–H_2SO_4–H_2O

No four-component system of this type has been thoroughly investigated. D'Ans has given a few data for solutions containing calcium sulfate. An investigation is in progress in this laboratory on such a system containing copper sulfate. It is to be hoped that investigators elsewhere may work out the data for other sulfates. The problem is an interesting one from a scientific standpoint as well as pointing out possible uses for niter cake.

Sheffield Chemical Laboratory
Yale University
New Haven, Connecticut

THE RECRYSTALLIZATION OF NITER CAKE[3]

By Blair Saxton

Received July 24, 1918

In this paper the solubility data of D'Ans[4] for 25° and of Pascal[2] for 0° will be used to calculate in some detail the extent of the separation of niter cake into its constituents which can be effected by leaching or crystallizing at these temperatures. The data of D'Ans are very good. Unfortunately Pascal has expressed his results in a triangular diagram only and data scaled from this are not reliable. Calculations have been made for 0°, however, and they are valuable in showing that the separation can be made more efficiently at that temperature than at 25°. Solubility determinations for temperatures lower than 25° are in progress in this laboratory and then the possibilities at these temperatures will be considered. Calculations somewhat similar to these which follow have recently been made by Hildebrand[5] and Blasdale.[6]

CRYSTALLIZATION AT 25°

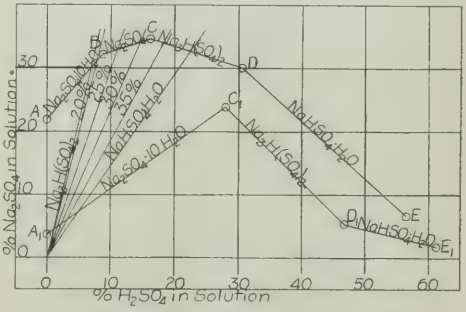
At this temperature we may crystallize the following solids: $Na_2SO_4.10H_2O$, Na_2SO_4, $Na_3H(SO_4)_2.H_2O$, $Na_3H(SO_4)_2$, $NaHSO_4.H_2O$, $NaHSO_4$, $NaH_3(SO_4)_2.1.5H_2O$, and $NaH_3(SO_4)_2$. Of these we may discard the last three, since their removal from solution takes out too much sulfuric acid. Further, $Na_3H(SO_4)_2.H_2O$ need not be considered since it rarely forms. The data of D'Ans, expressed in per cent of solution by weight, are given in Table I together with the composition of each solid phase considered.

Table I

Solid Phases	Solubility at 25° — Solution H_2SO_4	Solution Na_2SO_4	Solution H_2O
$Na_2SO_4.10H_2O$	0.00	21.90	78.10
$Na_2SO_4.10H_2O \rightleftarrows Na_2SO_4$	8.67	32.07	59.26
$Na_2SO_4 \rightleftarrows Na_3H(SO_4)_2$	16.34	34.64	49.02
$Na_3H(SO_4)_2 \rightleftarrows NaHSO_4.H_2O$	30.60	30.05[a]	39.35
$NaHSO_4.H_2O \rightleftarrows NaHSO_4$	56.49	6.68	36.83
Composition of Salts			
$Na_2SO_4.10H_2O$	0.00	44.10	55.90
$Na_3H(SO_4)_2$	18.70	81.30	0.00
$NaHSO_4.H_2O$	35.50	51.46	13.04
$NaHSO_4$	40.83	59.17	0.00

(a) Determined by H. W. Foote. D'Ans gives 26.30.

These solubility data are also plotted in the figure. Straight lines have been drawn between the points representing the univariant systems and the calculations are based on this approximation. Here also are shown lines radiating from the origin representing the composition of niter cakes of 20, 25, 30, and 35 per cent sulfuric acid, also similar lines for the two acid



sulfates, $Na_3H(SO_4)_2$ and $NaHSO_4.H_2O$. The intersection of one of these lines with the solubility curve gives the composition of solution which will first become saturated with the solid phase represented by that branch of the curve intersected. This of course tells what solid will form first on crystallizing at 25°. For instance, it shows that a niter cake which is 25 per cent sulfuric acid is never saturated with the decahydrate; hence it never forms on crystallizing.[1]

Considering the lines of the diagram as straight and letting x and y represent the concentrations of sodium sulfate and sulfuric acid, respectively, in saturated solution, the equations for these lines become as follows:

$$AB,\ x = 21.90 + 1.173\ y$$
$$BC,\ x = 29.17 + 0.335\ y$$
$$CD,\ x = 39.90 - 0.322\ y$$
$$DE,\ x = 57.67 - 0.903\ y$$

[1] *Compt. rend.*, **165** (1917), 787; **166** (1918), 115.
[2] *Loc. cit.*
[3] Published at the request of the Division of Chemistry and Chemical Technology of the National Research Council.
[4] *Loc. cit.*, preceding article.
[5] This Journal, **10** (1918), 96.
[6] *Ibid.*, **10** (1918), 347.

[1] The point of saturation can also be calculated by solving two simultaneous equations: one, the equation for a branch of the solubility curve; the other, the equation for the line showing the composition of the niter cake or solute. The line AB in the diagram is represented by the equation $x = 21.90 + 1.173\ y$. A 20 per cent acid niter cake is represented by the equation $x = 4\ y$. On solving these we obtain $x = 7.75$ and $y = 31.00$.

Given these equations and the composition of the solute before crystallization, it is possible to calculate the weight of the solid separating and the composition of the residual solution. For instance, let us consider the solid crystallizing to be Na_2SO_4. If we represent the weights of sodium sulfate and sulfuric acid in solution before crystallization as n and s, respectively, and the amount of Na_2SO_4 separating from solution as z, then at any point along BC the following relation must exist:

$$\frac{n - z}{s} = \frac{x}{y} = \frac{20.17 + 0.335y}{y}$$

and, solving for z, $z = n - s\left(0.335 + \frac{20.17}{y}\right)$,

or if we are dealing with a niter cake whose weight is c and which is s per cent sulfuric acid, this becomes:

$$z = c - cs\left(0.01335 + \frac{0.2017}{y}\right)$$

If the solid separating is $Na_3H(SO_4)_2$, the value of z is calculated by means of a similar equation, *i.e.*,

$$\frac{n - 0.813z}{s - 0.187z} = \frac{30.90 - 0.322y}{y}$$

Hence we are able to calculate how much of any solid will separate if we know the composition of the niter cake or the solution from it, and the per cent of sulfate acid in solution after crystallization.

Further, we can calculate the weight of water in the solution after crystallizing, or, which amounts to the same thing, the amount of water to be added to the solid niter cake in leaching at 25° in order to leave z grams of one of the solid phases. If we are evaporating the solution instead of leaching the solid, this weight of water added to c, the weight of the cake, will give the weight to which the solution must be evaporated, except when the solid separating is a hydrate, in which case the total weight is the sum of the weight of the solution—sodium sulfate, acid, water, and z. The extent to which the evaporation must be carried can also be very easily controlled by testing the acid concentration of the solution. Again considering the solid separating to be Na_2SO_4, w, the weight of water may be calculated as follows:

$$\frac{w}{s} = \frac{100}{y}\cdot\frac{(x + y)}{y} - \frac{70.83}{y} - 1.335$$

$$w = s\left(\frac{70.83}{y} + 1.335\right),$$

or if c is the weight of the niter cake or solute and s its acid concentration,

$$w = cs\left(\frac{0.7083}{y} + 0.01335\right)$$

Similarly, general calculations can be made for each of the other solid phases. The results for those phases which are here considered are assembled in Table II.

The equations are much simplified for any given value of s. For instance, if we take a solution of 100 g. of a 35 per cent acid niter cake which deposits crystals of $Na_3H(SO_4)_2$ first on crystallizing at 25°, we find that since $s = 35$ and $c = 100$,

$$z = 87.3 - \frac{744.8}{0.8732y - 7.461}$$

$$w = 65.0 - 0.187z\left(\frac{60.10}{y} - 0.678\right)$$

If we know the value of both x and y for the solution in equilibrium with a given solid, we may avoid using these general equations. Again, starting with 100 g. of 35 per cent acid niter cake, we may calculate the maximum amount of $Na_3H(SO_4)_2$ that can separate by using the data for the point D in the diagram. This gives us

$$\frac{65.00 - 0.813z}{35.00 - 0.187z} = \frac{30.05}{30.60} = 0.982,$$

from which z becomes 48.66. Then the weight of sulfuric acid left in solution, $35.00 - 0.187z$, becomes 25.90. This is the type of calculation which has been used mostly in this paper, since it tells us the most we can do in separating any one solid phase. Hence in speaking of crystallizing $Na_2SO_4.10H_2O$, Na_2SO_4, $Na_3H(SO_4)_2$, or $NaHSO_4.H_2O$, we refer to crystallizing each to the points B, C, D, and E, respectively. If, however, a specific use of niter-cake solution requires a certain acid concentration, one can tell from the figure what will first crystallize, and calculate how much will separate, and how much sodium sulfate and sulfuric acid will be left in solution by using the general equations.

In separating niter cake into its constituents either by leaching or crystallizing at 25° we have the following possible processes which may be used separately or combined:

(A) Remove $Na_2SO_4.10H_2O$ from solution. This may be done by evaporating the solution to a calculated weight, or just to an acid content of 8.67 per cent, or by leaching completely with the calculated amount of water. The solute (sodium sulfate + sulfuric acid) will then be 21.28 per cent acid. Of the niter cakes here considered only the one which is 20 per cent acid can deposit this salt at 25°.

(B) Remove Na_2SO_4 from solution. This can be done exactly as A. The acid content of the solution at crystallization, however, will be 16.34 per cent. The solute will be 32.05 per cent sulfuric acid.

(C) Remove $Na_3H(SO_4)_2$ from solution by processes similar to A and B. The concentration of sulfuric acid in the final solution should be 30.60 per cent, and in the solute, 50.45 per cent.

(D) Recrystallize the $Na_3H(SO_4)_2$ from C by first removing Na_2SO_4 by process B and then crystallizing $Na_3H(SO_4)_2$ from the filtrate. 100 g. $Na_3H(SO_4)_2$ when thus treated will give 41.66 g. Na_2SO_4 by evaporating to 156.1 g. or leaching with 56.1 g. of water. The filtrate will then deposit 33.81 g. $Na_3H(SO_4)_2$ when evaporated to 74.2 g. The solution will then contain 12.15 g. of sodium sulfate and 12.38 g. of acid. The end result in concentration is the same as C, but 12.38 g. of sulfuric acid have been recovered in solution which otherwise would be in solid $Na_3H(SO_4)_2$. The result of recrystallizing any amount of $Na_3H(SO_4)_2$ in this way can be calculated from these data.

TABLE II

SOLID PHASE	EXPRESSION FOR z	EXPRESSION FOR w
Na_2SO_4	$c - cs\left(0.01335 + \frac{0.2917}{y}\right)$	$cs\left(\frac{0.7083}{y} - 0.01335\right)$
	$n - s\left(0.335 + \frac{29.17}{y}\right)$	$s\left(\frac{70.83}{y} - 1.335\right)$
$Na_3H(SO_4)_2$	$c\left(1.145 - 0.007765s + \frac{8.544 - 0.4569s}{0.8732y - 7.461}\right)$	$(cs - 18.7z)\left(\frac{0.6010}{y} - 0.00678\right)$
	$\frac{39.90s - (0.322s + n)y}{7.461 - 0.8732y}$	$(s - 0.187z)\left(\frac{60.10}{y} - 0.678\right)$
$NaHSO_4.H_2O$	$c\left(1.197 - 0.001165s + \frac{24.51 - 0.6005s}{0.8351y - 20.47}\right)$	$(cs - 35.5z)\left(\frac{0.4233}{y} - 0.000973\right)$
	$\frac{57.67s - (0.903s + n)y}{20.47 - 0.8351y}$	$(s - 0.355z)\left(\frac{42.33}{y} - 0.0973\right)$

c = the weight of niter cake or solute.
s = the per cent of sulfuric acid in the niter cake or solute.
z = the weight of solid separating.
n = the weight of sodium sulfate in the niter cake or solute.
y = the per cent of sulfuric acid in solution after crystallization.
w = the weight of water in solution after crystallization.

(E) Remove $NaHSO_4.H_2O$ from solution by the methods given for A, B, and C. In this case the concentration of acid in the solute will be 89.43 per cent and in the solution, 56.49 per cent. The only advantage in crystallizing this acid sulfate is to raise the concentration of acid. By doing this, much of the acid is removed from solution. Some of this could be recovered by recrystallizing, first separating $Na_3H(SO_4)_2$ and then $NaHSO_4.H_2O$. In order to make a good recovery of acid, this would involve too many operations to be practical. $NaHSO_4.H_2O$ is 35.50 per cent sulfuric acid, 51.46 per cent sodium sulfate, and 13.04 per cent water and corresponds to a 40.83 per cent acid niter cake. Its saturated solution may contain as much as 56.49 per cent of acid. Uses may be found for its solution without further treatment.

Finally these processes may be combined to considerable advantage. In Table III will be found such combinations as BCD. This means that Na_2SO_4 has been removed from the solution of a niter cake, then $Na_3H(SO_4)_2$ has been crystallized from the filtrate, and, finally, this acid salt has been recrystallized and the residual solutions, having the same concentration, have been combined. In making calculations for these combined processes the writer found it convenient to work out the results which could be obtained with 100 g. of solute for each case and from that data to make the calculations desired. After completing process B, for example, the solutions will always have the same composition independent of the composition of the original niter cake. The same is true for process C. The data for these two solutions are as follows:

After Na_2SO_4 has been removed from solution, 100 g. of the solute in the filtrate will contain 32.05 g. of acid and 67.95 g. of sodium sulfate. This filtrate, on evaporation to 127.27 g., will give 57.96 g. of $Na_3H(SO_4)_2$ and a solution which contains 20.83 g. of sodium sulfate and 21.21 g. of sulfuric acid.

After $Na_3H(SO_4)_2$ has been crystallized from solution, 100 g. of the solute in the filtrate will contain 50.45 g. of acid and 49.55 g. of sodium sulfate. When this filtrate is evaporated to 123.5 g. it will deposit 92.21 g. of $NaHSO_4.H_2O$ and leave a solution which contains 17.71 g. of acid and 2.10 g. of sodium sulfate.

In Table III are the results of such treatments as have been outlined on 100 g. of niter cake of 20, 25, 30, and 35 per cent acid. In column four is given the weight at final crystallization in any series of processes. If the combined process is BC the weight for C is given, the weight for B having previously been given. If the final process is D, two weights are given, the first being the weight at which Na_2SO_4 separates, the latter that at which $Na_3H(SO_4)_2$ is removed in the recrystallization of $Na_3H(SO_4)_2$.

TABLE III

H_2SO_4 in niter cake Per cent	Treatment	Number of operations	Weight at final crystallization	H_2SO_4 in solution Per cent	H_2SO_4 in solute Per cent	H_2SO_4 recovered in solution Per cent	Na_2SO_4 left in solid Per cent
20.0	A	1	244.3	8.67	21.28	100.0	7.5
	B	1	160.0	16.34	32.05	100.0	47.0
	BC	2	79.4	30.60	50.45	66.2	83.8
	BCD	4	56.5, 26.8	30.60	50.45	88.5	78.3
	BCDD	6	19.1, 9.1	30.60	50.45	96.1	76.4
	C[1]	1	102.6	30.60	50.45	10.3	97.5
	CD	3	149.7, 71.2	30.60	50.45	69.7	82.9
	BCE	3	32.4	56.49	89.43	23.2	99.3
	BCDDE	7	33.8	56.49	89.43	33.8	99.0
25.0	B	1	175.0	16.34	32.05	100.0	29.3
	BC	2	99.3	30.60	50.45	66.2	78.3
	BCD	4	70.6, 33.6	30.60	50.45	88.5	71.0
	C[1]	1	112.9	30.60	50.45	40.0	86.9
	CD	3	125.1, 59.5	30.60	50.45	79.7	73.9
	CDD	5	42.3, 20.1	30.60	50.45	93.1	69.5
	BCE	3	40.5	56.49	89.43	23.2	99.1
30.0	B	1	190.0	16.34	32.05	100.0	9.1
	BC	2	119.3	30.60	50.45	66.2	72.1
	BCD	4	83.7, 40.3	30.60	50.45	88.5	62.7
	C[1]	1	123.1	30.60	50.45	59.9	74.5
	CD	3	100.5, 47.8	30.60	50.45	86.4	63.6
	BCE	3	65.1	56.49	89.43	23.2	98.8
35.0	C	1	133.3	30.60	50.45	74.0	60.9
	CD	3	76.0, 36.1	30.60	50.45	91.2	48.2
	CE	2	63.4	56.49	89.43	26.0	98.3
	CDE	4	78.2	56.49	89.43	32.0	98.0

[1] This can be done from the original solution by evaporating to the weight given and allowing to stand at 25°. All $Na_2SO_4.10H_2O$ and Na_2SO_4 will have changed into the acid salt at this concentration.

It is evident from these figures that the way to proceed with a niter cake of less than 25 per cent acid in order to produce a solute and solution which are 50.45 per cent and 30.60 per cent acid, respectively, is to remove Na_2SO_4 and $Na_3H(SO_4)_2$ consecutively from solution, recrystallize the acid sulfate, and combine the solutions (process BCD). This involves four operations and leaves 88.5 per cent of the acid in solution and over 70 per cent of the sodium sulfate in the solid. The recrystallization of the acid sulfate could be repeated, thus recovering 96.1 per cent of the acid but it would mean six operations and hence is hardly practical. If the niter cake is over 25 per cent acid, $Na_3H(SO_4)_2$ can be efficiently separated from the original solution, recrystallized, and the solutions combined. This takes only three operations. If the niter cake is 25 to 32 per cent acid, the recovery of sulfuric acid will be from 80 to 85 per cent. If the niter cake is 32 to 50 per cent acid, 91.2 per cent of the latter

will be recovered in solution. At 25° no method for concentrating the acid in solution as far as the point E in the diagram (a solution of 56.4 per cent, and a solute of 89.43 per cent acid) is possible without removing 70 to 80 per cent of the acid. Of course $NaHSO_4.H_2O$ can be removed so that the solution will have any desired concentration represented along the line DE. Proceeding for short distances along DE would not sacrifice an unreasonable amount of acid.

In order to test the practicability of these calculations, experiments were made on the removal of Na_2SO_4 and $Na_3H(SO)_2$ from solutions of 100 g. of 30 per cent acid niter cake. The solutions were made by warming 158.7 g. of recrystallized Glauber's salt with 31.6 g. of 95 per cent sulfuric acid in Erlenmeyer flasks. A small amount of anhydrous sodium sulfate remained undissolved.

One sample of such a solution, since it weighed 190.3 g., was cooled without further evaporation, corked, and immersed in a thermostat at 25° for 48 hrs. The Na_2SO_4 was filtered through a small suction filter and washed free from mother liquor with the solution recommended by D'Ans, consisting of 50 cc. of water, 10 cc. of concentrated sulfuric acid, and 75 cc. of alcohol. After removing the mother liquor, the salt was washed with alcohol and then with ether. When dry it weighed 7.0 g., while the amount calculated for the point C is 6.4 g. A little $Na_3H(SO_4)_2$ no doubt separated since the solution analyzed 16.42 per cent sulfuric acid and D'Ans found 16.34 per cent for the univariant point C.

A second sample of the solution was evaporated to 124 g. and treated in the same way. The calculated weight of the solution at crystallization is 123.1 g. but the last stages of evaporation offered some difficulties since the solution practically solidified. The acid sulfate was washed and dried in the same way as was the Na_2SO_4. When dry it weighed 68.5 g., while the calculated weight is 64.4 g. Here again the univariant point was reached, since the solution analyzed 30.61 per cent acid, while D'Ans found 30.60 per cent. The salt on analysis for sulfuric acid proved to be pure $Na_3H(SO_4)_2$. Considering the roughness of these experiments, both of them can be considered as satisfactory checks on the calculations.

RECRYSTALLIZATION AT 0°

The data of Pascal have been scaled from his diagram and are given in Table IV and plotted in the figure. They are expressed in per cent by weight of solution.

TABLE IV

Solid Phase	Solution H_2SO_4	Solution Na_2SO_4	Solution H_2O
$Na_2SO_4.10H_2O$	0.00	3.68	96.26
$Na_2SO_4.10H_2O \rightleftharpoons Na_3H(SO_4)_2$	28.14	23.93	47.86
$Na_3H(SO_4)_2 \rightleftharpoons NaHSO_4.H_2O$	46.81	5.26	47.60
$NaHSO_4.H_2O \rightleftharpoons NaHSO_4$	61.28	1.84	36.29

These data are inaccurate as has been pointed out, but they are valuable, as the following calculations will show. These calculations have not been carried out in as great detail as those for 25° because of the data on which they are based.

At 0° we have four solids which can reasonably be separated: $Na_2SO_4.10H_2O$, $Na_3H(SO_4)_2$, $NaHSO_4.H_2O$, and $NaHSO_4$. Solutions of niter cake of the range of compositions considered in this paper will first be saturated with Glauber's salt at 0°. The removal of this alone is very effective. It will leave all the acid in solution and the concentration of acid in the solution and solute will be 28.14 and 54.04 per cent, respectively. If $Na_3H(SO_4)_2$ is then crystallized from the solution, 82.6 per cent of the acid will be recovered, the solution will be 46.81 per cent acid, while the concentration of acid in the solute will be 89.90 per cent. Recrystallizing the acid sulfate, by removing $Na_2SO_4.10H_2O$ and $Na_3H(SO_4)_2$, successively, from its solution, and then combining the solutions will not change the composition of the solution or solute, but will recover in solution 97.0 per cent of the acid. 100 g. of $Na_3H(SO_4)_2$ recrystallized in this way at 0° will give 148.3 g. of $Na_2SO_4.10H_2O$ when treated with 114.7 g. of water or its solution evaporated to 214.7 g. The solution will then separate 17.43 g. of $Na_3H(SO_4)_2$ when evaporated to 50.3 g. The final solution will contain 1.73 g. of sodium sulfate and 15.44 g. of sulfuric acid.

If higher concentration of acid is desired this may be accomplished by evaporation and removal of $NaHSO_4.H_2O$. This also can be done efficiently as can be seen from a glance at Table V. By removing Glauber's salt, $Na_3H(SO_4)_2$, and $NaHSO_4.H_2O$, successively, from solution we are able to recover 77.7 per cent of the acid and obtain, as the result of these three operations, a solute and solution of 97.10 and 61.28 per cent sulfuric acid, respectively. From 98.7 to 99.4 per cent of the sodium sulfate in the cake is left in the solid. Any further desired concentration can be effected from this point since there is little sodium sulfate left in solution and very little if any of the acid salts can separate and hence little sulfuric acid can be removed. In other words, the solution now behaves like a solution of sulfuric acid only.

The results obtained with 100 g. of niter cake of several compositions are given in Table V. The meaning of the letters in column two is the same as in Table III.

TABLE V

H_2SO_4 in niter cake Per cent	Treatment	Number of operations	Weight at final crystallization	H_2SO_4 in solution Per cent	H_2SO_4 in solute Per cent	H_2SO_4 recovered in solution Per cent	Na_2SO_4 left in solid Per cent
20.0	A	1	213.9	28.14	54.04	100.0	78.7
	AC	2	53.8	46.81	89.90	82.6	97.7
	ACD	4	40.0, 9.4	46.81	89.90	97.0	97.3
	ACE	3	27.9	61.28	97.10	77.7	99.4
25.0	A	1	210.6	28.14	54.04	100.0	71.6
	AC	2	67.2	46.81	89.90	82.6	97.1
	ACD	4	50.0, 11.7	46.81	89.90	97.0	96.4
	ACE	3	34.9	61.28	97.10	77.7	99.2
30.0	A	1	207.4	28.14	54.04	100.0	63.6
	AC	2	80.7	46.81	89.90	82.6	96.0
	ACD	4	60.0, 14.0	46.81	89.90	97.0	95.3
	ACE	3	41.9	61.28	97.10	77.7	99.0
35.0	A	1	204.2	28.14	54.04	100.0	45.8
	AC	2	94.1	46.81	89.90	82.6	95.0
	ACD	4	70.0, 16.4	46.81	89.90	97.0	99.1
	ACE	3	48.9	61.28	97.10	77.7	98.1

It is evident that crystallization or leaching at 0° is much more effective than at 25° in that greater concentration and recovery of acid can be effected with fewer operations at the lower temperature. It is inter-

esting to note in this connection that Wood[1] has used a system of cold water percolation in order to concentrate acid in the solution from niter cake, and that this treatment has been recommended by Prideaux.[2] Unfortunately, at the present time the data are not available for temperatures between the two given. It may be possible that it is unnecessary to use a temperature as low as 0° in order to obtain a satisfactory separation. Solubility determinations for this system at 12° are being carried out in this laboratory by Professor Foote, who suggested this paper to the writer.

In the preceding paper reference has been made to the work of Matignon and Meyer on the solubility relations in the system Na_2SO_4–$(NH_4)_2SO_4$–H_2O. The writer proposes to treat this system as he has treated the system discussed in the present paper.

SUMMARY

General equations have been developed for the system Na_2SO_4–H_2SO_4–H_2O, at 25°, by means of which we can calculate how much of any one solid phase will separate from a solution if we know the composition of the original solute and the acid concentration of the solution after crystallization.

General equations have also been developed for this system at 25° by means of which we may calculate the weight of water in the solution after crystallization, or the weight of water to be added to the solid niter cake in order to leave a calculated weight of one of the solid phases.

A very simple type of calculation has been applied to niter cake of several compositions, by which the maximum amount of each solid phase which can be removed from solution at 25° and at 0° has been calculated.

Leaching or crystallizing processes have been suggested by which sulfuric acid may be concentrated in the solution and sodium sulfate in the solid, at the two temperatures mentioned.

It was found that this separation can be done much more efficiently at the lower temperature.

SHEFFIELD CHEMICAL LABORATORY
YALE UNIVERSITY
NEW HAVEN, CONNECTICUT

THE FORMATION OF AROMATIC HYDROCARBONS FROM NATURAL GAS CONDENSATE[3]

By J. G. DAVIDSON

Received May 23, 1918

INTRODUCTION

In several papers which have appeared recently Zanetti[4] has shown that it is possible to produce aromatic hydrocarbons by the thermal decomposition of straight-chain hydrocarbons of low molecular weight.

Previous to this, Bone and Coward[1] had passed ethane, ethylene, and acetylene through porcelain tubes at various temperatures from 500° to 1000° C. and had noted that the decomposition of ethylene gave a black, viscous tar. The quantity of tar was too minute to admit of analysis but they mentioned the fact that a few crystals of naphthalene were noticed also. They hold aromatic formation to be produced by the breaking down of ethylene to acetylene from which the aromatic hydrocarbons are produced by polymerization.

Pring and Fairlie[2] found that acetylene at high temperatures and in the presence of hydrogen produces methane for the most part, although some ethane was formed also. When ethylene and hydrogen were heated together no acetylene was produced even at very high temperatures. Methane, however, was produced in large quantities.

Jones[3] studied the formation of aromatic compounds in coal tar and is of the opinion that acetylene plays an unimportant part in the reaction, inclining more to the belief that the ring bodies are formed directly from olefines with the splitting out of hydrogen.

Previous work in this laboratory pointed to conclusions which were similar to Jones', and in an effort to get a further insight into the reaction the following work was undertaken:

It was decided to divide the work into several parts and investigate each as fully as time allowed, for it was quite evident from the beginning that any one of the separate fields was capable of large expansion with possible loss of the original aim.

The divisions of the work are as follows: (1) The effect of catalyzers on the decomposition of straight-chain hydrocarbons of low molecular weight. (2) The influence of temperature and of pressure on the production of aromatic hydrocarbons. (3) The formulation of the reaction,

Straight-chain hydrocarbons ⟶ Aromatic hydrocarbons

EXPERIMENTAL

MATERIAL—The material used was the ethane-propane fraction of natural gas condensate, supplied in steel tanks under high pressure. The tanks are built on the siphon system, a pipe reaching almost to the bottom, so the composition of the delivered gas remains almost constant. Analysis of the gas showed it to be composed almost entirely of the two hydrocarbons, although some butane, and possibly some pentane, was also present. No other gases were present in the original material, although tests were made for oxygen, carbon dioxide, olefines, and hydrogen.

[1] *J. Soc. Chem. Ind.*, **36** (1917), 1216A.

[2] *Ibid.*, **36** (1917), 1216B.

[3] This paper is condensed from a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Pure Science of Columbia University.

The work was begun under the direction of Dr. J. E. Zanetti and is, in part, a continuation of his work. After the summer of 1917, when Dr. Zanetti entered the Chemical Warfare Service, the work was carried on more or less independently although I am glad to thank Dr. Nelson, Dr. Freas, and Dr. Fisher for their many invaluable suggestions, and without whose help the work could not have been finished.

[4] "The Thermal Decomposition of the Propane-Butane Fraction from Natural Gas Condensate," THIS JOURNAL, **8** (1916), 674; "The Thermal Decomposition of the Ethane-Propane Fraction from Natural Gas Condensate," *Ibid.*, **8** (1916), 777; "Aromatic Hydrocarbons from the Thermal Decomposition of Natural Gas Condensate," *Ibid.*, **9** (1917), 474.

[1] "Thermal Decomposition of Hydrocarbons," *J. Chem. Soc.*, **93** (1908), 1197.

[2] "Synthesis of Hydrocarbons at High Temperatures," *Ibid.*, **99** (1911), 1796.

[3] "Aromatic Formation," *J. Soc. Chem. Ind.*, **36** (1917), 3.

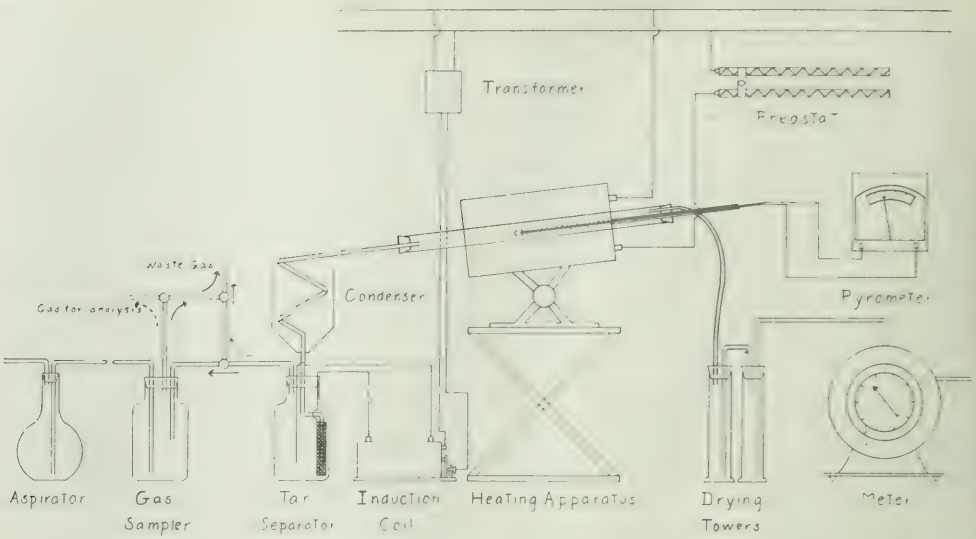


FIG. 1

APPARATUS—The arrangement of the apparatus will be understood from Fig. 1. The gas was led through the referee meter, capable of being read to one-thousandth part of a cubic foot, then through the calcium chloride towers to the cracking chamber. The cracking chamber was a silica tube one inch in diameter about 2 ft. long and could be heated by the resistance furnace shown. The temperature could be controlled within a few degrees by the adjustable rheostat, while its actual value was read by means of the pyrometer. After the gas had been cracked it was quickly cooled in the metal condenser and passed into the precipitator. (At first a small copper plate and a fine iron wire were kept charged at opposite sides of the bottle. This did not work satisfactorily and the inlet tube was then surrounded with wire gauze as shown in the figure. This worked well for a time, as the gas had to pass through the charged wire meshes to escape, and deposition therefore was easy. After some time the meshes of the gauze became stopped up and required frequent renewal. The form of precipitator was then changed to that shown in Fig. 2, which was very satisfactory.) From the tar precipitator the gas was allowed to escape, as shown by the light arrow, or by-passed in the direction of the heavy arrow when a sample was being collected. This arrangement was necessary to prevent a change in the rate of flow through the cracking chamber, which was caused when trying to take a sample direct from the tar precipitator.

After a sample of sufficient volume had collected in the gas sampler the gas was allowed to pass in the same direction for a half hour longer in order that all parts of the apparatus might be in equilibrium. Failure to do this produced results that could not be checked. After a half hour had elapsed the stopcocks were turned so the gas followed the light arrow again and the collected sample of gas was forced out into a gas collecting bottle by way of the dotted arrow.

The apparatus for the analysis of the cracked gas was a modification of Burrell's gas apparatus.[1] Nothing new is claimed for this apparatus except its greater accessibility and ease of manipulation. It is shown in Fig. 3. Babb pipettes with an extra stopcock blown in the bend, as shown, were substituted for the Ostwald pipette in Burrell's apparatus. This extra stopcock facilitates refilling and cleaning the pipettes without the necessity of disconnecting from the main part of the apparatus. Beyond this the form of the Babb pipette lends itself admirably to rapid and complete absorption.

The slow combustion pipette (B) was made of transparent quartz rather than glass in order to reduce breakage. When using the ordinary glass pipette for slow combustions the oxygen would sometimes catch fire and burn at the point where the capillary opens out into the pipette. This would always result in a fracture at that point; furthermore, it was necessary after a combustion to wait almost 5 min. before the glass was cool enough to allow the mercury, which always had some drops of water on the surface, to be raised. After considerable trouble from both of these causes it was decided to have the pipette made of silica. The pipette as described gives the best of satisfaction.

Copper oxide was used to determine the hydrogen. The copper oxide was also enclosed in a tube of transparent silica, in preference to glass, which will break if drops of condensed water are drawn into the hot part of the tube. Use of a silica tube was suggested for this purpose by Suydam,[2] but it was found best

[1] "New Forms of Gas Analysis Apparatus," THIS JOURNAL, 4 (1912), 296.

[2] "A New Model of the Burrell and Oberfell Apparatus for the Analysis of Illuminating Gas," THIS JOURNAL, 9 (1917), 972.

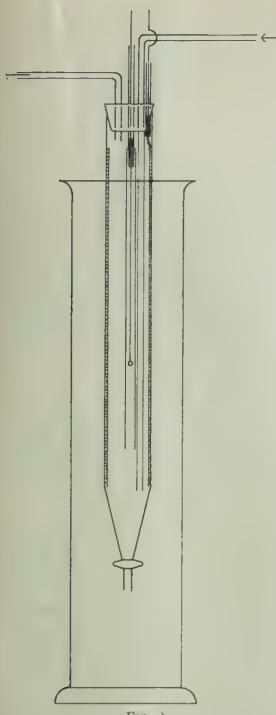


FIG. 2

to make the tube horizontal rather than vertical as he advises. This position prevents stoppages, which happen after a time with the vertical form.

PROCEDURE — The gas was led through the cracking chamber at the rate of 0.5 cu. ft. per hr., the rate of flow being frequently checked with a stopwatch. The temperature of the silica tube was rapidly raised to the desired point and kept there by adjusting the rheostat. When the temperature had become constant and the gas had passed through the tube and tar precipitator for sufficient time to sweep out all traces of gas from a preceding run, a sample was taken as described before, and the temperature of the tube raised for the next determination. While equilibrium was being reached again the first sample of gas was analyzed.

When catalyzers were used in the form of foil or gauze, pieces of uniform size were cut, rolled up to fit the tube snugly, and pushed in so the entire heated zone was filled with catalyzer. When small pieces of material had to be used for catalyzer the cracking tube was packed with loose material, which was held in place with a plug of copper gauze, preliminary work having shown that copper has no decided effect as catalyzer.

GAS ANALYSIS—All capillary errors and the larger error due to gas left in the copper oxide tube have been carefully determined and allowed for in the reports of analysis. As preliminary work showed no other gases to be present, unsaturated hydrocarbons, hydrogen, and saturated hydrocarbons were the only ones determined.

Pipettes 1 and 2 (Fig. 3) contained 30 per cent potassium hydroxide. Pipette 3 contained saturated bromine water.

The unsaturated hydrocarbons were determined by absorption in Pipette 3, one passage of the gas being sufficient if the olefine content of the gas was below 17 per cent. When the unsaturated hydrocarbons existed in greater amounts it was necessary to pass the gas through this pipette twice. Complete absorption is definitely shown by the presence of bromine vapor above the aqueous layer. Before measuring the amount of absorption it was necessary to pass the gas through Pipettes 1 and 2 to remove all traces of bromine vapor. Otherwise, the bromine causes a heavy sludge of mercuric bromide to form in the measuring pipette. This sludge clings to the sides of the tube and makes further work impossible.

It was necessary to use bromine water for the absorption of olefines, because sulfuric acid, either fuming or concentrated, was found to absorb some of the saturated hydrocarbons left in the gas which had been cracked at low temperatures. Above 750° C. the residual saturated hydrocarbons consisted solely of methane, so either sulfuric acid or bromine water could be used for gas cracked above this temperature.

After the contraction due to the absorption of the unsaturated hydrocarbons was measured, the gas was slowly passed through the copper oxide tube to the slow combustion pipette and back, until no further contraction occurred. The shrinkage was calculated as hydrogen. The temperature of the copper oxide tube was kept at 310° C. by means of a nichrome resistance heater controlled by a rheostat. This temperature was found to give rapid absorption of hydrogen, without noticeably attacking the saturated hydrocarbons still present.

The residue was then passed into the silica slow-combustion pipette, the wire brought to low whiteness, and the oxygen passed in. In samples taken above 600° C. the residue consisted solely of methane and ethane, and above 750° C. only methane survived.

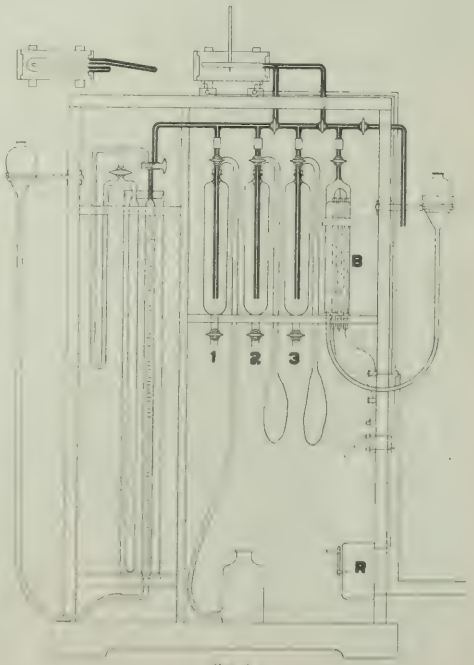


FIG. 3

CATALYZER	550° C.		600° C.		650° C.		700° C.		750° C.		800° C.		850° C.		900° C.		950° C.	
	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H	Unsat.	H
None[1]	4.0	0.9	8.0	4.8*	18.0	10.9	24.6	13.3	27.2	19.8	17.6	28.9	8.9	39.6	5.3	59.7	...	...
Pumice (Coarse)[2]	5.3	4.9*	12.8	2.8	23.7	4.8*	28.4	19.8	21.8	30.5	19.5	32.5*	9.9	43.4	2.7	57.9*	1.5	63.5*
Pumice (Fine)[3]	2.8	2.8	5.8	3.9	21.7	13.8	29.6	16.6*	24.2	27.0	19.8	33.5	8.5	45.7	1.9	55.4	1.7	63.0
Brass (Gauze)[4]	2.6	4.9*	9.3	3.2	12.7	7.3	24.8	10.1*	27.7	19.4*	15.8	26.2	12.1	36.5	6.9	44.9	3.7	53.6*
Nickel (Gauze)[5]	3.6	4.9*	9.3	10.3	3.6	61.0*	1.7	69.7	1.8	68.2	0.5	82.0	0.5	80.5	0.3	84.5	...	...
Iron (Gauze)[6]	3.6	6.1	10.9	7.1	21.5	11.9	26.9	21.2*	7.1	54.5*	...	...	1.9	62.8	1.5	66.8	...	...
Iron (Strips)[6]	2.0	3.5	11.0	5.9*	22.8	11.2	16.3	37.8*	5.6	56.0	1.5	64.2	...	...	0.8	60.3	0.0	70.5
Chromium (Lumps)[7]	4.6	2.1*	7.9	2.1*	18.4	6.9*	28.3	13.7	28.8	22.8	22.5	27.7	16.9	33.6*	8.9	44.4	3.9	54.7
Manganese (Lumps)[8]	1.2	4.4*	8.7	6.2*	22.4	12.5	23.1	26.1	21.4	33.4	19.9	38.1	13.1	49.4	3.2	53.7*	...	...
Calcium Carbide[9]	1.2	2.4	3.8	4.4	11.9	8.3*	24.4	20.1	24.2	28.5*	16.1	41.2*	9.5	48.2	5.2	57.3	0.6	64.3
Molybdenum (Wire)[10]	0.0	1.0	5.8	3.8*	23.6	9.0	30.1	15.2*	25.5	25.3*	17.3	30.2	9.8	39.7	3.1	49.2	1.6	54.7
Titanium (Lumps)	2.4	2.6*	7.0	2.9	19.5	8.6	28.1	14.9	23.7	25.1	23.5	26.3	11.5	36.1	4.4	50.0*	...	...
Calcium (Turnings)	1.8	0.0	7.8	3.4	28.4	9.3	30.2	15.8	26.5	22.9	15.2	34.9	Calcium melts above 800° C.					
Silicon (Lumps)	8.0	8.9	8.0	2.4	17.0	6.9*	28.1	11.5	25.7	18.8	18.0	27.2	9.6	34.3	2.2	50.9*	...	...
Cobalt (Strips)[11]	2.1	1.8	9.4	3.2	22.3	8.2	29.7	13.0	27.9	18.9*	14.8	43.2*	2.7	56.5*	1.0	60.8*	...	...
Tungsten (Rods)	6.2	2.1	14.9	4.8*	22.4	8.4	29.8	13.4*	27.6	18.5*	17.1	28.5	16.0	35.9	1.8	53.2*	...	...
Platinum (Foil)[12]	2.2	0.5	12.3	5.7*	21.1	8.9	30.2	14.6	30.2	17.6	17.9	25.3	9.4	36.8	6.5	42.1*	2.2	57.8
Gold (Foil)	1.6	1.7*	9.6	3.8	25.2	8.8	31.0	16.0*	25.2	29.8	20.7	23.4*	11.8	34.2*	5.2	46.3	...	...
Silver (Foil)	2.4	2.5	13.0	8.4	20.6	9.8	29.8	14.0	27.4	19.7	21.4	26.6*	10.5	37.1	5.8	43.7*	...	...

* For purposes of reference the observations are all grouped under nine temperatures. Where the actual observed temperature varied more than 5° from that which heads the column, an * marks the fact. The exact temperature may be found by consulting the curves.

[1] Light fog appeared at 615° C. Fog became heavy and brown at 800° C. and almost black at 900° C. Solid material was deposited at this higher temperature instead of liquid tar.

[2] Light fog appeared at 788° C. but soon disappeared. No tar was found in the precipitator, but a very small amount was found in the cool end of the condenser. Naphthalene crystals were found in the cool end of the cracking tube. Pumice was stained black through all the pores and had gained 2 g. in weight, but this could not be removed by heating in air.

[3] Traces of fog visible at times, other conditions similar to [2].

[4] No carbon on gauze at 650° C. Fog began at 740° C. Gauze examined again at 800° C. Surface was tarnished but no free carbon present. Heavy fog above 800° C. Heavy deposit of tar and naphthalene in the tar precipitator.

[5] Gauze changed after each determination as the carbon deposited in one run was sufficient to plug up the tube. No fog visible at any time and no tar.

[6] Remarks for nickel apply here[5].

[7] Heavy fog above 750° C. Considerable tar deposited. No free carbon. The chromium was seemingly unaffected.

[8] Yield of tar small. Some free carbon in cracking tube. The lumps of manganese which were made by the Goldschmidt process crumbled into pieces.

[9] No visible fog at any time. No tar deposited. At the end of run the pieces of calcium carbide were found cemented together by pieces of hard coke.

[10] Heavy fog above 750° C. Good tar deposit. A few hard lumps of coke were found adhering to the wire after two or three runs.

[11] Heavy fog but not much tar. Large amount of carbon in the form of soft lampblack in the cracking tube.

[12] Heavy fog and good tar yield. Platinum was tarnished at end of run but was easily cleaned. No free carbon deposited.

This was checked up so many times that finally this last determination was not carried out above 750° C.

The composition of the olefines will be taken up in a later part of this paper.

In no case where tar was formed during a run did it deposit in noticeable amounts before a temperature of 700° to 750° C. was reached. Slight bluish fogs were sometimes observed earlier, but in no case was tar recovered from them.

The tabulated results are shown above. See also Figs. 4 to 7 inclusive.

DISCUSSION OF RESULTS

In accordance with former work it is observed that a tar is produced by heating straight-chain hydrocarbons of low molecular weight to a temperature of 700° C. and above. This tar has been shown[1] to consist of a mixture of simple aromatic compounds, such as benzene, with more complex ones, such as phenanthrene. With the exception of nickel, iron, and cobalt, metals do not seem to have any great catalytic effect upon the reaction, nor does variation in the surface exposed seem to influence the reaction. It is to be noted in this connection that Bone and Coward[2] found that the decomposition of methane was a surface effect, but the decomposition of ethane and of ethylene was not.

The metals nickel, iron, and cobalt act as anticatalysts, so far as the production of tar is concerned. Their presence causes the main reaction to be of the order

Straight-chain hydrocarbons ⟶ Carbon + Hydrogen

The above reaction always takes place to a certain extent in the thermal decomposition of the hydrocarbons, but in most of the cases examined it is much less important than the reaction

Straight-chain hydrocarbons ⟶
Aromatic hydrocarbons + Hydrogen + Methane

It may also be pointed out here that many of the decompositions observed when a substance was "passed through a red-hot iron tube" may have been due to the specific catalytic action of the iron pipe, particularly in those cases where large amounts of free carbon were produced.

The carbon deposited in these experiments varied from hard, coke-like, and closely adherent material to soft, velvety lampblack (this latter when the three anticatalysts were used) that did not adhere to the tube. Bone and Coward[1] hold that the decomposition of methane gives the hard variety, while ethylene gives the soft material. Our work seems to confirm this, for in those cases where soft carbon was deposited the amount of methane in the gas was small.

THE INFLUENCE OF TEMPERATURE AND OF PRESSURE ON THE PRODUCTION OF AROMATIC HYDROCARBONS

In this part of the experimental work it was first attempted to ascertain at what temperature the maximum yield of tar was obtained, and definitely establish whether any of the catalysts previously used promoted the formation of tar.

The same apparatus was used, with the exception that an improved form of precipitator was used. This is shown in Fig. 2 and is simply a 2 in. tube drawn down on one end to a point which is fitted with a rubber tube and pinchcock. A cylinder of gauze which fits the tube tight was one electrode, the other was simply a fine iron wire insulated by a glass tube. This insulation was necessary to prevent sparking from the center electrode to the gauze. The same 2 in. spark coil was used as a source of current and the whole precipitator was immersed in a freezing mix-

[1] Zanetti, *Loc. cit.*

[2] *Loc. cit.*

[1] *Loc. cit.*

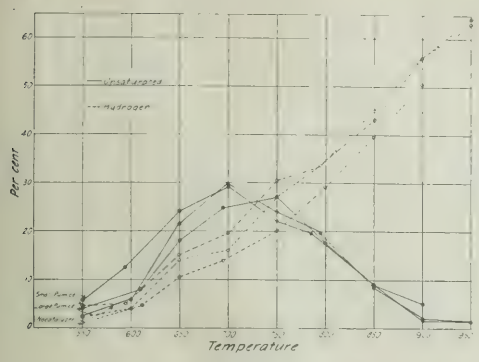


FIG. 4

ture. This precipitator worked so well that it was possible to pass the gas through the cracking tube at a rate of 3 to 4 cu. ft. per hr. and still have complete precipitation of the tar.

PROCEDURE—The furnace was brought up to the desired temperature and the gas admitted at the rate of approximately 1 cu. ft. per hr. The precipitator was started and the apparatus left to itself. At intervals, the temperature and the rate of flow were checked up, and while it was found possible to regulate the temperature within a few degrees, it was not always possible to regulate the rate of flow closer than 5 or 10 per cent of the rate desired. This was chiefly due to the gradual choking of the delivery pipe with naphthalene. At the end of a run the time was noted, the tar run out of the precipitator, its volume measured, and its specific gravity taken at 20° C. No analysis of the tar was attempted. The precipitator and tube were cleaned and a new run made the next day.

A few of the catalyzers which seemed most promising were introduced into the cracking tube, as before, and the yields determined after the most favorable temperature for the formation of tar had been worked out.

No records were made below 750° C., as the yields of tar were negligible.

The results are shown in both tabular and graphic form (Fig. 8).

Temp. Deg. C.	Vol. of Gas Used Cu. Ft.	Length of Run Hours	Vol. of Tar Obtained Cc.	Rate Cu. Ft. Per Hr.	Yield per Cu. Ft.	Sp. Gr.
750	8.2	7.7	16.3	1.06	2.24	0.9819
800	7.6	8.1	25.5	0.94	3.33	1.0040
850	7.9	8.2	42.0	0.96	5.30	1.0600
900(a)	7.3	7.2	1.2	1.01	0.16	..
			Copper as Catalyzer			
850	8.6	7.2	53.4	1.18	6.2	0.999
			Chromium as Catalyzer			
850	7.2	5.4	41.0	1.32	5.7	1.002
			Silicon as Catalyzer			
850	6.4	6.1	49.0	1.04	7.7	1.016
			Tungsten as Catalyzer			
850	8.6	7.0	45.4	1.23	5.3	1.038

(a) In the run at 900° C. a large amount of naphthalene was produced. It deposited on the sides of the precipitator and on the electrodes in such a way that its volume could not be measured.

It is evident from the above that a temperature of 850° C., or thereabouts, is the best for tar formation. The increasing specific gravity of the tar with higher temperatures shows a decreasing content of the lighter aromatic hydrocarbons such as benzene, and also indicates the formation of more complex substances such as naphthalene and phenanthrene. Other work, which is not yet completed, confirms this point.

The use of catalysts seems to give a slightly better yield of tar, but this may be due to the more advantageous transfer of heat to the gas when the packing tube is packed. The specific gravity and the general appearance of the tar resulting from the use of catalysts are also approximately the same as of the tar produced at the same temperature, but without the use of a catalyst.

It seems, therefore, that catalysts have no marked beneficial effect on tar formation from straight-chain hydrocarbons.

In order to gain an insight into the reactions taking place during tar formation it was thought worth while to investigate the effect of pressure on the gaseous products and on the yield of tar.

The effect of diminished pressure as well as increased pressure was studied. For diminished pressure the apparatus already described worked very well, after a few alterations had been made. A manometer for measuring the pressures had to be fitted and a slightly different method of by-passing the gas, when samples were collected, was necessary. The silica tube was entirely unsuited for the pressure work, however, and it was found impossible to heat a copper tube to the required temperatures in the electric furnaces at hand. It was therefore decided to build a furnace using the cracking tube as a core. An iron tube was inadmissible, of course, because of its anticatalytic effect, so copper, although rather soft and of low melting point, was decided upon. It has no catalytic effect and may be readily obtained in any size.

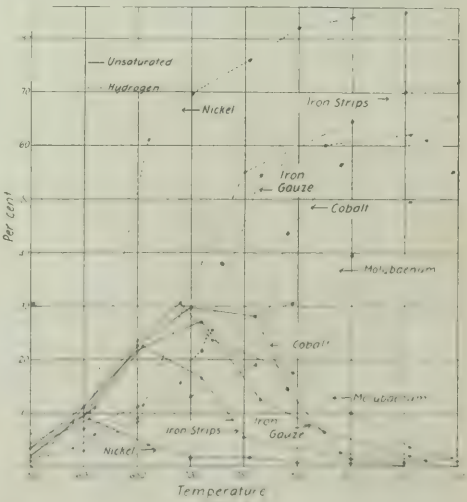


FIG. 5

The construction of the furnace is simple, but a few words of explanation may not be out of place. The tube itself was extra heavy copper pipe, 1 in. in diameter and 3 ft. long. It was found impossible to

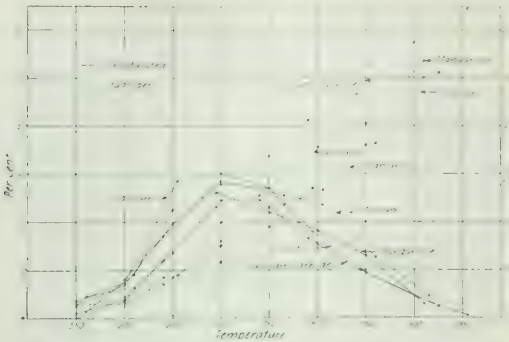


FIG. 6

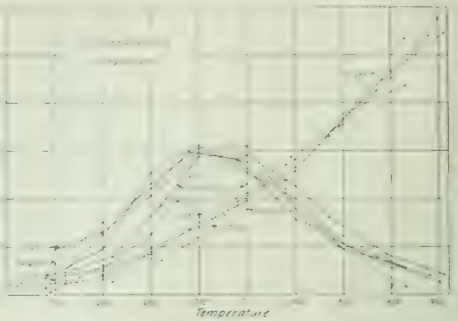


FIG. 7

cut good threads on the ends, so 6-in. sections of heavy brass pipe were brazed on and silver soldered to make a tight joint. These brass ends were threaded and fitted with hydraulic iron fittings and valves. All joints were made tight with litharge-glycerin cement. Twenty-inch strips of 1/4 in. asbestos board were first wired around the pipe, and the nichrome wire wound in two sections on the strips. The ends of the wires were brought out to 1/4 in. asbestos board heads.

The furnace would heat up to 900° C. in 20 min. Beyond that temperature we did not think it advisable to venture.

PROCEDURE—The procedure was about the same as before. The furnace was brought up to temperature, the rate of flow adjusted, and the pressure regulated. Vacuum was obtained by a motor-driven Nelson pump, and arrangement was made for altering the strength of vacuum by introducing a valve that could be opened to the atmosphere.

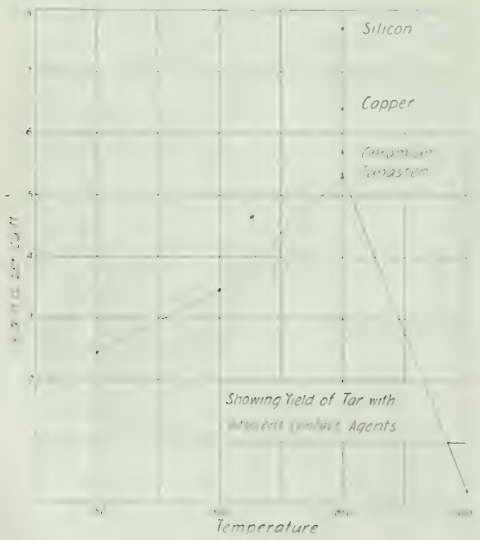


FIG. 8

Pressure was obtained by connecting the furnace directly to the tank of compressed gas through a pressure reduction valve that could be adjusted within a pound or two. An escape valve in the far end of the furnace provided another adjustment. The same runs were made as before and the cracked gas analyzed as described in Part I.

The work of high pressure was taken up first. After the furnace had been brought up to temperature, gas was run through it at atmospheric pressure, a sample taken, and the pressure raised to 25 lbs. While equilibrium was being reached in the furnace the first sample was analyzed. In the same way the pressure was raised to 50, 75, and 100 lbs., the temperature being held constant meanwhile. This usually constituted a day's work. The next day the work was repeated at the next higher temperature until the whole range of temperatures had been recovered. The results may be observed in the following graphs (Fig. 9).

From the results of the work it seems that two entirely different reactions take place in the cracking, and they may be divided into those that take place below 700° C. and those that take place above 700° C.

Up to 700° C. increase of pressure causes increase of unsaturated hydrocarbons and hydrogen in the cracked gas. At 700° C., however, a sharp change is noted, and from that point on increase of pressure *decreases* the amounts of unsaturated hydrocarbons and

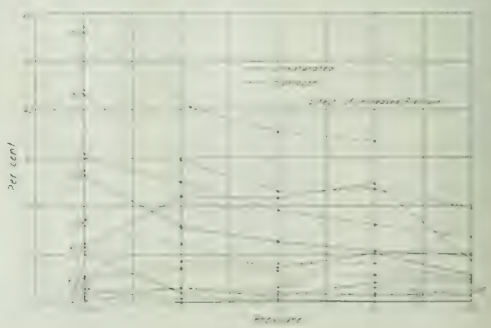


FIG. 9

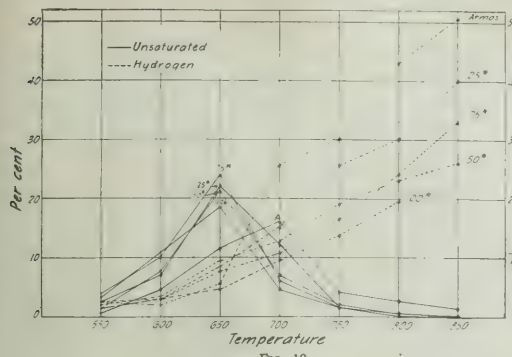


FIG. 10

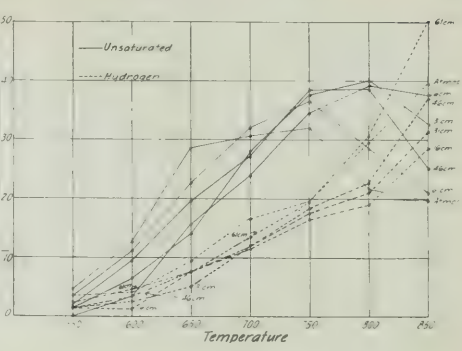


FIG. 11

hydrogen in the cracked gas. There is no doubt that many complex reactions are taking place in the heated tube, but below 700° C. decrease of volume is unquestionably taking place. Above that temperature we have supposed that condensation to aromatic hydrocarbons takes place. This point is well sustained by other writers, but, at the same time, large quantities of hydrogen are split off and much methane is liberated, so the sum total of the reaction is an increase of volume. Pressure therefore should inhibit the reaction.

This view is confirmed by the fact that in all the runs above 700° C. at atmospheric pressure the vapor in the tar precipitator is brown with tar, and tar is deposited as usual. As soon as pressure is applied, however, the vapors become colorless and no more tar is deposited. The first increment of 25 lbs. pressure was sufficient to prevent the formation of tar, in all cases but the last (850° C.), where a slight fog persisted until a pressure of 50 lbs. was reached.

The curves (Figs. 10 and 11) in which percentage composition of the gas is plotted against temperature, the pressure being constant, show great similarity among themselves and with the simple curves representing runs at atmospheric pressure.

In the diminished pressure work, the procedure was the same as above except that the samples had to be taken in a slightly different way, that need not be described here. The temperature was held constant while readings at atmospheric pressure, at 61, 46, 31, and at 16 cm. of mercury were taken. The exact degree of diminished pressure was rather difficult to maintain, but by careful adjustment of a stopcock which permitted access to the atmosphere at one end of a T-tube, the other end being connected to the tar precipitator, this was finally accomplished.

The results (Fig. 12) bear out in detail those obtained with increased pressure. As the pressure becomes less, the content of unsaturated hydrocarbons and of hydrogen in the cracked gas becomes less at all temperatures up to 700° C. This time 750° seems to be the transition point, the percentage of hydrogen falling slightly while the percentage of olefines increases somewhat. Thereafter the percentage of hydrogen decreases rapidly with diminished pressure while the percentage of unsaturated hydrocarbons increases correspondingly.

Tar made its appearance at 750° C., but diminished with the pressure. Very little tar was deposited at any temperature under diminished pressure, which may be due to two things. Under conditions of diminished pressure the gas is not exposed to the effect of heat as long as it is under atmospheric pressure. On the other hand, the formation of tar is a condensation, and as such would be impeded by diminished pressure. The point brought out is that the formation of tar takes place in two stages.

The first one involves splitting of the saturated bodies into unsaturated bodies, with the splitting out of hydrogen and consequent increase of volume. Diminished pressure accelerates this stage and in one case the percentage of unsaturated hydrocarbons rises as high as 39 per cent, which is considerably more than attained at any other time. The next step, however, requires the condensation of these unsaturated bodies into aromatic bodies, and pressures should favor this. It is true that hydrogen may split out also at this point, but, even so, condensation is difficult to effect under diminished pressure.

The curves in which percentage composition is plotted against temperature, while the pressure is held constant, show a constantly increasing maximum for the unsaturated bodies and also show that this maximum is reached at a higher temperature as the pressure becomes less.

In short, the pressure experiments definitely show that the main reaction concerned in the formation of aromatic hydrocarbons from straight-chain hydrocarbons of low molecular weight begins at a temperature around 700° C., and is a reaction that proceeds with increase of volume despite the fact that it is a condensation.

They show, furthermore, that the reaction proceeds in two steps, the first of which is impeded by pressure, the second of which is impeded by diminished pressure. Diminished pressure, however, largely increases the yield of unsaturated hydrocarbons, and as these will later be shown to be valuable substances, a new way is opened for the production of these bodies in large amounts.



FIG. 12

THE REACTION

SIMPLE STRAIGHT-CHAIN HYDROCARBONS ⟶ AROMATIC HYDROCARBONS

There are two views held concerning the formation of aromatic bodies from the straight-chain series. The theory claiming the largest number of adherents is the decomposition of the saturated hydrocarbons step by step to acetylene, which then polymerizes to benzene.[1]

The other view holds that aromatic bodies can be formed from olefine bodies directly without going through the acetylene stage.[2] It must be admitted that little experimental evidence has been produced to substantiate this latter view, the chief reliance being placed in the fact that it has been impossible to detect acetylene at any stage of the reaction. It was decided to investigate the reaction concerned in this work, with the hope that we could fit it to one or the other of these views.

The evidence of the polymerization of acetylene to benzene is incontrovertible, so this work was not repeated. The work was therefore begun by mixing known amounts of acetylene with the gas used in our previous work. This was accomplished by passing a definite amount of acetylene through the referee meter into an empty gas holder, following this by the addition of sufficient natural gas condensate to make up a mixed gas of desired acetylene content. The mixture was allowed to stand a day before being used, that thorough mixture might take place. It was then run through the cracking tube in the original apparatus and the cracked gas allowed to bubble through ammoniacal silver nitrate, followed by ammoniacal cuprous chloride.

The following mixtures were experimented with:

	Per cent		Per cent
Acetylene	0.1	Natural Gas Condensate	99.0
Acetylene	0.5	Natural Gas Condensate	99.5
Acetylene	1.0	Natural Gas Condensate	99.0
Acetylene	2.5	Natural Gas Condensate	97.5
Acetylene	5.0	Natural Gas Condensate	95.0
Acetylene	10.0	Natural Gas Condensate	90.0

As the mixed gas was led through the cracking tube, the temperature was raised from an initial temperature of 550° C. to one of 950° C., by steps of 50°. In every case the test for acetylene was positive. In the 0.1 per cent and 0.5 per cent mixtures the test was less pronounced at higher temperatures than at lower ones, but this was to be expected, as acetylene in the presence of large amounts of hydrogen passes partly to ethylene or ethane, and partly breaks up into carbon and hydrogen.[1]

The point to be noted here is that sufficient acetylene remains even in a 0.1 per cent mixture, which has been passed through a tube slowly (0.5 cu. ft. per hr.) and cracked at a temperature up to 950° C., to give a decided test for a triple bonded component.

We must conclude, therefore, that acetylene, if formed in appreciable amounts in the thermal decomposition of natural gas condensate, would not entirely decompose again. In any event, enough would remain to give a reaction with silver nitrate or cuprous chloride. Although the absence of acetylene has been reported in this connection, we repeated the tests, using clean gas, and could find no trace of acetylene.

Examination of the bromides formed by passing the cracked gas through bromine under water and cooled with ice and salt showed no tetrabromacetylene.

The absence of acetylene or other triple bonded hydrocarbons seems to establish the fact that aromatic formation is not in this case dependent upon their formation.

In order to study the unsaturated bodies more thoroughly, about 500 g. of mixed bromides were prepared as described above.

It has been pointed out before that methane was the only hydrocarbon remaining when the gas was cracked at a temperature of 750° C., or above, so simple bromides of ethane or propane need not be looked for. In order to make certain that substitution was not taking place in the methane, however, a preliminary experiment was run in which the bromine was used dissolved in carbon tetrachloride. Hydrobromic acid is given off from such a solution when substitution takes place as opposed to addition. The gases, after passing through the bromine solution, were cooled to —20° C., and then passed through glass wool at the same temperature to catch any volatilized bromine vapor. They were then allowed to bubble through standard potassium hydroxide. Back titration showed that almost no acid had come over, and therefore that substitution was not taking place to any appreciable extent.

The 500 g. of mixed bromides prepared above were distilled under 4 cm. vacuum with the following results:

	Volume Per cent	Sp. Gr.
1st drop at 29° C.	...	...
29°–50°	6.5	1.46
50°–60°	35.0	1.89
60°–64°	45.0	2.13
Residue	10.0	...
Loss	3.5	
	100.0	

No trouble was experienced in the distillation, as decomposition of the bromides did not take place. The liquid distillates were then mixed and redistilled at atmospheric pressure with the following results:

[1] Berthelot, *Ann. chim.*, [4] **9**, 469.

[2] D. T. Jones, "The Thermal Decomposition of Hydrogenated Hydrocarbons," *J. Chem. Soc.*, **107** (1915), 1582, and "The Thermal Decomposition of Low Temperature Coal Tar," *J. Soc. Chem. Ind.*, **36** (1917), 3.

[1] Bone and Coward, *Loc. cit.*

Temperature	Volume Per cent		Sp. Gr.
1st drop at 89° C.	...		...
89°–125°	10.3		1.492
125°–133°	44.7	Ethylene Bromide Fraction	2.108
133°–137°	12.8	Propylene Bromide Fraction	2.070
Residue	29.4		...
Loss	2.8		
	100.0		

The residue from the vacuum distillation was almost entirely tetrabrombutane, while a large amount of this same material was extracted from the thick liquid that remained in the distillation flask above. It is evident that the bromides are, as reported by Zanetti,[1] a mixture of ethylene bromide, a smaller amount of propylene bromide, and from 10 per cent to 20 per cent tetrabrombutane (butadien tetrabromide). Small amounts of other bromides are also present, but no acetylene tetrabromide (b. p. 137° C., sp. gr. 2.9) was found. The bromine content of the ethylene and propylene bromides was checked up by analysis and found to be correct within 0.5 per cent. The melting point of the tetrabrombutane was found to be 117° C. (correct value = 118° C.) and its bromine content corresponded to the formula $C_4H_6Br_4$.

The source of the tetrabrombutane needs inquiry. But very little butane exists in the original gas, which, as remarked before, consists of almost nothing but ethane and propane. The butane content is not large, and accounts in no way for the large yield of tetrabrombutane. A building-up process must therefore be responsible for the greatest part of the yield. It is a known fact that butadien yields tetrabrombutane on bromination and, since the presence of this compound was suspected, experiments were carried out to isolate it.

In order to prove this point, the gases, after cracking at 850° C., and after all the tar was removed by the precipitator, were cooled down in three stages. The cleaned gas was slowly led through three wide test tubes placed in thermos bottles containing cooling liquids. In Tube 1, the gas was cooled to —3° C. Any benzene still present was frozen out in this tube. Tube 2 was kept at a temperature of —90° C. by means of a mixture of alcohol and liquid air, while Tube 3 was placed in liquid air direct. The temperature of the gas in this last tube was about —170° C.

The boiling points of some of the substances we are dealing with are given as follows:

Methane	—164°	Propylene	— 50°
Ethane	— 89°	Butylene	— 5°
Propane	— 39°	Butadien	— 5°
Butane	+ 0.6°	Hydrogen	—256°
Ethylene	—103°	Benzene, f. p.	+ 5°

Ethane, propane, and butane can be ruled out at once, as methane is the only saturated hydrocarbon remaining in the gas at this temperature. Assuming all the rest of the gases to be present, it is evident that only benzene will be deposited in Tube 1. Propylene, butylene, and butadien will condense in Tube 2, while ethylene and some methane will condense in Tube 3. Hydrogen mixed with a large amount of the vapor of methane will pass on uncondensed.

Some solid did appear in Tube 1, showing that the precipitator does not remove all the benzene; Tubes 2 and 3 contained liquid condensates. These condensates were very mobile, almost colorless liquids with pronounced odors.

In Tube 2 we are concerned with the presence of butadien, so after 20 to 30 cc. of liquid had collected, the tube was disconnected and allowed to warm up slowly to —20° C. The propylene all boiled off in the process and the volume shrunk to less than one-half. Keeping the tube in the cooling mixture, pure bromine was dropped into the liquid which still remained. A reaction of almost explosive violence took place and the liquid began to boil rapidly.

Addition of bromine was continued until the liquid remained slightly red, then a little liquid from Tube 3 was added to combine with the excess bromine. About half the liquid remaining, after the propylene had boiled off, was lost in the bromination process which had generated enough heat to keep the bromides formed liquid for some time, even though the bath was still at a temperature of —20° C. Shortly afterward, however, the whole residue in the test tube solidified. The tube was withdrawn, a portion of the crystals recrystallized from alcohol, and the melting point determined. M. p. = 117° C. No butane dibromide, which would result from the presence of butene, was observed.

This experiment was repeated, but this time after 30 to 40 cc. of liquid had collected in Tube 2, it was disconnected and closed with a stopper and delivery tube, whose end was beneath bromine covered with water and cooled with a mixture of ice and salt. The gases evolved as Tube 2 warmed up to —20° C. were allowed to bubble through the bromine until the temperature of —20° C. was reached. Another tube containing bromine was then substituted for the first one and Tube 2, containing the condensed gas, was removed from the thermos bottle and allowed to come to room temperature, the evolved gases passing through the bromine as before. All the liquid in the tube had vanished before a temperature of —2° C. was reached.

By distillation, propylene bromide was readily obtainable from the first tube of bromine as a heavy, almost colorless liquid, with a pronounced and rather sweet odor, b. p. = 139.8° C., sp. gr. = 1.942 at 17° C. The liquid in the second tube solidified and was identified by its melting point as tetrabrombutane.

Tube 3 was now disconnected from the apparatus and transferred to a thermos bottle containing a mixture of liquid air and alcohol at a temperature of —115° C. Violent ebullition took place as it warmed up to this temperature, and methane (b. p. = —164° C.) boiled off. A clear liquid remained which was practically all ethylene. It was identified by brominating a small portion of it and taking the melting point (m. p. = +9° C.).

The experiment was repeated once more, but this time, after the propylene had boiled off Tube 2 and

[1] *Loc. cit.*

the methane off Tube 3, the remaining material as it volatilized was led in each case to a small gasometer. The gas so obtained represented a mixture of approximately 30 per cent butadien and 70 per cent ethylene.

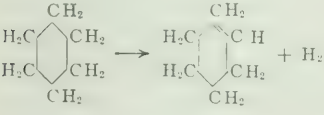
This mixed gas was passed through the original apparatus and cracked at a temperature of 850° C. A small amount of tar similar in all respects to the original tar was obtained. Its specific gravity was 1.010. Further analysis was not attempted, owing to the small amount formed. The cracked gas was then analyzed and shown to be 50 per cent unsaturated, 20 per cent methane, and 30 per cent hydrogen. The cracked gas, when cooled down as before, gave a large amount of ethylene in Tube 3 along with some ethane. Tube 2 had only a trace of condensate, showing that all the butadien had combined.[1]

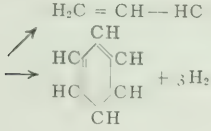
CONCLUSIONS

The presence of butadien in large quantities in the cracked gas can be explained only by the combination of two molecules of ethylene, with the splitting off of hydrogen, thus

$$H_2C = CH_2 + H_2C = CH_2 \longrightarrow H_2C = CH - HC = CH_2 + H_2$$

If now we presume that another molecule of ethylene can unite with the butadien, we have all the necessary steps for the formation of benzene. D. T. Jones[2] finds that cyclohexane on heating to 500° C. passes to cyclohexene which then decomposes in two ways, yielding benzene on one hand and butadien with ethylene on the other.





The present work merely requires the union of the ethylene and butadien of this equation to form cyclohexane which most likely has no separate existence, breaking down at once into benzene and hydrogen. This reaction involves an increase of volume and would therefore be inhibited by increase of pressure, a fact which has already been proved true above.

In support of these views we have the work of Jones,[2] who inclines to the belief that olefines condense to aromatic bodies. He states, "It is highly probable that a necessary transient stage is the formation and condensation of the stable conjugated double linking, —CH = CH — CH = CH—." The presence of this linkage in its simplest form, butadien, has been demonstrated above.

Staudinger,[1] starting with isoprene, showed that 45 to 55 per cent of this material was converted into a tar by passing it through a tube at 750° C. This tar contained aromatic hydrocarbons similar to those Zanetti found in his tar. Staudinger also cracked butadien alone and obtained from it a tar that contained about 25 per cent benzene.

It seems to be established, therefore, that diolefines, on cracking, pass in large part to closed chain bodies. It has been demonstrated in this work that simple olefines and diolefines are produced by the cracking of the ethane-propane fraction of natural gas condensate. The aromatic bodies found in the tar comes from the condensation of the diolefines and this therefore gives us all the necessary steps in the formation of aromatic bodies from straight-chain hydrocarbons of less than four carbon atoms, and without the necessity of passing through the stage of acetylene.

SUMMARY

I—It has been shown that most metals are without action on the reaction

Paraffin hydrocarbons ⟶ Aromatic hydrocarbons.

The metals nickel, iron, and cobalt are anticatalysts for the above reaction, but promote to a marked degree the reaction

Paraffin hydrocarbons ⟶ Carbon + Hydrogen.

II—The effect of temperature and pressure on the production of aromatic hydrocarbons has been studied. It has been pointed out that a temperature of 850° C. is most favorable for the formation of liquid tar and that the formation of complex aromatic bodies increases with the temperature.

III—Increase of pressure inhibits the formation of tar while diminished pressure increases the yield of unsaturated bodies but also decreases the actual yield of tar.

IV—Butadien has been isolated in fairly large amounts from the unsaturated bodies produced in the thermal decomposition of natural gas condensate.

V—Acetylene has been shown to be without action in the formation of the aromatic compounds.

VI—Tar containing aromatic bodies has been produced from the cracking of a mixture of butadien and ethylene.

VII—The most probable reaction for the formation of aromatic bodies from natural gas condensate is

Saturated straight-chain hydrocarbons (Ethane) ⟶ Simple olefines (Ethylene) ⟶ Higher olefines with conjugated bonds (Butadien) ⟶ Aromatic hydrocarbons (Benzene)

DEPARTMENT OF CHEMISTRY
COLUMBIA UNIVERSITY
NEW YORK CITY

[1] For references on the preparation and properties of butadien see *J. Chem. Soc.*, **27** (1874), 406; *J. Chem. Soc.*, **49** (1886), 80, and *Ann.*, **308** (1899), 333.

[2] *Loc. cit.*

[1] *Ber.*, **46** (1913), 2466

LABORATORY AND PLANT

METHODS OF ANALYSIS USED IN THE COAL-TAR INDUSTRY. III—HEAVY AND MIDDLE OILS

By J. M. Weiss

Received September 9, 1918

HEAVY OIL TESTS

TEST H2—WATER[1]

APPARATUS—Same as given under B2 (see Fig. II, Paper I, This Journal, **10** (1918), 735).

METHOD—200 cc. of oil shall be measured in a graduated cylinder, and poured into a copper still, allowing the cylinder to drain into the still for several minutes. Attach lid and then the clamp, using a paper gasket slightly wet with oil, around the flange of the still. Heat shall be applied by means of the ring burner, which shall be placed just above the level of the oil in the still at the beginning of the test, and gradually lowered when most of the water has distilled over. The distillation shall be continued until the vapor temperature, indicated by the thermometer with the bulb opposite the off-take of the connecting tube, reaches 205° C., the distillate being collected in the separatory funnel. When the distillation is completed, and a clear separation of water and oil in the funnel has taken place, the water shall be read by volume and drawn off; and any light oil distilled over with the water shall be returned to the oil in the still after it has cooled sufficiently. The dehydrated oil from the still shall be used for the distillation and other tests.

TEST H3—SPECIFIC GRAVITY (SPINDLE)[1]

APPARATUS—Hydrometer and cylinder (See Fig. II, Paper I, This Journal, **10** (1918), 735). Two hydrometers with ranges 1.00 to 1.08 and 1.07 to 1.15 will suffice. These shall be calibrated at 15.5° C. (60° F.).

METHOD—The oil shall be brought to a temperature of 38° C. (100° F.) and the determination shall be made at that temperature unless the oil is not entirely liquid at 38° C. The cylinder shall be filled with dry oil, the latter stirred, and the temperature noted. The hydrometer shall be inserted and the reading taken. In case the oil requires to be brought to a higher temperature than 38° C. in order to render it completely fluid, it shall be tested at the lowest temperature at which it is completely fluid, and a correction made by adding 0.00075 to the observed specific gravity for each degree Centigrade above 38°, at which the test is made.

PRECAUTIONS—Before taking the specific gravity the oil in the cylinder should be stirred thoroughly with a glass rod, and this rod when withdrawn from the liquid should show no solid particles at the instant of withdrawal. Care should be taken that the hydrometer does not touch the sides or bottom of the cylinder when the reading is taken, and that the oil surface is free from froth and bubbles.

ACCURACY—0.002.

NOTE—The correction factor, 0.00075, does not apply with equal accuracy to all oils, but serious error due to its use will be avoided if the precaution of avoiding unnecessarily high temperature is observed.

The factor 0.00075 and its method of use are approximations.

TEST H4—SPECIFIC GRAVITY (WESTPHAL)

APPARATUS—Westphal balance. 25 cc. glass cylinder.

METHOD—The balance shall be set up and adjusted so that the plummet when suspended to swing freely in air exactly balances the beam. A reading shall then be taken in water at 15.5° C. and if the balance is properly made and adjusted, this will be unity. A second reading in oil at 15.5° C. gives the specific gravity directly.

PRECAUTIONS—If the reading in water at 15.5° C. is not unity when the balance is adjusted in air so that the plummet balances the beam, the balance shall not be adjusted in water, but the oil reading divided by the water reading shall be taken as the specific gravity.

Boiled distilled water shall be used. Care shall be taken to see that the wire from which the plummet is suspended is immersed in both oil and water to the same point when the instrument is in balance. Care must be taken to see that the plummet is clean and dry before immersion.

NOTE—If the specific gravity is to be taken at a temperature above 15.5° C., a reading must be taken in water at the same temperature and the specific gravity at $t/t°$ C. obtained. This may be converted into specific gravity at $t°/15.5°$ C. by multiplying by the density of water at $t°/15.5°$ C. These density figures for water may be found in reference books such as Van Nostrand's Chemical Annual. To calculate from 38°/38° to 38°/15.5° C. the factor is 0.99385. From the foregoing it will be readily seen that it is incorrect to calculate the specific gravity at 38°/15.5° by dividing the reading in oil at 38° by the reading in water at 15.5° C. as is occasionally done.

TEST H5—INSOLUBLE IN BENZOL[1]

All matter as to apparatus, method, notes, and precautions as given under B7[2] apply to this test on these materials.

ACCURACY—0.2 per cent.

NOTE—At least 10 g. of oil shall be taken for the test.

TEST H6—RETORT DISTILLATION[1]

APPARATUS—Retort: This shall be a tubulated glass retort of the form and approximate dimensions shown in Fig. XII with a capacity of 250 to 290 cc. The capacity shall be measured by placing the retort

[1] See A. S. T. M. Method D-38-17, A. S. T. M. Standards adopted in 1917

[1] See A. S. T. M. Method D-38-17, A. S. T. M. Standards adopted in 1917.

[2] This Journal, **10** (1918), 736.

with the bottom of the bulb and the end of the off-take in the same horizontal plane, and pouring water into the bulb through the tubulature until it overflows the off-take. The amount remaining in the bulb shall be considered its capacity.

Condenser tube: This shall be a suitable form of tapered glass tubing of the following dimensions:

Diameter of small end, 12.5 mm.; permissible variation, 1.5 mm.
Diameter of large end, 28.5 mm.; permissible variation, 3.0 mm.
Length, 360.0 mm.; permissible variation, 4.0 mm.

Shield: An asbestos shield of the form and approximate dimensions shown in Fig. XII shall be used to protect the retort from air currents and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

Receivers: Erlenmeyer flasks of 50 to 100 cc. capacity are the most convenient form.

Thermometer: This shall conform to specification as given under C7.

Assembly: The retort shall be supported on a tripod or on rings over two sheets of 20-mesh gauze, 6 in. square, as shown in Fig. XII. It shall be connected to the condenser tube by a tight cork and the thermometer inserted in a tight cork in the tubulature, with the bottom of the bulb 1/2 in. from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a vertical rule graduated in divisions not exceeding 1/16 in. back of the retort when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb. The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 24 nor less than 20 in. The burner shall be protected from draughts by a suitable shield or chimney (see Fig. XII).

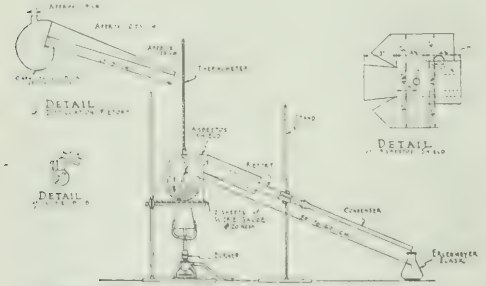


FIG. XII—ASSEMBLY OF DISTILLATION TEST FOR HEAVY OIL
A. S. T. M. D-38-17

METHOD—Exactly 100 g. of oil shall be weighed into the retort, the apparatus assembled, and heat applied. The distillation shall be conducted at the rate of at least one drop and not more than two drops per second, and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the following points: 210°, 235°, 270°, 315°, and 355° C. The receivers shall be changed as the mercury passes the dividing temperature for each fraction. When the temperature reaches 355°, the flame shall be removed from the retort, and any oil which has condensed in the off-take shall be drained into the 355° fraction.

NOTES—The residue shall remain in the retort with the cork and the thermometer in position until no vapors are visible; it shall then be weighed. If the residue is to be further tested, it shall then be poured directly into the brass collar used in the float test or into a tin box and covered and allowed to cool to air temperature. Care must be taken not to pour at a temperature high enough to cause loss of oil vapors. If the residue becomes so cool that it cannot be poured readily from the retort, it shall be re-heated and completely melted by holding the bulb of the retort in hot water or steam and not by the application of a flame.

For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

When any measurable amount of water is present in the distillate it shall be separated as nearly as possible and reported separately, all results being calculated on the basis of dry oil. When more than 2 per cent of water is present, water-free oil shall be obtained by separately distilling a larger quantity of oil, returning to the oil any oil carried over with the water, and using dried oil for the final distillation (see H2).

TEST H7—SPECIFIC GRAVITY FRACTIONS (WESTPHAL)[1]

APPARATUS—A special type of Westphal balance is obtainable, designed for testing very small quantities. However, the ordinary type of Westphal balance can be adapted to testing small fractions by the use of a special plummet. The plummet can readily be made in the laboratory from a piece of ordinary glass tubing 7 mm. outside diameter, sealed at the end, and melting into the glass, where sealed, a short platinum wire. After cooling place 9 to 10 g. of mercury in the tube, making a column 35 to 40 mm. high. Seal off the tube within 20 mm. of the top of the mercury column with blowpipe flame. The plummet shall have a length of about 55 to 60 mm. over all and shall weigh between 10 and 12 g.

METHOD—The weights necessary to balance the plummet in air and in water of the required temperature shall be noted and similarly the weight necessary to balance the plummet in oil at the same temperature.

If a = weight to balance in air
b = weight to balance in water to $t°$
c = weight to balance in oil at $t°$

$$\text{Specific gravity } t°/t° = \frac{c - a}{b - a}$$

PRECAUTIONS—When using the small plummet, special care is needed that the adjustment of the balance be accurately made.

NOTE—For corrections from $t°/t°$ C. to $t°/15.5°$ C., see note under H4.

[1] See paper by J. M. Weiss, THIS JOURNAL, 7 (1915), 21, and A. S. T. M. Method D-38-17, A. S. T. M. Standards adopted in 1917.

This method is adapted to fractions which are liquid under 60° C. and may usually be applied to the 235° to 315° fraction.

TEST H8—SPECIFIC GRAVITY FRACTIONS (PLATINUM PAN)[1]

All matter under B6[2] applies to this test on this material.

NOTE—This method is adapted to solid and semi-solid fractions such as are usually obtained from 315° to 355° C.

TEST H9—FLOAT TEST ON RESIDUE[3]

All matter as to apparatus, method, precautions and notes, as given under C8, applies to this test on these materials.

TEST H9—FLOAT TEST ON RESIDUE MATERIAL[3]

All matter as to apparatus, method, precautions and notes as given under C8 applies to this test on these materials.

TEST H10—COKE[4]

APPARATUS—Hard glass bulbs as shown in Fig. XII shall be used.

METHOD—The bulb shall be warmed slightly to drive out all moisture, cooled in a desiccator, and weighed. Then the bulb shall be heated again by placing it momentarily in an open Bunsen flame, the tubular placed underneath the surface of the oil to be tested, and the bulb allowed to cool until sufficient oil is sucked in to fill the bulb about two-thirds full.

Any globules of oil sticking to the inside of the tubular shall be drawn into the bulb by shaking, or expelled by slowly heating it. The outer surface shall be carefully wiped off and the bulb reweighed. This procedure will give about 1 gram of oil.

A strip of thin asbestos paper about 1/4 in. wide and about 1 in. long shall be placed around the neck of the bulb and the two free ends caught close up to the neck with a pair of crucible tongs. The oil shall then be distilled off as in making ordinary oil distillation, starting with a very low flame and conducting the distillation as fast as can be maintained without foaming.

When oil ceases to come over, the heat shall be increased until the highest temperature of the Bunsen flame is attained, the whole bulb being heated red-hot until the evolution of gas ceases, and any carbon sticking to the outside of the tubular is completely burned off. The bulb shall then be cooled in a desiccator, weighed, and the percentage of coke residue calculated on water-free oil.

PRECAUTIONS—Be careful to heat the oil slowly at the start to avoid spurting. If the oil contains over 2 per cent of water it should be dried before testing. The oil must be thoroughly liquefied and uniform throughout.

NOTES—A large diameter cork with a cup-shaped hole cut in the center forms a convenient holder in which to weigh the bulb. When a stock of bulbs is received, one or more should be given a heat test to determine hardness. Occasionally bulbs have been found too soft, therefore melting below the temperature required to coke the oil and thus producing low results.

TEST H11—TAR ACIDS (CONTRACTION METHOD)

APPARATUS—Tar-acid separatory funnel, type 1 (see Fig. XIII). Tar-acid separatory funnel, type 2 (see Fig. XIV). Distillation apparatus.

METHOD—100 cc. of oil shall be placed in a distilling apparatus such as is used under test F5 and distilled until at least 95 per cent of distillate has been obtained or until the vapor temperature has reached 400° C. The entire distillate shall be transferred to a tar-acid separatory funnel—type 1 designed for oils which have 25 per cent tar acids or over, or type 2 for oils containing less than this amount. The funnel with the oil shall be placed in a water bath and kept at a constant temperature of 60° C. until no change in volume takes place. It shall then be extracted with successive portions of 50 cc. each of 10 per cent caustic soda solution until no further diminution in volume occurs. The soda shall be added to the oil, the whole thoroughly shaken, then returned to the bath at 60° C. and allowed to settle completely. After settling is complete, the soda layer shall be drawn off and the volume of residual oil noted. When the point of no further contraction is reached the diminution in volume of the oil shall be considered as tar acids.

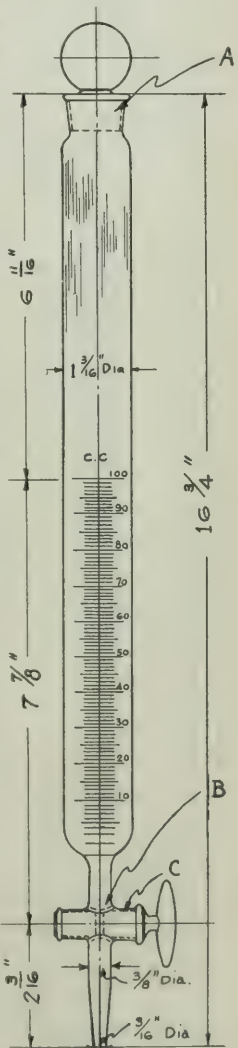


FIG. XIII DETAIL OF TAR-ACID SEPARATORY FUNNEL, TYPE 1
A—Ground glass stopper
B—Capacity given from stopcock up
C—Ground glass stopcock

NOTES—In some cases (such as creosote tar solutions containing small amounts of acids), there will be insufficient material to bring the oil up into the

[1] See paper by J. M. Weiss, THIS JOURNAL, 7 (1915), 21, and A. S. T. M. Method D-38-17, A. S. T. M. Standards adopted in 1917.

[2] THIS JOURNAL, 10 (1918), 736.

[3] See standard method of the Am. Wood Pres. Assoc. adopted in 1916 and A. S. T. M., D-38-17, tentative method, A. S. T. M. Proceedings 1917, Part 1, p. 826.

[4] *Ibid.*, p. 828.

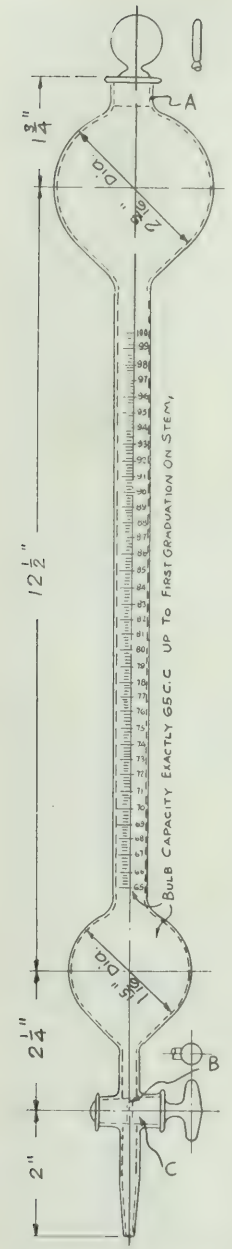


FIG. XIV—SEPARATORY FUNNEL FOR ACID DETERMINATION, TYPE 2

A—Ground glass stopper
B—3/8 in. drilled hole
C—Ground glass stopcock

graduated section of type 2 separatory funnel. In such cases, sufficient tar-acid-free, clean, heavy naphtha may be added to dilute the oil and bring it within the graduated portion. If this is done, the extracted oil cannot be used for subsequent dry salt tests but an additional portion must be extracted for this purpose.

This test is recommended for all general work in oil specifications and general comparative tests, but gives results slightly higher than the true tar-acid content of the oil. The reason for this is that soda withdraws from creosote oil certain compounds which are not subsequently liberated from the soda solution in the form of an oil. These substances are evidently acid in nature but not phenolic bodies.

TEST H12—TAR ACIDS (LIBERATION METHOD)

APPARATUS—Same as used under H11. Water and tar separatory funnel (see Fig. II, Article I, THIS JOURNAL, **10** (1918), 735.

METHOD—100 cc. of oil shall be distilled as prescribed under H11. (Where the content of tar acids is very low, a distillation may be made on 200 cc. so as to obtain a more accurate test.) The oil shall be shaken in a separatory funnel with successive 50 cc. portions of 10 per cent caustic soda or until no more tar acids are removed. The well-settled separated carbolate shall be acidified in a small beaker with 40 per cent sulfuric acid, taking care to keep the mixture cool at all times. (If the content of tar acids is under 5 per cent, use the water in tar separatory funnel and measure carefully into it 10 cc. of "Hiflash" naphtha. The liberated tar acids and sulfate solution are then poured through this layer of naphtha several times, drawing the material off at the bottom of the funnel into the original beaker and pouring it back into the top of the funnel. This washes out the beaker and allows all the tar acids to be absorbed by the naphtha.) The funnel shall then be allowed to stand until the layers separate perfectly clearly when the sulfate solution shall be drawn off and the increase in volume of the naphtha taken as the dry tar acids present. When the content of acids is over 5 per cent, the same procedure can be used, measuring 65 cc. of "Hiflash" naphtha into the tar-acid separatory funnel, type 2.

PRECAUTION—All results must be figured on the basis of dry oil.

NOTES—In distilling 200 cc. of oil, it is necessary to use a distilling bulb of about 500 cc. capacity. "Hiflash" naphtha may be obtained from The Barrett Company Chemical Department.

This method gives approximately the amount of tar acids that can be recovered from an oil in practice.

Results by this method are usually about 90 per cent of the results obtained by the method as given under H11.

TEST H13—HEMPEL DISTILLATION[1]

APPARATUS—Forest Service Hempel flask.[2] Condenser tube (see Fig. II, Article I, THIS JOURNAL, **10** (1918), 735). Thermometer, graduated from 0° to 400°; specifications as under C9. Glass beads. Asbestos shield.

The apparatus assembly is shown in Fig. XV.

METHOD—The empty flask shall be tared, 250 g. of melted, well-shaken oil introduced, and a second weight taken. The flask shall be supported on an asbestos board with a slightly irregular opening of very nearly the largest diameter of the flask, and the apparatus assembled as in Fig. XV. The distillation shall be run at the rate of 1 drop per sec., and fractions collected in weighed flasks between the following temperatures: Up to 170°, 170° to 205°, 205° to 225°, 225° to 235°, 235° to 245°, 245° to 255°, 255° to 285°, 285° to 295°, 295° to 305°, 305° to 320°, and if feasible, 320° to 360°.

The character of the fractions and their weights shall be recorded.

PRECAUTIONS—Drafts on the distilling apparatus must be avoided.

NOTE—In noting the character of the fractions, the operator should observe the apparent amount of salts separating at room temperatures and roughly approximate the nature of the fraction, *e. g.*, solid, half solid, liquid, etc.

TEST H14—INDEX OF REFRACTION OF FRACTIONS

APPARATUS—Zeiss-Abbé refractometer.

METHOD—Water at 60° C. shall be circulated through the water jacket which surrounds the main

[1] Adapted from *Forest Service Circular* **112**, U. S. Dept. Agriculture
[2] A. H. T. 28220, E. & A. 3072.

prisms. After the temperature of the water in the jacket has been brought to this point, the prisms shall be separated and a few drops of the oil to be tested placed between them. They are then brought together and locked in position. The prisms shall now be rotated until the field of view consists of a light and dark portion. The telescope is provided with a recticule which can be brought into exact coincidence with the observed border line between the light and dark field. The compensator prisms are rotated until a sharp line of demarcation is produced. The index of refraction shall be read on the scale through the eye piece on the left side of the refractometer.

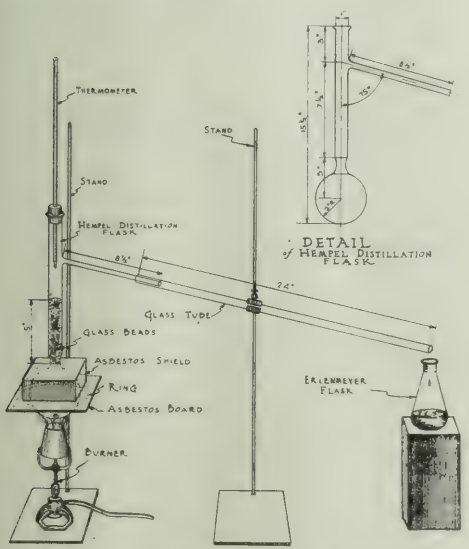


FIG. XV—ASSEMBLY OF HEMPEL DISTILLATION TEST FOR HEAVY OIL FOREST SERVICE METHOD

PRECAUTIONS—The temperature must be kept at 60° C. throughout the test. The lenses and prisms should be kept perfectly clean. Special lens paper should be used for this purpose so as to avoid scratching or damaging the surfaces.

Take care that the reflector does not show the line of a window sash which may be mistaken for the border line. Such a reflection can be detected by moving the mirror, when the true line does not move.

NOTES—The light is regulated by the reflector beneath the prisms until suitable illumination is obtained.

If the line cannot be produced, either there is insufficient oil between the prisms or the index of refraction of the material lies outside the range of the instrument.

With each refractometer is supplied a solid disc of known refractive index for use in checking the original adjustment of the instrument. Directions for its use accompany the instrument.

TEST H15—SULFONATION RESIDUE[1]

APPARATUS—Milk bottles, A. H. T. 33,964, E. & A. 4,450.

Centrifuge: Any milk bottle centrifuge will do; there are many types; refer to any apparatus catalog. A convenient type where only few tests are run is A. H. T. 33,936, E. & A. 1,883. Where many tests are being handled, A. H. T. 33,940, E. & A. 1,978 is better.

METHOD—Ten grams of the fraction of oil to be tested shall be weighed into a Babcock milk bottle. To this shall be added 40 cc. of 37 *N* sulfuric acid (total SO_3, 80.07 per cent), 10 cc. at a time. The bottle with its contents shall be shaken for 2 min. after each addition of 10 cc. of acid. After all the acid has been added the bottle shall be kept at a constant temperature of from 98° to 100° C. for one hour, during which time it shall be shaken vigorously every 10 min. At the end of an hour the bottle shall be removed, cooled, filled to the top of the graduation with ordinary sulfuric acid, and then whirled for 5 min. in a Babcock separator. The unsulfonated residue shall then be read off from the graduations. The graduated portion of the bottles measures 2 cc. and is divided into 10 major graduations. These major graduations are subdivided into either 5 or 10 smaller divisions. The reading, expressed in terms of major divisions, multiplied by 2, gives per cent directly.

PRECAUTIONS—The unsulfonated residue should be a clear transparent oil. If there is an apparent residue of dark or gummy appearance, the sulfonation is probably incomplete and the test should be repeated.

The addition of the acid should be regulated so that the mixture ceases to heat up on shaking, before another portion is added. If acid is added too quickly, foaming results.

Sometimes the material will start to foam on removal from the hot bath. Immersion in cold water will usually stop the foam. Proper strength of sulfuric acid is essential.

ACCURACY—0.1 per cent of amount taken, that is, 0.01 cc., unless the per cent residue exceeds 5, when 0.5 per cent variation is allowable.

NOTES—Occasionally a solid residue of white paraffin is obtained. In this case the bottle should be warmed sufficiently to melt the paraffin and re-whizzed. The reading may be taken while the material is liquid.

This method differs from the original Forest Service method in that the oil is weighed and not measured. On solid fractions an accurate measurement is impossible. Therefore, we have specified weight and our per cent result really represents cc. per 100 g. If a real per cent by volume is required the result should be multiplied by the determined specific gravity of the oil fraction and the result reported as per cent by volume (calculated).

The 37 *N* acid should contain 80.07 per cent total SO_3. It is made by mixing analyzed ordinary concentrated sulfuric acid with analyzed fuming sulfuric acid in the proper proportions. It is best to run a check test on the mixture to insure the fact that the strength is correct.

[1] Adopted from *Forest Service Circular* **191**, U. S. Dept. Agriculture.

TEST H16—TAR BASES

This test shall be carried out exactly as described under H11, using 20 per cent sulfuric acid instead of 10 per cent caustic soda. As there are rarely more than 5 per cent of bases in any coal-tar oil, the tar-acid funnel, type 2, should be used for this purpose.

TEST H17—DRY SALTS AT 4.5° C. (40° F.)

APPARATUS—Copper beaker, 500 cc., A. H. T. 21,812, E. & A. 750. Buchner funnel (a suitable type is A. H. T. 28,616, E. & A. 3,254). Filter flask (a suitable type is A. H. T. 28,248, E. & A. 3,090). Letter press. Vacuum pump.

METHOD—The whole sample of oil after the extraction of tar acids as in H11 or H12 shall be used. (Note that this represents 100 cc. of the original oil.) It shall be placed in the copper beaker and cooled with stirring to 4.5° C. (40° F.) in a suitable bath and held at that temperature for 15 min. The contents of the beaker shall then be quickly filtered off on the Buchner funnel and the oil removed from the solids as quickly as possible. The solid cake shall then be removed from the filter and pressed *repeatedly* in a letter press between strips of blotting paper or filter paper until only a trace of oil is given up to the paper. The solids shall then be weighed. Their weight in grams divided by the specific gravity of the oil gives the per cent by weight of dry solids.

PRECAUTIONS—To quicken the filtering, a spatula should be used to press the solids down in the funnel and avoid channeling.

ACCURACY—±1 per cent.

TEST H18—LIMPID POINT

APPARATUS—Test tube, 5 in. long by 1 in. inside diameter. Thermometer reading from 0° to 80° as used in D6. Distillation apparatus.

METHOD—Fifty cc. of dry oil shall be taken in a clean distilling apparatus such as used for naphthas and light oils and distilled to *dryness*, no thermometer being used. The condenser water shall be kept hot to avoid solidification of the distillate.

The distillate shall be well mixed and 30 cc. transferred to the test tube. This shall then be cooled, using a freezing mixture (3 parts of shaved ice to 1 part of salt) if necessary. During cooling the oil shall be kept agitated by stirring with the thermometer and cooling continued until a strong separation of crystals has taken place. The tube shall now be removed from the cold bath and warmed at the rate of 2° C. per minute, continually stirring, until all crystals disappear. The temperature registered by the thermometer at this moment shall be recorded as the limpid point.

PRECAUTIONS—If free water should be present in the oil, this might be mistaken for crystals, hence dry oil must be used.

ACCURACY—±2° C.

NOTES—The best method to maintain the rise at 2° C. per min. is to place the tube in a beaker of water or brine 3° to 5° C. above the oil temperature and warm the bath, at about the 2° C. rate.

For oils with limpid points below 0° C. a special thermometer graduated from —30° to 50° C. may be used. The lowest temperature obtainable by the above freezing mixtures is about —20° C. If no crystals separate at this temperature a *very small* amount of powdered naphthalene may be added to seed out the solids. If no separation can be obtained in this manner, report should be made "no separation obtainable."

MIDDLE OIL TESTS

The usual tests made are water, specific gravity, distillation, tar acids, dry salts, tar bases, and limpid point, and these are made in the same manner as the corresponding tests given above under heavy oil.

THE BARRETT COMPANY
17 BATTERY PLACE, NEW YORK CITY

THE POLARISCOPE SITUATION AND THE NEED OF AN INTERNATIONAL SACCHARIMETRIC SCALE

By C. A. BROWNE

Received August 5, 1918

Among the many claims which are being made upon industry as a result of the present war there are probably none more pressing than the demand for certain kinds of scientific apparatus.

In the sugar industry alone there is a most serious shortage of polariscopes, refractometers, and colorimeters, and with the inability to obtain certain repairs the number of such instruments available for technical control is constantly growing less.

Seventy years ago practically all of the sugar testing apparatus used in the United States came from France, and although most excellent saccharimetric instruments have always been obtainable from that country, nearly all of the polariscopes used in the sugar and food laboratories of the United States at the present time were manufactured in Germany or Austro-Hungary. There are several explanations for this preference for instruments of German manufacture: (1) Since the time of Liebig the technical schools and universities of Germany have been most frequented by American students, the result being a greater familiarity on the part of scientists in this country with instruments of German origin. (2) At the time when many of our industries were established German emigrants were the most available for certain positions and German methods and apparatus were thus naturally introduced. (3) German manufacturers have been much more active than their French competitors in bringing their instruments to the attention of the American public.

With the entrance of the United States into the present war the importation of scientific apparatus from Germany and Austria came to an end. Those who needed polariscopes were thus obliged, as 70 years ago, to turn to France, the birthplace and original home of this instrument. The optical establishments of France were so taxed, however, with the manufacture of periscopes, field glasses, gun sights, etc., that no time could be spared for manufacturing other apparatus, although the instrument-makers of France

expressed their willingness to supply the needs of foreign customers as soon as conditions permitted.

In a recent letter upon this subject, addressed to the writer, the head of one of the oldest establishments in Paris stated that he was most anxious to bring his polariscopes and other apparatus to the attention of the American public. He expressed himself as even willing to modify the types of his apparatus to satisfy individual preferences, but with one very important exception, *viz.*, that he should not be asked to copy or imitate German instruments. This exception happens, however, in the case of polariscopes, to be a very important one, for nearly all instruments used at present in the United States are provided with the so-called Ventzke or German sugar scale, which requires a normal weight of 26 g. In this connection the French manufacturer just mentioned writes as follows:

Il y a de plus la question de la charge type 26 gr. qui parait adoptée aux Etats-Unis.

M. Pellet, qui s'est servi de 26.048 gr., puis de 26 gr., aussi bien que de 16.29 gr., m'assure que 20 gr. est beaucoup plus commode et que c'est 20 gr. la charge type internationale.

Il n'y a pas plus de difficulté pour moi à faire 26 gr. que 20 gr. ou 16.29 gr.—toutes basées sur le même pouvoir rotatoire du sucre.

Je suis néanmoins obligé de dire que je n'aimerais pas faire 26 gr., car j'aurais l'air de copier les Allemands. Or ce sont les Allemands qui en réalité n'ont fait que nous copier, car les instruments à lumière blanche aussi bien que les instruments à lumière jaune ont été étudiés et construits pour la primière fois dans ma maison.

The feelings of national and local pride, which this manufacturer expresses so openly, are in every respect praiseworthy. The discoveries of Arago, Biot, Soleil, Laurent, and Duboscq have, without question, placed the contributions of France to the science of polarimetry above those of other nations. Subtract from the sum total of our knowledge in this field the part which France has contributed and the remainder is pitifully small. In certain particulars, however, English and German physicists have made important contributions and nothing is more certain than that the true scientist in the choice of his instruments will always be guided by expediency and not by prejudice or feeling. If the user of a polariscope desires his instrument to be equipped with a Jellet, or a Laurent, or a Lippich polarizing system, manufacturers should meet this wish irrespective of their own feelings of national or personal preference.

But apart from all this the question raised by the French manufacturer of substituting an international scale for the present German standard has at the present time a new and more far-reaching importance in view of the increasing consolidation of interests among the different allied nations. Leaving aside the fact that the Ventzke sugar scale is a German invention, there is much to be said in favor of the United States and all the other allied nations adopting a standard which was proposed as long ago as 1896 and which is known as the international sugar scale.

In 1896, at the Second International Congress of Applied Chemistry, Sidersky and Pellet advocated the adoption of a new international sugar scale, the normal weight of which should be 20 g. Among the advantages suggested for its adoption are the following: (1) The 20 g. scale being a compromise between the French 16.29 g. scale and the German 26 g. scale is free from all national bias. (2) The results obtained with the 20 g. normal weight are easily converted into percentages by multiplying by 5, while the results obtained by the French or German normal weights are not thus easily transformed. (3) Aliquot portions of 50, 25, 20, 10, and 5 cc. of the 100 cc. international scale normal solution represent even gram quantities (10, 5, 4, 2 and 1 g., respectively) which is not the case with the French or German standards. (4) The specific rotation of sucrose at a concentration of 20 g. in 100 cc. (18.62 per cent) is about the maximum, while it is perceptibly lower at concentrations above or below this amount. (5) A 20 g. normal weight is always available as a one-piece unit in the analytical set. The French and German normal weights are not always available as one-piece units and to make up the quantity from an analytical set of weights is inconvenient as well as open to error.

No immediate action was taken by the Second International Congress upon the proposition of Sidersky and Pellet, but the matter was again brought up at the third, fourth, and fifth meetings of this Congress, more especially by Dupont, who emphasized the statement made by Sidersky in 1896 "that without revolutionizing or disturbing the sugar industry the adoption of the proposed international scale would mark a decided step in advance. It would remove all the uncertainties which exist in saccharimetric standards as well as all the inconveniences and mistakes which result therefrom, since it would put in the hands of industrial and commercial sugar chemists analytical apparatus, whose graduation, being upon an identical basis, would furnish results that were everywhere alike."

While the various Congresses mentioned realized the numerous advantages of the proposed international sugar scale the influence of established usage was too strong to permit its displacing the national standards then in vogue. The representatives of the Teutonic nations were particularly opposed to the replacement of the German normal weight by the new international standard.

In 1912, at the seventh meeting of the International Congress in New York, Bates reported that investigations conducted at the U. S. Bureau of Standards showed the present German standard to be inaccurate inasmuch as 26 g. of pure sucrose would not polarize 100 upon saccharimeters provided with the Ventzke scale under the prescribed conditions of analysis. A committee was appointed to investigate the question and make a report in 1915, but the outbreak of the war put an end to all further proceedings.

In view of the uncertainty regarding the accuracy of the present German scale and in consideration of the numerous advantages of the proposed international scale, the present would seem to be a fitting time for the adoption of a saccharimetric normal weight of 20 g. by all the allied nations. The increasing shipment of sugar from the United States and

Cuba, to England, France, and Italy makes a concerted action of this kind especially necessary just at present, and it is all the more desirable in view of the probability of an economic league in the near future between the various allied countries. If this could be done our sugar and food chemists would have at their disposal a convenient, rational, accurate standard, while our confrères in France, relieved from the embarrassment of having to copy a German scale, would be free to supply the demand for polariscopes, the increasing shortage of which is becoming at present a serious detriment in many industries.

An objection which has been urged against a change in the present sugar scale is that all polariscopes now in use would be rendered valueless. This objection, however, as Dupont pointed out at the Fifth International Congress of Applied Chemistry, is not a serious one. Polariscopes can be equipped with the new scales at little cost and without changing the optical construction of the instruments. If the adjustment of the new scale could be performed by our National Bureau of Standards the various polariscopes of the country would for the first time be placed upon a strictly uniform basis of comparison. Differences of as much as 0.3 have been noticed by the author between the 100° point of different German saccharimeters supplied to the American trade.

Preliminary to the adoption of the proposed international sugar scale a committee of scientists from the different allied countries should agree upon a constant for the angular rotation of a normal quartz control plate which shall read 100° upon a saccharimeter whose 100° point has been established by polarizing 20 g. of dry, chemically pure sucrose under the prescribed conditions of analysis. When this rotation value of the normal 100° quartz plate has been established for sodium, mercury, or other monochromatic light, instrument-makers and users of polariscopes will have an infallible means of verifying the accuracy of their scales.

If instrument-makers will then show a disposition to meet the wishes of their patrons in minor matters of construction there is no reason why the manufacturers of the allied nations cannot win for themselves a share of the market which heretofore has belonged almost exclusively to the Central Powers.

The manufacturers of the United States could find no better time than the present in which to make plans for the manufacture of polariscopes, saccharimeters, refractometers and other instruments that were formerly imported from Germany and Austria. Before entering this field, however, they should make it their aim to adopt only those standards and types which are most convenient in the opinion of the chemists who use them. Heretofore chemists have been obliged to take what the manufacturer was content to offer. It is time to reverse this illogical method of procedure. Let the chemists outline their specifications and give their orders to the manufacturer who is most ready to meet them. The writer is already in consultation with sugar chemists upon specifications for saccharimeters.

As it will probably be many years before commercial and scientific relations are resumed with the Central Powers, it would be the height of folly to wait for the resumption of such relations before restoring our depleted stocks of apparatus. It is time that we made ourselves independent of the Central Powers in this respect as in all others.

Uniformity of standards will make it much easier for one allied nation to supply the wants of another and will greatly help towards preserving that spirit of united action which a common enemy has brought about. The same intimate coöperation which exists between the Allies at the battle front will be necessary in the great work of reconstruction that is to follow. In the recent words of Mr. Lloyd-George, "Let us not make the mistake of dissolving the partnership the moment the fighting is over."

NEW YORK SUGAR TRADE LABORATORY
80 SOUTH STREET, NEW YORK CITY

ADDRESSES

THE POTASH SITUATION[1]

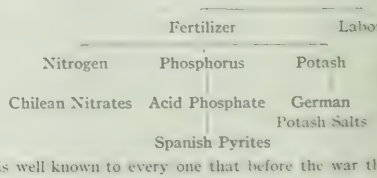
BY A. W. STOCKETT

In the last year or two potash has been very prominently before the public, and so much information and misinformation has been published that it is very difficult to present any new facts on the subject. As over ninety per cent of all the potash used before the war was in the manufacture of fertilizer, the reading of this paper before the AMERICAN CHEMICAL SOCIETY may seem somewhat inappropriate.

Our dependence before the war on foreign sources for an important element in our food supply may be shown by the accompanying diagram.

The writer would be prepared to go even further than the above and for the present have our labor also dependent on a foreign source in the form of interned German prisoners of war.

The prospect of becoming independent of these foreign sources after the war is promising. When the nitrogen fixation plants now being erected by the Government are in full working order, there should be a sufficiency of nitrogen. The development of our pyrite supply and the establishment of sulfuric acid plants should insure a supply at reasonable prices. The potash supply is the only weak link in the fertilizer chain, and the writer is of the opinion that it is possible to develop a domestic potash industry.



It is well known to every one that before the war the entire world was dependent on Germany for its potash supply, and this country was importing annually about 1,000,000 tons of potash salts of various grades, containing approximately 240,000 tons of K_2O.

[1] Paper delivered in the Symposium on Potash held by the Division of Industrial Chemists and Chemical Engineers at the 56th Meeting of the American Chemical Society, Cleveland, September 12, 1918.

The enactment of the "Potash Law" by Germany in 1910, which at one time threatened to become a serious diplomatic question, first drew attention to our entire dependence on Germany for a very important element of plant food, and in 1911 Congress made an appropriation for investigating our own sources of supply. It was not, however, until Germany put an embargo on the exportation of potash salts in January 1915, that the question became acute, and a serious attempt was made to develop our domestic sources.

The year 1915 may be said to have marked the beginning of the American potash industry, as in that year a little over 1,000 tons of K_2O were produced. This was increased to 9,720 tons in 1916, to over 32,000 tons in 1917, and it is probable that the production for the present year will reach 60,000 tons of K_2O.

At the present time over 60 per cent of the total is being obtained from natural brines, principally Searles Lake, California, and the lakes of Western Nebraska. The Desert Basin and Death Valley have long been names that appealed to the general public as probable locations of immense deposits of potash. These districts have been carefully examined by the U. S. Geological Survey, and as a result it may be stated that Searles Lake is the most promising individual source of potash at present known in this country. The extent of this has not been definitely determined, but it has been estimated to contain from 10,000,000 to nearly 20,000,000 tons of K_2O, which would be sufficient to meet the entire requirements of this country for from 20 to 40 years. Two companies are operating here and one of them, the American Trona Corporation, is said to be the largest individual producer of potash in this country. The eventual capacity of this plant may reach 75,000 to 100,000 tons of K_2O per year. The brine from the lake is treated by evaporation at Trona, on the edge of the lake, and it is intended to ship the crude salts thus obtained to the refinery at San Pedro on the coast. The brine is of a somewhat complex composition, and the successful treatment of it commercially was an interesting problem for our chemists. Borax and soda, and possibly salt as well, will be produced, and this should assist in enabling this plant to continue operations at a profit when the price of potash becomes normal. The geographical location of Searles Lake is very unfortunate, as more than 90 per cent of the pre-war supply of potash was used east of the Mississippi River. A low ocean freight rate *via* the Panama Canal would be an important factor in competing with foreign supplies.

The Nebraska lakes are at present supplying nearly half of the total amount of potash produced. These comprise a number of lakes, usually of small extent, located in the sand-hill region of the State. They usually consist of a shallow lake of brine, with a bottom of muck and hardpan, underlain by a sand impregnated with brine similar in composition to the lake waters. This is the principal source of the potash. It has not been found possible to make an estimate of the total potash content of these lakes, but it has been stated by the Director of the Nebraska Conservation and Soil Survey that with the plants now producing and building, the stores of high-testing brines would be greatly reduced within four years. One of the lakes that had been pumped dry has since filled up again, and it is claimed that there was no decrease in the grade of the brine. It may be, therefore, that the life of these lakes will be considerably prolonged and this is very much to be desired, as this source of potash has so far been the foundation of the domestic supply. The district is handicapped by its geographical location, entailing high freight rates to the points of demand. It is probable that eventually a central refining plant will be erected, and by producing a very high-grade product, freight rates per unit of K_2O could be reduced by one-half.

The giant kelps of the Pacific Coast ranked second as a source of supply in 1917, having produced 11 per cent of the total for that year. As this source is being described by Mr. Turrentine it will not be further dealt with here, except to point out that it would be almost impossible to locate a source that is further from the principal centers of demand, as the Pacific Coastal states, including Hawaii, use less than 2 per cent of the normal supply of potash.

A little over 2,400 tons of K_2O were produced from the alunite deposits near Marysvale, Utah. This was mostly in the form of a high-grade sulfate 97 per cent pure. The alunite is crushed to about $1/2$ in. mesh, and roasted in a rotary kiln, using pulverized coal as fuel. The calcined material is leached with hot water in a closed tank at a temperature equivalent to 60 lbs. steam pressure, which takes the potassium sulfate into solution. The solution is filtered in a Kelly filter press, and the clear filtrate is then evaporated in Swenson triple-effect evaporators, and the resulting crystals centrifuged and sacked for shipment. No estimate of the cost of production is available, but unless it is possible to utilize the alumina in the residue, which is not being done at present, it does not seem that potash can be produced from this source at a profit at normal prices. In *Bulletin* **451**, published by the Bureau of Soils, entitled "The Recovery of Potash from Alunite," by Messrs. Waggaman and Cullen, the possibilities of obtaining both alumina and sulfuric acid, as well as potash, is discussed, and it was estimated that this should be very profitable at present prices, and possibly at normal prices also. Calcined alunite, containing 15 per cent of K_2O, has also been marketed in small quantities for use in fertilizers, as it has been found by experiment that this is as effective per unit of K_2O as the soluble sulfate and chloride salts. If a deposit of alunite could be discovered in the East near the centers of demand for fertilizers, it is probable that this calcined product could be produced at a profit at normal prices, but with the location of the present known deposits, the high freight rate per unit of K_2O will be prohibitive.

In the opinion of the writer, the dust from the cement kilns is probably the most promising source of a permanent domestic potash supply. As the result of a careful investigation by the Bureau of Soils, it has been estimated that the maximum amount of potash that might be recovered from all the cement works in the country would be 100,000 tons of K_2O.

It is not probable that this figure will ever be reached, as some plants do not have sufficient potash in the raw mix to make its recovery profitable, and others for various reasons would not find it advisable to install plants. It does not, however, seem unreasonable to expect that the amount from this source should reach 50,000 tons of K_2O per year, which is 20 per cent of our normal requirements. The geographical position of the cement industry is exceptionally fortunate, as approximately 70 per cent of the total amount of cement manufactured is produced east of the Mississippi, and this region consumes approximately 90 per cent of the normal supply of potash. The first cement plant to recover potash from this kiln dust was the Riverside Portland Cement Company, of California. Owing to litigation with the fruit growers in the vicinity, who claimed that the fine dust escaping from the kilns was causing damage to the fruit trees, the company was compelled to take steps to abate the dust nuisance. A Cottrell electrical precipitation plant was installed, and when the dust thus collected was analyzed, it was found to contain about 10 per cent of K_2O, so that at present prices of potash this is a very profitable part of the plant. The installation was completed early in 1913, and has been in continuous and successful operation ever since, so that there is no longer any question about the practicability of this method. By the end of this year there will be about a dozen cement plants recovering potash from the kiln dust, with a probable production of 10,000 to 12,000 tons of K_2O per year. The recovery of the maximum amount of potash and its concentration from the flue dust involved some very interesting chemical problems, which appear to have been successfully solved. Published figures show that potash can be produced profitably from this

source for 50 cents per unit of K_2O, which should insure the permanence of this source of supply under any conditions.

Another source which has even greater possibilities than the cement plants, although up to the present but very little has been done, is the dust from the blast furnaces manufacturing pig iron. Mr. R. J. Wysor made some investigations and experiments at the plant of the Bethlehem Steel Company, and it was found that with the Cottrell electric precipitation, practically all the dust and fume entering the treater could be precipitated successfully. In many cases the iron ore used in manufacturing the pig iron contains sufficient potash to make its recovery profitable, with the additional great advantage of cleaner-gas for use in the stoves and boilers. The amount of potash available from this source has not been definitely estimated, but it is probable that it would be from 200,000 to 300,000 tons of K_2O per year.

As far as the writer has been able to learn, there is at present only one plant being installed at any of the blast furnaces for the recovery of potash. All of the manufacturers are at present so intent on producing the maximum amount of pig iron that there is very little possibility of getting them to realize the importance of developing a domestic potash industry.

Another source which promises a small but permanent supply is the waste from distilleries where molasses is used to produce alcohol. This source ranked third in 1917, with a production of 2,800 tons of K_2O. Recent improvements in methods are claimed to have reduced costs and increased the potash extraction, and as this is practically a by-product it is probable that potash can be produced at a profit after the war.

There are some thirty or forty small producers of potash from wood ashes, mostly in Michigan and Wisconsin, but the total amount from this source is only about 400 tons of K_2O per year, and it is not probable that they will be able to continue operations under normal prices.

The greatest potential sources of potash are the potash-rich silicate rocks, and of these the most promising are the greensands or glauconite of New Jersey, the Cartersville slates of Georgia, and the leucite rocks of Wyoming. Any one of these sources would be capable of supplying our entire requirements for many centuries. Many patents have been issued in the last fifty years for methods of extracting potash from these silicates, but no general commercial process has yet been developed. Several companies have been experimenting on the greensands on what may be called a commercial demonstration scale, and claim that under normal conditions they will be able to produce potash at less than $1 per unit of K_2O.

Another company is operating on a small scale on the Cartersville slates, and producing a material containing 4 per cent of water-soluble K_2O, which is being used locally as a fertilizer. Experiments have also been carried out on the leucite rocks, which give promise of being successful.

There are several million tons of tailings from the gold mines in the Cripple Creek district of Colorado, averaging about 10 per cent of K_2O. These are already finely ground and are close to transportation and supplies. Experiments have also been made with these, but so far without success.

The development of a commercially successful process of treating the silicate rocks would solve the potash question permanently, and this problem should not be beyond the skill of our chemists and metallurgists.

In conclusion, the writer is of the opinion that the sources of potash already discovered are sufficient to supply the requirements of this country, if sufficiently developed. He also thinks the prospects of this development are favorable, but it will probably require some kind of assistance by the Government. This might perhaps best be done by subsidizing the domestic industry to a suitable degree. In this way, the cost to the Government would be moderate and the expense would be distributed, and it would thus be possible to break the German monopoly without placing a hardship on any particular class.

U. S. Bureau of Mines
Washington, D. C.

RUSSIA'S PRODUCTION OF PLATINUM[1]

By Albert R. Merz

Received September 23, 1918

Russia became the chief center of the production of platinum soon after its identification as a product of the Urals in 1823. Exploitation began in 1824. Previous to this time Colombia, then having an annual production of approximately 16,000 ounces, had been the only purveyor of platinum to the world's market. For a few years the production of Russian platinum was in quite small quantities and obtained as a by-product in the washing of gold-bearing sands, but as acquaintance with its value grew and sale was found for it, the output gradually increased.

In 1827 the Russian Minister of Finance, Count Egor Frantsovich Kankrin, wishing to increase the yield of platinum and to furnish the government with an important source of income, proposed the coinage of platinum. This was approved by the Czar and coinage was instituted in 1828. Simultaneously with the introduction of platinum money the government prohibited the export of platinum abroad and also imposed a tax of 10 to 15 per cent on its production. This tax which was in kind was not, however, burdensome to the Russian platinum producers for they used the labor of serfs in working the mines and in consequence the cost of securing the platinum was very little. The price paid by the government to the producers was fixed at $4.21 an ounce.[2]

The first year after the realization of the measure providing for the coinage of platinum the output rose to over 50,000 ounces and in 1843 it reached 112,571 ounces. In 1845 the coinage of platinum money and the purchase of the metal by the treasury were discontinued and the restrictions on its use for other purposes were removed.

In all, for the 18 years (1828–1845) there were coined 453,014 ounces of platinum. After the discontinuance of coinage in 1845 the government began gradually to withdraw from circulation the money which had been issued and secured about 80 per cent of it. The Russian platinum industry left thus upon its own resources was for a time benumbed and the annual production dropped to less than 1,000 ounces.

With the end of the fifties the production of platinum began to develop anew and in 1862 the output reached 75,060 ounces. In 1859 the mint had accumulated a stock of platinum amounting to 472,706 ounces, of which 234,412 ounces was in coin. Sales of the metal had been made in small quantities to the Parisian manufacturer, Quennesen, and to others, but in 1862 the entire quantity remaining in the treasury was sold to the London firm of Johnson, Matthey & Co., refiners to the Bank of England, after which the tax in kind was revoked. The consumption of platinum meanwhile continued to grow with each year and parallel with this increasing consumption the quantity of platinum secured in the Urals also increased so that in the closing years of the 19th century it attained to 130,000 to 190,000 ounces annually, approximately 90 per cent of the world's total annual output. Simultaneously with this growth in production there arose among the big foreign platinum dealers a desire to seize control of the platinum industry, and companies were formed abroad who monopolized the Russian industry and fixed according to their own whim the price of the metal. The price from this time on began to be subject to violent fluctuations though the average gradually increased. The complete

[1] Prepared as a part of the work on platinum in the course in chemical economics and statistics at George Washington University.

[2] On the basis of 1 ruble equivalent to 77 cents. The value of the Russian ruble was changed from 77 to 51 cents by a law promulgated on September 10 August 29 of the year 1897.

lack of stability in price and the uncertainty of sale placed the independent Russian producers in a most irksome position and deprived them of the possibility of making expenditures for explorations and for the development of technical improvements in the working of their deposits. As a result, the production of platinum by the independent and smaller producers has been greatly reduced. The yield of platinum since the beginning of the present century has consequently had a downward tendency.

The platinum beds of Russia which have a commercial importance are not only all located in the Ural Mountains, but they are concentrated in a very limited territory. These beds are alluvial in character and consist of placers formed from the destruction of the mother-rock containing the platinum. These placers are likewise auriferous and are associated with certain olivine rocks called dunite.

At the time of the outbreak of the war in 1914 the greatest proportions of the platinum output in the Urals were secured in the Nizhne Tagil and Isov districts. The beds of the first district are found, for the most part, on the west slope of the Urals, while those of the second are distributed along its eastern slope and can in turn be divided into two districts, the Goroblagodat and the Bisersk. Besides these there has been in comparatively recent years a development of production in the northern Urals in the Nikolae-Pavdinsk and the Rastes districts, and also in the mines of the Sysertsk mining district.

In the Isov district the production of platinum is concentrated in the rivers and channels composing the system of the River Is. To the north of this region, towards the borders of the Rastes and Nikolae-Pavdinsk districts, platinum is furnished by the Sosnovki, Kytlymi, and Mala Kos'va Rivers. Platinum is obtained together with gold still farther to the north on the left tributary of the Vagran and on the system comprising the rivers Lobva, Nias'ma, Lialia, Aktai, Emekh, Talits, and others; here the platinum is met with in subordinate quantities with gold and it is similarly obtained on the Mala Kos'va; more to the east of the above-designated districts it is secured in the placers of the Ivdevl River.

To the south of the Isov area in the region of the Baranchinsk, Verkhne-Turin, and Nizhne-Turin works, platinum mines are worked on the tributaries of the Tagil River and on the Imiann and Tura Rivers, as well as on the tributaries of the Salda River.

In the boundaries of the Nizhne-Tagil district the richest placers are found in the valleys of the Visim, Mart'ian, Sisim, Chaush, Cherna Rivers, and others. Farther to the south there is observed a disappearance of the reliable platinum beds and they are met with after that, together with gold, in the placers of the Nev'ian, Verkhne-Iset, Bilimbaev, Alapaev, Sysert, Kyshtym, and Mias areas and also on the Tanalyk, Sakmar, and Urtazym Rivers. In many placers of the southern Urals platinum is replaced by other metals of the platinum group, principally osmiridium.

The placer deposits of platinum cannot be distinguished in any way by their manner of occurrence from those of gold and, besides, in many cases the placers contain both precious metals simultaneously. As a consequence of their mode of occurrence the platinum placer mines are worked by methods differing but little from those employed in the exploitation of the gold placers.

As has already been indicated, the world's requirements for platinum have been almost entirely supplied by Russia from early times, and in 1914 that country furnished all but 7 per cent of the world's production for the year. In Table I there is given the annual production of platinum in Russia from the first year of the exploitation of the platinum (1824) to the year 1915:

TABLE I—PRODUCTION OF CRUDE PLATINUM IN RUSSIA

Year	Troy ounces		Year	Troy ounces	
1824	1,066		1871	65,918	
1825	6,116		1872	48,974	
		7,182	1873	50,688	
1826	7,120		1874	64,770	
1827	13,571		1875	49,603	
1828	50,111				279,953
1929	41,457		1876	50,670	
1830	56,088		1877	55,504	
		168,347	1878	66,529	
1831	56,891		1879	72,809	
1832	61,394		1880	94,744	
1833	61,749				340,256
1834	54,561		1881	95,982	
1835	55,509		1882	131,293	
		290,104	1883	113,666	
1836	61,973		1884	71,952	
1837	62,520		1885	83,316	
1838	64,291				496,209
1839(a)	49,500		1886	138,785	
1840	49,360		1887	141,721	
		287,644	1888	87,361	
1841	57,398		1889	84,746	
1842	64,106		1890	91,461	
1843	112,571				544,074
1844	52,128		1891	136,204	
1845	24,878		1892	147,032	
		311,081	1893	163,963	
1846	619		1894	167,481	
1847	632		1895	141,936	
1848	1,053				756,616
1849	4,964		1896	158,522	
1850	5,079		1897	180,105	
		12,347	1898	193,452	
1851	6,135		1899	191,701	
1852	8,677		1900	163,624	
1853	32,402				887,404
1854	355		1901	204,850	
1855	513		1902	197,267	
		48,082	1903	193,225	
1856	757		1904	161,270	
1857	4,065		1905	168,416	
1858	5,444				925,028
1859	29,413		1906	185,756	
1860	32,380		1907	173,587	
		72,059	1908	157,787	
1861	55,454		1909	164,594	
1862	75,060		1910	176,331	
1863	16,084				858,055
1864	12,770		1911	185,617	
1865	73,123		1912	177,467	
		232,491	1913	157,731	
1866	56,129		1914	157,178	
1867	57,399		1915	119,789	
1868	64,560				797,782
1869	75,310				
1870	62,649				7,630,761
		316,047			

(a) Estimated. The actual production for the first half of 1839, according to the *Annuaire du Journal des Mines de Russie*, was 26,047 oz. Neumann gives 1,505 kg., equivalent to 48,387 oz., as the entire production of platinum in Russia in 1839, but the writer has been unable to find his authority for this figure.

The figures for this table were obtained from official statistics of the Russian government with the exception of the value for the year 1915, which was secured from "Mineral Industry," and this value is stated to have been taken in its turn from official figures.

The total yield of crude platinum according to these values from 1824 to 1915, inclusive, amounted to 7,630,761 Troy ounces. This aggregate yield, however, should really be increased to approximately 9,500,000 ounces, for the official data fail to give the total production at the mines because a portion of the actual output was stolen by the miners and another portion was concealed by the producers to avoid the payment of tax upon it. Estimates of the amount thus not officially accounted for vary considerably and by some it has been placed as high as 60 per cent of the production officially announced. The value usually quoted is 25 per cent.

The values for production given in Table I are shown graphically in Fig. 1.

The most salient characteristics of this curve together with their probable causes may be mentioned. First, there is to be noted a sudden rise of the production curve in 1828, the year in which coinage was commended. The curve continues high until 1843, when it reaches a pronounced peak which is accentuated by the sudden drop through the years 1844 and 1845 to the minimum of 1846. In 1843 the question arose whether the coinage of platinum should be suspended. Before making a definite decision on this question it was determined to continue the coinage of platinum two years, but only in such quantity as to take the output obtained by the platinum producers up

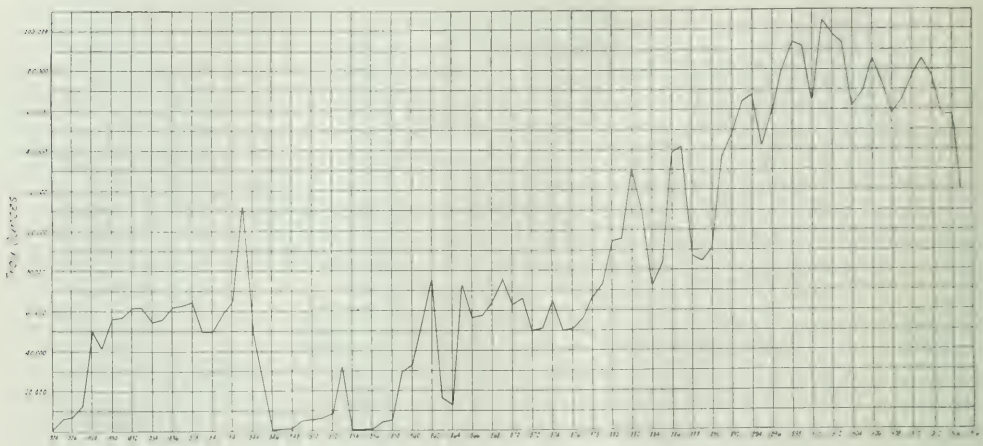


FIG. 1—PRODUCTION OF CRUDE PLATINUM IN RUSSIA, 1824-1915

to April 1, 1844. The producers were also informed that the platinum obtained after that date could not be accepted by the government. In 1345 complete suspension of the coinage of platinum was brought about by an imperial ukase of date June 22. The platinum industry now fell into such a state of decline that whereas there had been an annual production of 50,000 ounces or more the yield of the metal was reduced to that obtained as a by-product of gold mining.

The slow rise in production from the minimum for 1846 was again brought to an abrupt end in 1853 with the commencement of the Crimean War. During the years of this struggle which continued till 1856, the annual production became less than at any period in the history of the Russian industry. The extent to which the platinum industry had become dependent upon French and English purchasers is very forcibly brought to view. Other mining industries of Russia not thus dependent failed to show any such decrease in production for these years. Thus the yields of gold, silver, and copper for the years 1852 to 1857 were as follows:

YEAR	Gold Ounces	Silver Ounces	Copper Short tons
1852	719,796	559,892	7,413
1853	770,828	539,130	7,143
1854	840,886	555,495	7,056
1855	868,627	549,281	6,836
1856	871,853	545,818	6,848
1857	912,984	557,273	6,102

The year 1859 marks the commencement of a rapid rise in the production of platinum. Two causes apparently had an influence in bringing about this upward turn. First, there was an increased demand for the metal due to the introduction of Deville and Debray's process in the manufacture of platinum vessels and other ware which considerably lowered the cost of production of such manufactured ware. Second, there was the effect of the appointment of a commission by the Crown in 1859 for the purpose of considering the advisability of again coining platinum. This commission in 1862 recommended that coinage be again instituted. It is to be noted that the emancipation of the serfs, which in 1862 had a very depressing influence upon practically all the mining industries of Russia, had apparently no effect upon the production of platinum.

The chasm-like gap in the curve which appears for the years 1863 and 1864 seems to have had a number of causes. The intention to again coin platinum was definitely abandoned in 1863. There was also a lessened demand for platinum in foreign countries brought about by poor trade conditions and war, and an accumulation of unsold and unpurified metal in the hands of the producers.

The minima for the years 1866 and 1875 were probably the consequences of the financial panics in England during those two years.

In 1877 Johnson, Matthey & Co., who had up to this time controlled the greater part of the platinum trade, increased the price which they had been paying for the crude metal and the effect of this advance in price is seen in another upward shoot of the curve. Demands on the supply of platinum for use in the manufacture of incandescent lights and for other electrical appliances now began to have a marked influence on the platinum market.

The decreased production for the years 1883 to 1885 was the result of the exhaustion of some rich deposits of the metal by intensified working in 1882

The diminished production for the years 1888 to 1890 has been attributed to the drafting of employees in the Urals by the Russian government for the building of the Trans-Siberian Railway. This is claimed to have depleted the mines of laborers and made it difficult to keep up the usual output. Unfortunately the writer has been unable to secure official figures of the number of workers engaged during the years 1885 to 1887 in producing platinum for comparison with the number of those similarly engaged during the years in question. A comparison of the number of persons employed in the recovery of platinum during the years 1882 to 1884 with the number thus engaged for the years 1888 to 1890 does not tend to confirm this claim. The numbers of employees for the years compared are as follows:

YEAR	Workers	YEAR	Workers
1882	2,196	1888	4,959
1883	2,074	1889	5,461
1884	1,768	1890	5,853

Officially the decrease in output for these years was assigned to a diminution in the number of active mines in the Goroblagodat mining district where there were but 69 mines in 1888 against 85 in 1887. The quantity of sand washed was smaller in consequence and the content of platinum in the sand had also decreased. The main cause of the fall in output appears to have been the diminution in richness of the platinum sands washed for the first two years and of the quantity of sands washed for 1890.

It is stated that in 1895 long-continued rains did not permit washing through the whole season and production was therefore reduced. Certainly a lower content of platinum in the sands washed contributed to the decrease in the yield.

The year 1898 was an important one for the Russian platinum industry, as it was marked by the establishment of the "Société Anonyme d'Industrie du Platine" in Paris, which began to purchase mines, to lease others, and to enter into long-term contracts with the proprietors of the largest placers, whose mines it was unable to buy for the purchase of their entire output. It thus gradually secured control of the greater part of the platinum industry. The production of platinum as well as the refining of the metal now fell almost entirely into the control of foreigners.

Floods in 1900 are said to have caused the decrease in output for that year. The following year is distinguished by the maximum yield for any year of the industry in Russia.

The richness of the platinum deposits continued to decrease and in order to secure a given quantity of platinum, greater quantities of the lower grade sands had to be washed. In the early years of the 20th century dredges were introduced in the valley of the River Is, where the most productive placer deposits occurred. There were, however, but few of these used and hand washing continued to be the main method of working the sands. In 1909, it is said, four dredges delivered about 13 per cent of the total production and the next year about 20 per cent of the entire output was recovered by dredges or other mechanical excavators. In 1914 about one-third of the platinum produced was secured by modern methods of working.

The Russo-Japanese war in 1904–1905 is claimed by a number of writers to have caused a curtailment of production on account of the drafting of many of the Ural miners. Also the internal disturbances which arose in Russia immediately afterwards are claimed to have had a like influence. A study of the official figures relating to the period in question does not bear out such statements. The chief factor influencing the variations in annual output from the commencement of the 20th century through 1906 seems to be the content of platinum in the sands washed. Thus, in spite of the two causes above claimed as responsible for the drop in 1904–1905, the number of mines, the number of miners employed in producing platinum alone, and the number of tons of sands washed, all had upward tendencies.

In Table II are contained statistics of the number of deposits worked, the number of miners employed, the number of tons of sand washed, and the yield of platinum per ton of sand, so far as they could be obtained.

TABLE II—STATISTICS OF THE PLATINUM INDUSTRY OF RUSSIA

YEAR	Mines	Miners	Sand Washed Tons	Wt. of Platinum Grains per Ton
1864	...	...	16,445	...
1865	...	...	112,530	...
1881	66	...	271,514	...
1882	82	2,196	363,437	208
1883	107	2,074	276,164	...
1884	71	1,768	352,138	...
1885	58	...	313,974	...
1886	83	...	415,981	...
1887	93	...	1,115,409	...
1888	75	4,959	1,062,746	39
1889	72	5,461	1,213,122	33
1890	82	5,853	854,688	51
1891	102	6,120	1,417,868	46
1892	87	8,061	1,588,665	44
1893	97	7,234	1,723,084	45
1894	97	5,546	1,833,675	43
1895	77	5,628	1,729,247	39
1896	73	6,981	1,904,032	40
1897	77	8,050	2,235,701	39
1898	82	8,034	2,671,242	31
1899	78	9,197	3,148,221	29
1900	100	1,763	749,657	.
1901	120	2,025	776,712	.
1902	122	1,803	644,942	.
1903	110	2,699	1,084,186	.
1904	133	3,066	1,398,524	.
1905	141	3,498	1,805,462	.
1906	152	3,292	1,837,684	.
1907	157	787	238,682	...
1908	158	555	345,914	...
1909	154	864	289,776	...
1910	189	1,587	999,176	...

From 1906 on the number of miners and the quantity of sand washed is given for only those mines where platinum alone is produced.

As has been previously stated, the refining of platinum has been almost entirely in foreign hands and consequently the crude platinum with the exception of a very small quantity has been exported from Russia to be refined in other countries. The small amount refined in Russia was that required for local consumption. The largest platinum refining works was formerly that of Johnson, Matthey & Co., in London, but Heraeus & Co., of Hanau, Germany, early in the eighties, took the lead from that company and maintained it into the 20th century. Since the establishment of the Société Anonyme d'Industrie du Platine, its platinum refinery in Paris has refined most of the crude platinum produced in Russia. As a result of foreign control, the prices of crude platinum were subject to much speculation which had a very unfavorable reaction upon the condition of the Russian platinum industry. In view of this a law proposed by the Ministry of Trade and Industry was enacted, of date Dec. 20, 1913, which placed a prohibition on the exportation of crude platinum and provided for the establishment of a refinery in Russia. All the platinum in the country was subject to strict registration which made impossible the secret sale of the metal to foreign buyers. As a result of this, the position of many platinum producers became extremely embarrassing since they were unable to realize on their stocks of platinum in view of the limited consumption of the metal within the country. The State Bank in order to relieve the distress of these producers issued loans to them on the platinum that they held.

The prohibition of export was found to be in conflict with certain international treaties and it was then determined to place an export tax of 30 per cent *ad valorem* on platinum from July 1915, the price of the crude metal to be fixed by the Council of Ministers.

TABLE III—EXPORTS OF PLATINUM FROM RUSSIA TO

YEAR	Great Britain	France	Germany	Austria-Hungary	Total
1861	...	...	..	..	30,546
1862	...	...	...	..	25,806
1863	5,266	1,198	..	..	6,464
1864	20,539	..	9,840	..	30,019
1865	..	...	6,596	..	6,596
1866	..	2,357	20,025	..	22,383
1867	..	...	22,304	..	22,304
1871	31,941	...	33,310	..	65,251
1872	99,299	...	36,905	..	136,204
1873	76,891	...	10,533	..	87,424
1874	76,364	...	17,379	1,053	94,796
1875	131,135	...	23,699	..	154,834
1876	21,066	...	13,693	..	34,759
1878	24,752	..	18,433	..	43,185
1880	24,752	...	...	..	24,752
1881	...	..	...	..	31,072
1882	...	..	..	..	48,978
1883	30,545	..	27,386	..	57,931
1884	14,746	..	54,245	..	68,991
1885	14,746	..	137,455	527	152,728
1886	27,386	..	124,815	..	152,201
1887	26,333	..	138,509	..	164,841
1888	26,859	..	93,743	..	120,602
1889	20,539	...	113,756	..	134,295
1890	6,846	...	102,170	..	109,016
1891	...	..	99,536	..	99,536
1892	..	527	116,916	..	117,443
1893	..	..	71,097	..	71,097
1894	..	..	57,404	..	57,404
1895	122,709		26,859	..	149,568
1896	122,183		28,966	..	151,148
1897	66,358	527	86,370	..	153,255
1898	93,317	1,053	50,032		144,302
1899	9,480	1,053	99,536	.	110,069
1900	23,699	11,060	12,640	..	47,399
1901	61,618	7,373	2,633	..	71,624
1902	38,972	527	1,053	..	40,552
1903	10,533	28,439	22,119	527	61,618
1904	23,699	31,599	36,865	.	92,163
1905	18,433	9,480	33,705	..	61,618
1906	28,966	125,869	48,978	.	203,813
1907	32,126	110,069	14,746	.	156,941
1908	12,639	99,537	63,197	527	175,900
1909	10,006	127,449	122,182	.	259,637
1910	22,119	135,875	101,116	Sweden 13,693	272,803
1911	1,053	168,527	51,612		221,192
1912	2,107	169,580	50,558	.	222,245
1913	1,580	140,618	58,458		200,653
1914		64,778	17,906		82,684
1915	66,884	7,900	..	United States 5,266	80,050

In Table III is given the quantity of platinum exported from Russia and the countries to which it was sent for those years for which statistics were obtainable.

A study of this table yields some interesting and even surprising information in view of the fact that the literature is everywhere permeated with statements indicating that first Johnson, Matthey & Co. and then the French "Compagnie Industrielle du Platine" monopolized the refining of Russian platinum and were absolute masters of the market. A summation of the exports of platinum from Russia to France, England, and Germany for the years 1863 to 1915 (data for 7 years missing) shows that France received 1,245,392 ounces, England 1,448,384 ounces, and Germany 2,279,280 ounces. The total exports for four of the seven years for which detailed information is lacking are less than 150,000 ounces and those for the remaining three years are certainly not more than 250,000 ounces. Therefore, and since Germany undoubtedly secured a large share of this platinum also, the above sums would not be vitally affected by the missing data. We find, then, that the Germans actually received more platinum than the French and English monopolists.

Dividing the period 1863–1915 into five subperiods, we have the exports for each of these given below:

Years	France Ounces	England Ounces	Germany Ounces
1863–1880	3,555	512,005	212,717
1881–1890	0	167,999	792,079
1891–1900	14,220	437,645	649,356
1901–1910	676,217	259,111	446,594
1911–1915	551,400	71,624	178,534
	1,245,392	1,448,384	2,279,280

It is seen from these figures that Germany received more platinum from Russia than England did during each of these periods, except the first, and though its importations for the last two periods were exceeded by those of France that it nevertheless secured over 28 per cent of the total exports even then.

As already stated, the literature contains numerous references to the "monopolies" of the English and of the French and it is interesting to note in this connection that even the official Russian publication prepared for the World's Columbian Exposition at Chicago has, in an apparent endeavor to foster this impression, reversed the exports to England and Germany for the years 1885 to 1890 in its table of exports for the years 1884 to 1890.

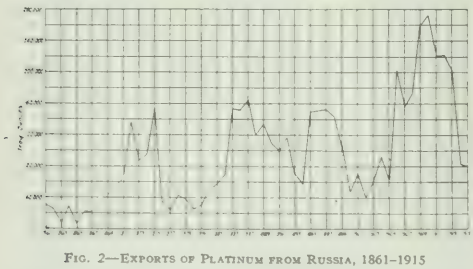


FIG. 2—EXPORTS OF PLATINUM FROM RUSSIA, 1861–1915

The annual exports of Russia are shown graphically in Fig. 2. It is to be noted that the curve is subject to quite pronounced fluctuations and therefore it is necessary to take a more or less long period of time for the determination of the relation of export to production of platinum.

Taking the period from 1882 to 1914 for this purpose, we find that the quantity of platinum exported amounted to 83.4 per cent of the production. It must be considered also that official statistics on the export of platinum abroad for the period in question gave figures considerably lower than the actual export as part of the platinum was sent abroad by mail and baggage and thus escaped registration.

Making a more detailed study of the production of platinum in the Urals, we find that the output for the 5 years 1910–1914 was divided as follows:

District	1910	1911	1912	1913	1914
South Verkhotur	111,070	121,314	118,048	102,552	106,528
Perm	46,068	46,885	38,709	36,878	38,050
North Verkhotur	11,862	11,362	13,166	11,376	7,426
Cherdyn	6,359	5,016	6,162	6,109	4,753
South Ekaterinburg	972	1,040	1,382	816	421
	176,331	185,617	177,467	157,731	157,178

We see from an inspection of the above table that for the year 1914 the South Verkhotur district produced 67.8 per cent of the total production, the Perm district 24.2 per cent, the North Verkhotur 4.7 per cent, and the remaining 3.3 per cent were obtained in the Cherdyn and the South Ekaterinburg districts.

In the South Verkhotur and Perm districts there are great enterprises which use dredges in working the platinum placers. These are able to work the placers with a low content of platinum. The working of the majority of the small and medium-sized mines, however, is carried on by very primitive means, especially by the help of "starateli" or tributers.

The Iuzhno (South)-Verkhotur district takes first place in the production of platinum. The greatest quantity of platinum is obtained here on the Nizhne-Turin, Verkhne-Turin, Kushvin, Baranchin, and Znamen areas of the crown lands where in 1913 there were 136 mines yielding 55,772 ounces of platinum. Next comes the areas of the Nizhne-Tagil possessional district belonging to the heirs of P. P. Demidov, where 6 mines gave a yield of 42,409 ounces. Finally, on the lands of the peasant proprietors, 89 mines in the Visimo-Shaitan, Cherno-Istochin, Nizhne-Turin, and Verkhne-Turin areas furnished 4,371 ounces.

The decrease of yield in this district in 1913, in comparison with 1912, is explained by (*a*) a curtailment of the production of the Demidov mines by about 3,500 ounces in conjunction with the unfavorable condition of the platinum market, (*b*) a decrease in yield of the mines situated on the peasant owner lands by approximately 500 ounces, and (*c*) a fall in production of the mines of the crown lands, chiefly those of the Société Anonyme d'Industries du Platine, by about 11,500 ounces.

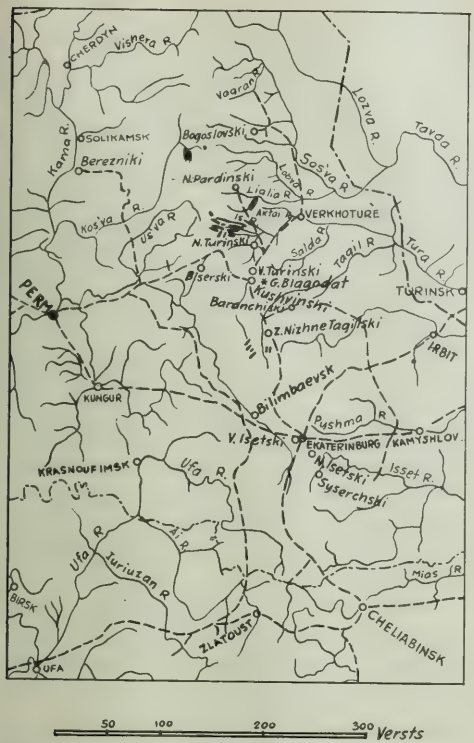
About one-third of the platinum produced in the district is secured by dredging while the remainder is obtained by hand labor, partly by the work of starateli.

In 1914 the yield of platinum in this district again rose and reached 106,528 ounces, which is explained by an increase in the number and the production of the mines on the peasant lands. The number of mines increased from 89 to 134 and their output from 4,371 ounces to 15,786 ounces. In spite of an increase in the number of mines on the crown lands their production decreased by 7,557 ounces. Altogether there were 296 mines worked in this district in 1914, 65 more than in 1913.

The Perm district takes second place in respect to the quantity of platinum produced. The precious metal is obtained here in the Krestovozdvizhen ("Erection of the Cross") mines belonging to the company "Lys'venskii Mining District of the Heirs of Count P. P. Shuvalov." Notwithstanding that some of the mines were worked by means of dredges, endless chain elevators, Archimedean screws, and other improved apparatus, almost 80 per cent of the platinum was secured in 1914 by hand working, and one-third of the production was secured by starateli.

In the five-year period, 1909–1913, the output of the Krestovozdvizhen mines fell continually. The growth in output for 1914 was caused by an increase in the production of three dredges and the introduction of steam shovels. Of the entire quantity of platinum acquired in 1914 (38,050 ounces), 8,150 ounces were gotten by the help of dredges and 29,900 ounces by hand labor.

In the Sievero-Verkhotur (North Verkhotur) district platinum was produced in only 9 mines; in the Nikolae-Pavdinsk district,



MAP OF THE MINING REGION OF THE URALS (Copied from an Official Russian Map)

Borders of governments — · — · — · Rivers ———
Railroads — — — — — Platinum mines —

in 3 mines; in the Iuzhno-Zaozer district in 1 mine; in the Lialia crown area in 1 mine; in the Znamen crown area in 3 mines; and there was 1 mine on the land of the peasant owners. The decrease of output for 1913 and 1914 for this district was caused by the curtailment of work by the starateli since they have been, in the places formerly worked by them, gradually replaced by dredges.[1] Thus the yield of platinum diminished by 3,950 ounces in 1914. This decrease fell entirely on the mines of the Nikolae-Pavdinsk district, where in the beginning of operations for 1914 the work of starateli was stopped altogether. These had formerly produced most of the platinum obtained. Dredges obtained 2,370 ounces of the platinum output in this district in 1914.

In the Cherdyn district are located the mines of Prince Abamelek-Lazarev, which are situated on the Mala and Bolshaia Kos'va rivers (Little and Big Kos'va) and the Tylai, as well as the mines of four "possessors," Count Stroganov, Count Balashev, Prince Golitzen, and Prince Abamelek-Lazarev, located in the Verkh-Iaiven area. The output of the district decreased from 1912 to 1914, though the same mines were worked in 1913 and 1914. The decrease of yield was shown by all the mines except the Mala-Kos'vin belonging to Abamelek-Lazarev.

In the Iuzhno (South)-Ekaterinburg district the output of platinum is very small. Besides that recovered in this district there was also an insignificant quantity of platinum (3.7 ounces) secured in the Sievero-Ekaterinburg district as a by-product in working the gold mines.

REFERENCES

1. *Annuaire du Journal des Mines de Russie*, St. Petersburg, 1840–5.
2. "The Industries of Russia, Manufactures and Trade," World's Columbian Exposition at Chicago, 1893.
3. Freidrich Matthai, "Die Industrie Russlands," Leipzig, 1873.
4. *Gornosavodskaia promyshlennost, Rossiia*, St. Petersburg.
5. Bernhard Neumann, "Die Metalle," Halle a/S, 1904.
6. *The Mineral Industry*, New York, 1892–1916.
7. Obshchii obzor glavnykh otraslei gornoi i gornozavodskoi promyshennosti, Petrograd, 1915.
8. *Obzor vnieshnei torgovli Rossii*, St. Petersburg (Petrograd), 1866–1915.
9. Maurice Verstraete, "La Russie industrielle," Paris, 1897.
10. *The Russian Year Book*, London, 1911–5.
11. *Sbornik statisticheskikh sviedenii po gornoi chasti*, St. Petersburg, 1864–7.
12. *Statisticheskiia tablitsy po gornoi promyshlennosti Rossii*, St. Petersburg, 1879.
13. P. von Winkler, *Gornyi Zhurnal*, 1893, pp. 578–611.

BUREAU OF SOILS
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

THE PREPARATION OF SEVERAL USEFUL SUBSTANCES FROM CORN COBS[1]

By F. B. LAFORGE AND C. S. HUDSON

It has been shown by Hudson and Harding[2] that corn cobs yield about 12 per cent crystalline xylose through acid hydrolysis. The strength of acid employed was 7 per cent sulfuric and the hydrolysis was carried out by several hours' boiling. We undertook to determine whether this acidity could not be decreased considerably by carrying out the hydrolysis at a higher temperature in an autoclave. This proves to be possible with an acidity as low as 1 3/4 per cent at a temperature of 130°, and there is thereby opened up a way for the preparation of crystalline xylose on a commercial basis. It was noticed that a volatile acid is produced in noteworthy amount along with the xylose during the hydrolysis of the corn cobs, and the identification of this acid as acetic indicates that it may be a valuable by-product in the preparation of xylose from corn cobs. A strength of 1 to 2 per cent sulfuric acid appears to be necessary in order to obtain a good yield of xylose. If the acidity is lower there is little sugar produced, although a considerable quantity of the corn cobs passes into solution. Indeed, there may be extracted from corn cobs by water alone, at the somewhat higher temperature of 140° to 160°, a water-soluble gum which is probably a form of xylan. However, its hydrolysis by acids yields xylose in only moderate proportions, accompanied by a sirupy mother liquor which does not crystallize. It was therefore sought to remove this gum from the corn cobs by water digestion in order that the subsequent acid hydrolysis of the residue might yield xylose with a smaller proportion of uncrystallizable sirup. This has proved possible and in addition it has been found that the gum has excellent properties as an adhesive which render it a useful product. The solid residue that remains from the corn cobs after acid hydrolysis consists principally of cellulose. It is very absorbent and might be used as an ingredient in molasses, stock feeds, possibly also as an absorbent for nitroglycerin in the manufacture of dynamite, and for other such purposes. It has been found that it is readily gelatinized by 70 to 75 per cent sulfuric acid and may then be hydrolyzed to glucose after dilution with water, according to well-known methods. The glucose so produced crystallizes well and could doubtless be used in the same ways that crystalline glucose from starch is employed. The manufacture of alcohol by the fermentation of corn-cob glucose appears possible provided sulfuric acid is obtainable cheaply.

Direct uses for xylose, as such, seem difficult to find. Its possible food value needs investigation because it is probably

[1] Contents of Address presented before the New York Section of the American Chemical Society, May 10, 1918, by F. B. LaForge.

[2] *J. Am. Chem. Soc.*, **39** (1917), 1038.

oxidized to some extent, especially by herbivorous animals, but the limit of tolerance is not known. Xylose is about half as sweet as cane sugar. Its after-taste is not bitter, as is that of mannose, for instance, and if uses for xylose as human food could be established its taste is in its favor. It is well known that xylose may be converted by the cyanhydrin synthesis to gulonic lactone. We would call attention to the suggestion that such lactones of the sugar group may furnish an excellent material for use as a crystalline acid ingredient in baking powders. Gulonic lactone stands out prominently as suitable for such uses, because of its ease of crystallization and the fact that it can be produced fairly cheaply from xylose. We have made experiments with mixtures of gulonic lactone and bicarbonate of soda and find that a very satisfactory baking powder may be so prepared. The preparation of gulonic lactone from xylose has been made by a method that is more satisfactory than that usually employed. It will be described in a separate paper by one of us (L.).

We will now describe in detail the preparation from corn cobs of the various useful substances that have been mentioned.

PREPARATION OF ADHESIVE GUM

The coarsely broken cobs are placed in an autoclave with sufficient water to cover them. The contents are then heated to 140°, and the temperature then raised to 160° during one hour. After cooling below the boiling point of water the autoclave is opened and the contents removed. The liquid in the autoclave is almost fully absorbed by the dry cobs in the process of heating. The next step consists in the extraction of the solution from the solid residue in which it is absorbed; this is accomplished by subjecting the wet material to strong pressure. The solution thus obtained is evaporated in an open kettle to the consistency of a thick sirup, which constitutes the adhesive gum. It is ready for use without further treatment, and is recommended as a cheap adhesive in the fiber board and paper-box industry, in bill posting, labeling, etc. The use of this substance in place of starch, dextrine, and flour paste would make possible an enormous saving of these foodstuffs.

The solid residue which is left in the press serves for the preparation of other products which are described below.

PREPARATION OF XYLOSE AND ACETIC ACID

For the preparation of the sugar, xylose, and of acetic acid the residue from the preparation of the adhesive gum is treated as follows:

An autoclave, such as was used in the preparation of the adhesive, is filled to about three-fourths of its capacity with the solid residue from the pressing operation above referred to. A solution of sulfuric acid containing about one and three-quarters per cent of acid is added in sufficient quantity to cover the solid material in the container. Heat is then applied and the temperature of the contents of the apparatus raised to 130° C. where it is maintained for one hour. This treatment causes the liberation and solution of xylose and acetic acid. After cooling, the contents of the autoclave are removed and subjected to pressure to expel the solution from the undissolved solid material. This solution is then heated in contact with a second charge as before and thus a solution containing approximately double the amounts of xylose and acetic acid in a given volume is obtained. To isolate the acetic acid from this solution some of the steam from the heated autoclave is allowed to escape through a condenser and the distillate collected. This weak solution of acetic acid may be built up or fortified by causing it to pass through several such operations as just described, using the weak acetic acid solution instead of water as in the first instance. In this manner more and more acetic acid is accumulated in a given volume until the desired strength of acid is reached. This concentration may be made to attain 5 or 6 per cent.

The xylose solution remaining in the autoclave after the second heating operation is separated by pressure from the solid residue in which it is absorbed and from this solution the sugar is obtained. To accomplish the isolation of the xylose the solution referred to is evaporated under diminished pressure to a thick sirup which is seeded with xylose and left for itself for about 12 hours. In order to obtain crystals of sufficient size to separate from the mother liquor by means of a centrifuge the following conditions must be observed: First, the solution should be concentrated without undue delay; second, the proper consistency, which is about that of ordinary commercial molasses, should be attained; third, crystallization should take place at a temperature not lower than 20° nor higher than 35° C.; fourth, after crystallization has been induced by seeding, no more sirup should be added to the magma.

The solid residue from the pressing operations above referred to, which consists chiefly of crude cellulose, may be used in the preparation of stock feed.

For this purpose the press cake is coarsely ground, mixed with a small amount of lime or soda to neutralize the slight amount of sulfuric acid which it contains, and in this state is mixed with any desired amount of molasses or other sirup and dried by any suitable means. Such a mixture, if fed in connection with seed press-cake meal, may constitute cheap and good feed for cattle or other animals.

A second use to which the crude cellulose residue may possibly be put is that of an absorbent for nitroglycerin in the manufacture of dynamite. For this purpose the material must be purified by washing with dilute caustic soda to remove a brown material present as an impurity. The excess of the reagent must be removed from the cellulose by washing with water.

The cellulose may also be of use in the manufacture of artificial silk, leather substitutes, filaments, and plastics, by any of the processes now in common use. Other uses to which the impure cellulose residue may be put are the manufacture of glucose and of alcohol.

PREPARATION OF GLUCOSE FROM CRUDE CORN-COB CELLULOSE

The residue of impure cellulose above referred to, from which gum and xylose have been removed as already described, is ground to a rather fine powder and intimately mixed with about an equal weight of sulfuric acid of about 75 per cent strength. In determining the strength of acid to be used allowance should be made for the small amount of moisture left in the cake after the pressing operation. The resulting mixture is a stiff dough which is black in color. After the "dough" has been allowed to stand at room temperature for about 6 hrs., it is mixed with a convenient amount of water (5 to 8 parts), and the mixture is boiled for about one hour, after which the undissolved solid residue is removed from the very slightly colored solution by means of a filter press. Slaked lime which has been sifted free from lumps and suspended in water is added to the filtrate in quantity sufficient to very nearly neutralize the free acid in the solution. The calcium sulfate which separates out on this treatment is removed by means of a centrifuge or filter press. The solid residue of calcium sulfate is washed with water and the washings are added to the filtrate. The resulting liquid is a dilute solution of glucose. This solution is added to a second portion of ground press cake which has been treated with sulfuric acid as above described and the subsequent operations of boiling, filtering, etc., repeated as before. This process may be again repeated until the sugar content of the solution has been increased to the desired degree.

In order to isolate the glucose in the crystalline state the final solution is exactly neutralized with lime, filtered, and concentrated to a thick sirup. This sirup soon crystallizes to a solid mass. Glucose prepared after this manner has a slight brown color but is free from any objectionable taste and can be used directly as an ingredient of stock feed

In case the product were to be used for human food, very pure sulfuric acid and lime would have to be used in this preparation and decolorizing carbon or bone char would doubtless have to be employed.

The glucose solution above referred to is very rapidly and completely fermented by yeast and hence could be used for the production of alcohol.

By the process above described, about 50 per cent of the weight of the crude corn-cob cellulose is converted into glucose.

The solid residue from the first treatment of the material which was removed by the filter press, may again be subjected to digestion with 75 per cent sulfuric acid, as was the original material, and again a yield of 50 per cent of its weight of glucose may be obtained by the above process, making the total yield 75 per cent, or 37.5 per cent of the weight of the corn cob.

From two tons of sulfuric acid of the above-mentioned strength one ton of glucose could be prepared. In order to compete with glucose or molasses from other sources for the manufacture of alcohol, sulfuric acid of 75 per cent strength would have to be obtained at a price not much greater than $8.00 per ton.

CONCLUSION

While the methods for obtaining these principal products from corn cobs have not as yet been tested out on a large factory scale, they can be said to be already out of the laboratory stage, since the work has been carried on by means of autoclaves, powerful presses, vacuum stills, centrifuges, etc.

The yields of the various products constitute approximately the following percentages of the weight of the dry corn cobs:

PRODUCT	Per cent
Adhesive Gum	30
Crystalline Xylose	5
Acetic Acid	2.5 to 3
Crystalline Glucose	37

The United States is the world's greatest producer of corn. Our annual crop ranges from 2½ to 3 billion bushels, and represents nearly 75 per cent of the world's production. Other countries which rank as great corn producers are Austria-Hungary, Mexico, Argentine, and Italy. For every bushel of corn there is approximately a bushel of cobs which, however, weigh only one-fourth as much as the grain. Corn cobs are not utilized to any great extent. They have a certain value as fuel and also have been used as an ingredient of stock feeds. They contain, however, little or nothing that is directly available for animal nutrition. They are one of the great waste products of our agriculture. We believe, however, that the methods of utilizing them which have been described in this article may eventually render them a valuable source of raw material for manufacturing.

CARBOHYDRATE LABORATORY, BUREAU OF CHEMISTRY
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

STATISTICS OF GARBAGE COLLECTION AND GARBAGE GREASE RECOVERY IN AMERICAN CITIES

BY RAYMOND PEARL

Received August 28, 1918

In July 1917, the writer inaugurated in the Statistical Division of the United States Food Administration a system of voluntary statistical returns from the leading cities in the country, regarding the amount of garbage collected monthly and, where possible, the amount of grease recovered from the garbage collected. The purpose underlying the plan was to obtain information which would serve the officials of the Food Administration as an index of the effectiveness of their propaganda campaign urging the people to avoid waste in the preparation and use of food. In view of the somewhat novel character of the statistical material which has been collected in this work, it seems desirable to give it permanent record by publishing it where it will be available to public health officials and others who may be interested. Accordingly there is presented here the records of two complete years, from May 1916 to April 1918, inclusive.

The statistical material was obtained through the voluntary coöperation of municipal officials. In the first instance the mayors of all the larger cities in the country were asked if they would not arrange to have the proper official in their municipalities make a monthly report to the Food Administration on the amount, in tons, of garbage collected each month in the current year and the corresponding month of the previous year, beginning with May 1917. The response was very gratifying, particularly in regard to the willingness, not to say eagerness, to coöperate, of those asked. In a rather considerable number of cases it developed, apparently quite as much to the astonishment of the city officials as to ours, that the city had no record, nor any ready method of finding out how much garbage was collected in that city in a given interval of time. Finally, however, we were able to get 96 cities, with an estimated aggregate population of over 26,000,000 reporting regularly and for each month in the 2 years from May 1916 to May 1918. These cities include roughly about one-fourth of all the people living in this country. The numbers are sufficiently large to give considerable trustworthiness to the data as indicative of urban conditions in the country in general. The statistics are certainly much more comprehensive in their scope than any garbage statistics for the United States that have hitherto been brought together, so far as the writer is aware.

At the end of the year a tabulation of all the monthly returns which had been made was returned to the reporting city official for verification or correction. In this way it is believed that the figures here given are accurate so far as concerns the reporting of the municipal records. The original records themselves in some cases obviously do not include the whole of the garbage produced. In a few they are grotesquely far from the mark.

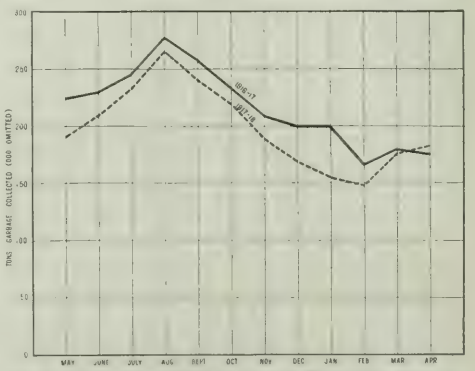


FIG. 1—THE SEASONAL CURVE OF GARBAGE PRODUCTION, BASED ON AVERAGE RETURNS FROM 96 LARGEST CITIES

It is, for example, inconceivable that the hundred odd thousand people who live in Nashville, Tenn., *produce* only about 400 tons of garbage in a year, while about an equal number, say 10,000 fewer, of people living in Norfolk, Va., produce in the neighborhood of 30,000 tons in a year. The fact is that the figures given in this paper refer to tonnage of garbage officially *collected* either by or under the official control of the municipality so that the amount is a matter of city record. Only in cities where by ordinance it is forbidden to dispose of garbage in any other way than by delivery to the organized official collecting agency of the city can the statistics here given be regarded as representing the total amount produced.

TABLE I

Total Garbage Collections, by Tons, from 96 Cities for the 2 Years May 1917–April 1918 and May 1916–April 1917

City	Population	Tons Collected May 1917–April 1918	Tons Collected May 1916–April 1917	Relative figure 1917–18 to 1916–17 taken as 100
Akron, Ohio	150,000(a)	10,084	8,529	118.2
Allentown, Pa.	80,000(a)	12,591	12,340	102.0
Atlanta, Ga.	196,000(a)	42,412	44,798	94.7
Atlantic City, N. J.	57,660	15,373	18,792	81.8
Augusta, Ga.	41,040	47,480	49,338	96.2
Aurora, Ill.	33,022	1,509	1,805	83.6
Baltimore, Md.	594,000(a)	34,685	37,915	91.5
Berkeley, Cal.	66,000(a)	8,874	9,726	91.2
Boston, Mass.	781,628(a)	46,335	52,650	88.0
Bridgeport, Conn.	172,113(a)	18,166	19,897	91.3
Brockton, Mass.	67,449	4,117	5,794	71.1
Buffalo, N. Y.	468,558	15,382	21,817	70.5
Cambridge, Mass.	112,981	7,138	7,605	93.9
Cedar Rapids, Iowa	40,667(d)	2,282	2,230	102.3
Charleston, S. C.	61,041(b)	26,909	32,114	83.8
Charlotte, N. C.	50,000(a)	9,410	8,612	109.4
Chelsea, Mass.	47,000(a)	1,746	2,455	71.1
Chicago, Ill.	2,497,722	93,235	124,496	74.9
Cincinnati, Ohio	416,300(a)	34,103	40,692	83.8
Cleveland, Ohio	674,073	55,466	59,708	92.9
Colorado Springs, Col.	36,000(a)	3,832	3,974	96.4
Columbus, Ohio	220,000(a)	17,295	20,393	84.8
Dallas, Texas	124,537	220	267	82.4
Dayton, Ohio	155,000(a)	15,677	16,621	94.3
Detroit, Mich.	750,000	64,270	72,785	88.3
East Orange, N. J.	39,852	3,746	3,980	94.1
El Paso, Texas	85,222(a)	15,948	15,969	99.9
Erie, Pa.	100,000(a)	6,927	8,257	83.9
Everett, Mass.	40,000(a)	1,750	1,975	88.6
Fort Wayne, Ind.	81,057(a)	7,862	10,203	77.1
Galveston, Texas	35,000(b)	6,954	11,858	58.6
Grand Rapids, Mich.	140,000(a)	7,339	8,678	84.6
Hartford, Conn.	145,000(a)	13,829	14,644	94.4
Haverhill, Mass.	51,870(a)	3,541	3,852	91.9
Holyoke, Mass.	62,301(b)	1,708	2,310	73.9
Houston, Texas	165,192(a)	30,203	28,567	105.7
Indianapolis, Ind.	271,758	19,929	23,267	85.7
Jacksonville, Fla.	100,000(a)	17,654	24,732	71.4
Jersey City, N. J.	316,889(b)	106,846	106,856	100.0
Joliet, Ill.	40,000(a)	3,232	3,636	88.9
Kansas City, Mo.	297,847	1,730	1,860	93.0
Lexington, Ky.	41,097(c)	1,985	2,607	76.1
Los Angeles, Cal.	600,000	47,345	51,062	92.7
Lowell, Mass.	107,978(a)	3,935	4,272	92.1
Lynn, Mass.	102,425	8,591	10,153	84.6
Manchester, N. H.	85,000(a)	4,477	7,868	57.0
Memphis, Tenn.	148,995	15,231	17,146	88.8
Milwaukee, Wis.	474,000(a)	30,008	35,928	83.5
Minneapolis, Minn.	390,000(a)	21,041	23,307	90.3
Mobile, Ala.	60,060	19,145	19,655	97.4
Nashville, Tenn.	117,057	410	406	100.9
New Bedford, Mass.	118,158	8,774	10,162	86.3
New Orleans, La.	385,000(a)	83,459	98,710	84.5
Newport, Ky.	32,000	1,906	2,726	69.9
New York City, N. Y.	5,377,456(a)	445,237	487,451	91.3
Niagara Falls, N. Y.	60,000(a)	2,900	2,865	101.2
Norfolk, Va.	106,159(b)	27,251	31,512	86.5
Oakland, Cal.	198,604	32,610	33,787	96.5
Oklahoma City, Okla.	92,943	2,658	2,854	93.1
Pasadena, Cal.	46,500(a)	2,727	1,865	146.2
Passaic, N. J.	70,000(a)	28,987	27,599	105.0
Paterson, N. J.	138,443	31,359	31,985	98.0
Philadelphia, Pa.	1,709,518	114,160	101,678	112.3
Pittsburgh, Pa.	579,090	72,612	73,758	98.4
Pittsfield, Mass.	39,607(a)	1,418	1,789	79.3
Portland, Maine	63,867	5,012	7,046	71.1
Portland, Oregon	311,000(a)	30,674	33,876	90.5
Quincy, Mass.	45,500(a)	506	627	80.7
Racine, Wis.	48,000(a)	3,751	4,268	87.9
Reading, Pa.	112,561(a)	8,546	11,584	73.8
Richmond, Va.	160,000	26,188	30,942	84.6
Roanoke, Va.	40,574	4,568	6,058	75.4
Rochester, N. Y.	275,000(a)	25,926	30,782	84.2
Sacramento, Cal.	77,500(a)	16,901	23,894	70.7
St. Louis, Mo.	905,650(a)	8,657	44,555	86.8
St. Paul, Minn.	276,000(a)	14,593	17,105	85.3
Salem, Mass.	46,994	1,994	2,198	90.7
San Diego, Cal.	92,000(a)	173	257	67.3
San Francisco, Cal.	550,000(a)	131,653	150,415	87.5
San José, Cal.	40,000	4,549	4,976	91.4
Savannah, Ga.	68,805	9,262	11,516	80.4
Schenectady, N. Y.	108,000	4,111	4,419	93.0
Scranton, Pa.	146,811	12,698	15,518	81.8
Somerville, Mass.	90,500(a)	5,870	5,875	99.9
Springfield, Ill.	70,000(a)	47,910	28,315	169.2
Springfield, Mass.	108,942	10,394	11,640	89.3
Syracuse, N. Y.	158,624	12,895	14,055	91.7
Tampa, Fla.	53,886	18,081	18,023	100.3
Terra Haute, Ind.	66,083	11,730	19,631	59.8
Toledo, Ohio	220,000(a)	22,180	23,971	92.5
Trenton, N. J.	111,593(a)	14,751	16,166	91.2
Washington, D. C.	400,000(a)	46,732	46,293	100.9
Wheeling, W. Va.	50,671	4,603	5,658	81.4
Wilmington, Del.	94,365	18,986	14,187	133.8
Worcester, Mass.	187,000(a)	6,992	6,828	102.4
Youngstown, Ohio	120,000(a)	8,424	9,827	85.7
TOTAL	26,034,685	2,388,932	2,609,134	90.1

(a) Population in 1918 (b) Population in 1917.
(c) Population in 1916. (d) Population in 1915.

The fact that the figures are for collection rather than production does not invalidate relative comparisons of one year with another, provided of course that the scope of official collection did not change in the period. Pains have been taken to make sure by correspondence that no such changes in the plan of collection came in in the cities dealt with during the period covered.

The basic statistics are contained in Table I, in which the 96 cities covered are listed alphabetically. The data given are (*a*) population, (*b*) gross tonnage of garbage collected in 1917–18, (*c*) gross tonnage of garbage collected in 1916–17, fiscal year ending April 30 being taken in both cases, (*d*) a relative figure which expresses the 1917–18 collection as a percentage of the 1916–17 collection for the same city.

The totals of this table show that in the 96 cities included in the tabulation 10 per cent less garbage was collected in 1917–18 than in the previous year. The figures demonstrate a genuine conservation of food by the urban population of the country during the past year, in the sense that 10 per cent of the usual wastage in the preparation of food and in the incomplete usage of food after its preparation was eliminated. The gross tonnage figures do not, however, give a true picture of the real amount of conservation or of the effectiveness of the Food Administration's teachings. This can only be demonstrated by the grease figures to which we shall come presently.

Of the 96 cities included in Table I, 81 showed smaller collections in 1917–18 than in 1916–17, and 15 had larger collections. The distribution of relative figures for these 81 cities was that shown in Table II.

TABLE II

Distribution of Relative Figures of Cities Showing Smaller Collections in 1917–18 than in 1916–17

Relative Figure	Number of Cities
50–59	2
60–69	2
70–79	14
80–89	31
90–99	32

Roughly speaking, three-fourths of these 81 cities had relative figures of 80 or above, indicating reduction of collections from 1 to 20 per cent. The four cities giving relative figures under 70, namely, Manchester, N. H., Galveston, Texas, Terre Haute, Ind., and San Diego, Cal., make very creditable showings indeed.

The 15 cities showing an increase in garbage collections in 1917–18 are separately treated in Table III, which has the same arrangement as Table I.

TABLE III

Fifteen Cities in which the Annual Garbage Collections Increased in 1918 Relative to 1917, in Order of Increase

Order	City	Tons Collected May 1917–April 1918	Tons Collected May 1916–April 1917	Relative figure 1917–18 to 1916–17 taken as 100
1	Tampa, Fla.	18,081	18,023	100.3
2	Nashville, Tenn.	410	406	101
3	Washington, D. C.	46,732	46,293	101
4	Niagara Falls, N. Y.	2,900	2,865	101
5	Allentown, Pa.	12,591	12,340	102
6	Cedar Rapids, Iowa	2,282	2,230	102
7	Worcester, Mass.	6,992	6,828	102
8	Passaic, N. J.	28,987	27,599	105
9	Houston, Texas	30,203	28,567	106
10	Charlotte, N. C.	9,420	8,612	109
11	Philadelphia, Pa.	114,160	101,678	112
12	Akron, Ohio	10,084	8,529	118
13	Wilmington, Del.	18,986	14,187	134
14	Pasadena, Cal.	2,727	1,865	146
15	Springfield, Ill.	47,910	28,315	169

Of these 15 cities, the first seven may at once be dropped out of account as the increase is very small, 2 per cent or less. Of the remainder, 5, namely Passaic, Philadelphia, Akron, Wilmington and Springfield, Ill., are places which have received considerable increments of population within the last year on account of war activities of one sort or another, such as munition making and the like. The effect of such sudden increase

in population on garbage collection is obvious. To show its effect in detail, Table IV has been prepared, which gives the monthly collections for the four industrial cities showing the greatest increases in garbage collections.

TABLE IV

The 4 Industrial Cities Showing the Greatest Increase in Garbage Collection in 1918 Relative to 1917, Giving Collections by Months

	Springfield, Ill.		Wilmington, Del.		Akron, Ohio		Philadelphia, Pa.	
	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative
May 1917	3,690	293	923	77	1,005	172	8,017	102
May 1916	1,260	...	1,203	...	583	...	7,823	...
June 1917	3,528	280	970	83	894	148	9,588	119
June 1916	1,260	...	1,165	...	604	...	8,053	...
July 1917	2,322	158	1,200	93	864	105	11,042	131
July 1916	1,474	...	1,287	...	825	...	8,434	...
Aug. 1917	2,393	224	4,120	222	1,094	113	14,883	140
Aug. 1916	1,068	...	1,853	...	967	...	10,604	...
Sept. 1917	919	124	3,582	208	1,165	118	13,690	142
Sept. 1916	742	...	1,722	...	985	...	9,665	...
Oct. 1917	2,745	235	1,436	97	1,069	129	11,183	132
Oct. 1916	1,170	...	1,476	...	828	...	8,498	...
Nov. 1917	2,650	142	1,995	183	792	96	8,174	107
Nov. 1916	1,872	...	1,089	...	829	...	7,655	...
Dec. 1917	3,438	102	1,282	139	630	122	6,647	90
Dec. 1916	3,375	...	925	...	515	...	7,423	...
Jan. 1918	2,217	58	927	106	539	102	7,928	103
Jan. 1917	3,792	...	876	...	528	...	7,702	...
Feb. 1918	3,220	66	743	89	576	133	7,054	67
Feb. 1917	4,912	...	838	...	432	...	10,559	...
Mar. 1918	11,280	253	799	84	698	114	7,962	101
Mar. 1917	4,450	...	952	...	613	...	7,879	...
Apr. 1918	9,508	323	1,009	126	759	93	7,992	108
Apr. 1917	2,940	...	801	...	820	...	7,374	...

Table V gives the monthly collections in the 10 largest cities covered in the statistics, with the relative figures for each month, comparing that month in 1917–18 with the corresponding month in 1916–17.

TABLE VI

Total Tons of Garbage Collected in 96 Cities, by Months, May 1916 to April 1918

	Garbage Collected (tons) 1917–18	1916–17	Relative
May	191,129.06	226,066.56	85
June	209,937.90	230,724.72	91
July	233,853.43	245,198.66	95
August	265,409.63	278,948.91	95
September	241,317.59	258,751.64	93
October	220,943.29	234,148.73	94
November	190,012.89	209,090.07	91
December	170,391.67	200,067.75	85
January	156,711.35	200,096.45	78
February	148,785.15	167,391.84	89
March	177,392.25	181,306.00	98
April	183,119.69	177,342.50	103
Totals	2,388,931.92	2,609,133.83	92

From this diagram and table it is possible to get considerable information as to the normal distribution of the garbage production in the different months of the year. The month of maximum collection is August and the month of minimum collection is February. Following February, the curve begins to rise and goes up rather steadily along something approaching a straight line to the maximum point. The fall from the maximum point in May to the minimum point in February is again nearly a straight line.

Table VI also enables one to see in what month the conservation propaganda has been the most effective. In the months of May and June and December and January, the degree or extent of the lowering of the 1917–18 collections, as compared with the 1916–17 collections, is largest. During the other months of the year the curves run very closely parallel. During the last month of the fiscal year the two curves cross; that is to

TABLE V

Garbage Collections from the 10 Largest Cities, Giving Comparisons by Months

	New York, N. Y.		Chicago, Ill.		Philadelphia, Pa.		St. Louis, Mo.		Boston, Mass.		Cleveland, Ohio		Los Angeles, Cal.		Baltimore, Md.		Pittsburgh, Pa.		San Francisco, Cal.	
	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative	Tons collected	Relative
May 1917	36,602	81	2,990	27	8,017	102	2,794	70	4,416	89	4,165	74	3,451	91	2,886	96	5,490	88	10,803	87
May 1916	45,197	...	11,177	...	7,823	...	3,997	...	4,980	...	5,660	...	3,812	...	3,006	...	6,244	...	12,438	...
June 1917	44,590	93	8,386	65	9,588	119	3,882	92	4,042	88	4,613	89	3,454	84	3,199	97	6,019	95	10,211	87
June 1916	48,099	...	12,826	...	8,053	...	4,205	...	4,572	...	5,176	...	4,120	...	3,307	...	6,303	...	11,760	...
July 1917	49,295	94	11,239	79	11,042	131	4,631	84	3,870	87	5,431	90	4,453	83	4,854	97	6,728	99	10,318	85
July 1916	52,173	...	14,302	...	8,434	...	5,540	...	4,440	...	6,068	...	5,337	...	5,012	...	6,810	...	12,078	...
Aug. 1917	51,545	97	12,583	78	14,883	140	6,247	88	4,265	91	5,680	89	5,431	95	5,063	93	7,340	96	11,846	86
Aug. 1916	53,368	...	16,093	...	10,604	...	7,078	...	4,680	...	6,384	...	5,729	...	5,473	...	7,652	...	13,780	...
Sept. 1917	45,903	94	11,142	82	13,690	142	5,597	99	4,310	92	5,639	93	5,167	101	4,567	97	7,623	102	11,121	82
Sept. 1916	48,934	...	14,774	...	9,665	...	5,645	...	4,668	...	6,069	...	5,111	...	4,709	...	7,481	...	13,541	...
Oct. 1917	42,971	96	11,259	90	11,183	132	3,815	94	4,033	87	5,955	109	4,440	97	3,833	97	7,440	106	11,861	88
Oct. 1916	44,629	...	12,462	...	8,498	...	4,075	...	4,632	...	5,473	...	4,596	...	4,041	...	7,045	...	13,482	...
Nov. 1917	35,551	90	8,967	93	8,174	107	2,495	81	3,631	83	4,580	92	3,395	90	2,099	95	5,877	97	10,926	90
Nov. 1916	39,299	...	9,663	...	7,655	...	3,081	...	4,368	...	4,973	...	3,779	...	2,216	...	6,034	...	12,173	...
Dec. 1917	28,739	83	6,661	91	6,647	90	1,896	74	3,415	79	4,165	104	3,481	90	1,787	89	4,613	79	11,414	86
Dec. 1916	34,691	...	7,280	...	7,423	...	2,575	...	4,332	...	4,012	...	3,862	...	2,011	...	5,840	...	13,347	...
Jan. 1918	24,935	76	2,388	30	7,928	103	1,362	57	2,910	63	3,751	84	3,605	90	1,780	76	4,095	69	11,537	84
Jan. 1917	32,975	...	7,897	...	7,702	...	2,403	...	4,608	...	4,485	...	4,026	...	2,357	...	5,907	...	13,696	...
Feb. 1918	22,350	85	4,347	74	7,054	67	1,498	90	3,093	81	3,352	100	3,246	93	985	52	5,362	117	10,211	90
Feb. 1917	26,399	...	5,904	...	10,559	...	1,668	...	3,812	...	3,366	...	3,498	...	1,899	...	4,586	...	11,313	...
Mar. 1918	29,283	98	6,051	102	7,962	101	2,011	100	4,175	103	3,552	87	3,721	99	1,769	93	5,988	132	10,800	89
Mar. 1917	29,995	...	5,936	...	7,879	...	2,020	...	4,051	...	4,087	...	3,740	...	1,905	...	4,539	...	12,092	...
Apr. 1918	33,650	106	6,222	101	7,992	108	2,483	107	4,175	119	4,583	116	3,501	101	1,763	89	6,037	114	10,605	99
Apr. 1917	31,692	...	6,182	...	7,374	...	2,268	...	3,507	...	3,955	...	3,452	...	1,979	...	5,317	...	10,715	...

The first noteworthy feature of this table is the considerable variation among the different cities as to the constancy of the relative figure for the different months of the year. In some of the cities it maintains a fairly even level throughout the year, notably in Baltimore and San Francisco, and to a lesser degree, Boston. The seasonal fluctuations in savings in these cities, as indicated by the relative figures, follow rather closely the *general* seasonal distribution of the garbage collections in the cities named. Others of the cities show widely varying figures in this respect, notably in Philadelphia, where, in the course of the year, the relative figure changes all the way from 57 to 142.

Some general features of the seasonal distribution of garbage collection are indicated in Table V. The normal seasonal curve of garbage production, however, is better shown by the sums by months of all the cities covered in Table I. This is done in Table VI, where there are exhibited the total collections of garbage for the 96 cities reporting, in each month of the two fiscal years for which reports are available.

say, the April 1918 collections were slightly larger than the April 1917 collections. This is probably due chiefly to the fact of an increased use in April 1918 of various vegetable foods with a comparatively large amount of inedible refuse, which increases in turn resulted from the shortage of wheat and wheat flour. People were urged to substitute and undoubtedly did so to a very considerable extent, vegetables for the scant cereals. This was particularly true of potato consumption. Another factor in the case is undoubtedly the increase of the population in a considerable number of the cities of the United States as a result of the war conditions, munitions making, shipbuilding, etc.

We may turn now to a consideration of the grease recovery from garbage. The grease is the profitable constituent of garbage as it is ordinarily handled. The raw material also, of course, contains valuable protein and carbohydrate, but in the usual methods of reduction the tankage from which the grease has been extracted goes to fertilizer. Unfortunately, only

TABLE VII

Tons of Garbage Grease Recovered in 12 Cities for the 2 Years May 1917–April 1918 and May 1916–April 1917

City	Population	Tons of Garbage		Tons of Grease Recovered			Percentage of Grease		
		May 1917–April 1918	May 1916–April 1917	May 1917–April 1918	May 1916–April 1917	Relative Figure	May 1917–April 1918	May 1916–April 1917	Relative Figure(b)
Boston, Mass.	781,628(a)	46,335	52,650	1,401	2,140	65	3.02	4.06	74
Buffalo, N. Y.	468,588	15,382	21,817	314	494	63	2.03	2.26	90
Chicago, Ill.	2,497,722	93,235	124,496	1,656	2,869	58	1.77	2.30	77
Cleveland, Ohio	674,023	55,466	59,708	1,415	1,821	78	2.55	3.05	84
Columbus, Ohio	220,000(a)	17,295	20,393	354	639	55	2.04	3.13	65
Dayton, Ohio	188,000(a)	15,677	16,621	250	358	70	1.59	2.13	75
Indianapolis, Ind.	271,788	19,929	23,267	454	793	57	2.27	3.40	67
New Bedford, Mass.	118,158	8,774	10,162	199	270	74	2.26	2.65	85
Pittsburgh, Pa.	579,090	72,612	73,758	1,554	2,117	73	2.14	2.87	75
Philadelphia, Pa	1,709,518	114,160	101,678	1,178	1,164	101	1.03	1.14	90
Schenectady, N. Y.	105,000	4,111	4,419	84	91	93	2.04	2.04	100
Wilmington, Del.	94,265	18,986	14,187	49	92	53	0.25	0.65	38
Totals	7,684,771	481,962	523,156	8,906	12,843	70	1.85	2.45	76

(a) Population 1918.
(b) Relative figure expressing the monthly collection for the present year as a percentage of that of the same month last year; that is, relative figures under 100 mean smaller collections and figures over 100 mean larger collections.

comparatively few cities have municipal reduction plants and are able to furnish statistics of grease recovery. Such data as it has been possible to collect are exhibited in Table VII. The arrangement is the same as that of the earlier tables in this paper.

The data of Table VII show in the clearest manner the remarkable effect of the conservation campaign. The 12 cities show a reduction of 30 per cent in the gross tonnage of grease recovered from garbage in 1917–18 as compared with 1916–17. The average percentage of grease in the garbage dropped from 2.45 to 1.85. The figures demonstrate that not only was there a quantitative conservation of food affected during the last year, but also, and even more important, there was a proportionally much greater qualitative conservation. There must have been in these 12 cities a very great reduction in the amount of meats and fats going into the garbage can.

The two cities showing the greatest qualitative food conservation, as indicated in garbage statistics, were Columbus, Ohio, and Wilmington, Del., with relative figures of 55 and 53, respectively. In these two cities the garbage in 1917–18 contained only a little more than half as much fatty material in 1917–18 as in 1916–17. This is truly a remarkable record.

Putting all the data together, it appears that, in so far as the sampling of cities may be considered representative of the urban portion of the country as a whole, there has been a substantial conservation of food by the American people during the past year. A reduction of 10 per cent in the gross tonnage of garbage, and of 30 per cent in the tonnage of fat recovered can only have been accomplished by a real and widespread saving and utilization of food materials which ordinarily go into the garbage can.

SCHOOL OF HYGIENE AND PUBLIC HEALTH
JOHNS HOPKINS UNIVERSITY
BALTIMORE, MD.

COTTON OIL INDUSTRY IN THE WAR[1]

By DAVID WESSON

Many things have been turned upside down by the war. The cottonseed industry is one of them. Before the war there was a constant competition between the oil mills for seed. Money was advanced to seed buyers, and the seed, in many instances, was accepted containing large quantities of foreign matter, which had to be taken and paid for or else the mills would shut down.

Since the Food Administration has become very much interested in the value of the products of the cottonseed for supplying this country and our Allies with food and ammunition materials, they have taken the industry under control and established a department of the Food Administration in Washington dealing specially with cottonseed products.

Before the war, if oil mill men got together and decided they could pay a certain price for the seed, they were sent to jail under the anti-trust laws of the various states. If the refiners of the crude oil who made their product into lard compounds got together and attempted to regulate the prices of their products in order that there might be some profit left in the business, they violated the anti-trust laws and were apt to find Canada or some foreign clime far more salubrious than the good old U. S. A. Now all of this is changed. The oil mill men go down to Washington and with the Food Administration agree on a price which they can afford to pay for cottonseed. They also agree with the Food Administration on a suitable price to charge for their oil, meal, and hulls. The Government tells them how much oil, meal, hulls, and linters they should produce per ton of seed. The prices are arranged so that the manufacturer, working with ordinary good management, should make a profit. The agreement is, in a sense, a gentleman's agreement, and there is no law against breaking it, but all the manufacturers are licensed and if they should break the agreements they would lose their licenses. The effect of this arrangement is to stabilize prices and to secure the largest possible production.

The approximate yields per ton of seed are at present:

Oil	41 to 43 gal.
Meal	960 lbs.
Hulls	480 lbs.
Linters	145 lbs.

Before the war 40 or 50 lbs. of linters were considered a reasonably good yield, while the hulls used to be about 600 lbs. per ton.

Although the title "Cotton Oil Industry in War" was selected the words "Vegetable Oil Industry" would have been fully as appropriate, because at the present time cottonseed oil represents approximately only about two-thirds of the oils handled in the plants, which were originally started to crush cottonseed and refine its products.

In 1900 this country crushed 2,480,000 tons of seed, costing $11.55 per ton, and produced products worth $42,412,000. During the crushing season just passed about 4,200,000 tons of seed were handled, for which was paid $65 per ton, and the combined value of the products was in the neighborhood of $400,000,000, or about ten times as great as in 1900.

The cotton oil industry proper gives the country from the seed about 3,200,000 barrels of edible oil, 2,000,000 tons of cake and meal, 1,000,000 tons of hulls used as cattle feed, and 280,000 tons of linters which furnish much of the cellulose for the manufacture of explosives.

In refining the oil there are obtained 192,000 barrels of fatty acids used in the soap industry, and last, but not least, about 3,800,000 lbs. of glycerin used in the manufacture of explosives.

The great muscular activity of the men in the armies and those in the iron and steel and shipbuilding industries calls for a great amount of food which will furnish energy. This is largely supplied by edible fats and oils. Before the war the dairy, the cotton oil industry, and the packing houses furnished a normal

[1] Presented at the 56th Meeting of the American Chemical Society, Cleveland, September 11, 1918.

supply for this country and exported considerable to Europe. Since the war has started, between short crops of cotton and the big demand for edible fats, materials other than cottonseed oil have been drawn upon to keep up the supply. All told, something like 1,700,000 barrels of vegetable oils were imported during the year either as oil or in the form of oil seeds such as copra, peanuts, sesame, and soy beans. Coconut oil has entered the country largely as copra and much of it has been crushed in cottonseed oil mills. Peanut oil has been imported in large quantities from the Orient and has also been crushed from the peanuts grown in the South and West. The refined oils have gone largely into butter substitutes, some into lard, and some into soap.

Besides furnishing the best edible oils, lard, butter substitutes, cattle feed, cellulose for explosives, soap material, and glycerin to aid the war, the cotton oil industry is furnishing men from its mills, and the places of many of the men are being taken by women.

THE SOUTHERN COTTON OIL COMPANY
120 BROADWAY, NEW YORK CITY

THE BUREAU OF FOREIGN AND DOMESTIC COMMERCE ITS RELATIONS TO AMERICAN CHEMICAL INDUSTRY

Papers presented before the New York Section, American Chemical Society, October 11, 1918

GOVERNMENT TRADE-BUILDING INFORMATION

By CHAUNCEY DEPEW SNOW

Assistant Chief, U. S. Bureau of Foreign and Domestic Commerce

In my work in the Bureau of Foreign and Domestic Commerce since the outbreak of the European war I have had more to do with business men connected with the chemical industry than with those connected with any other American industry. Back in 1914 and 1915, when I had just returned from an official visit of observation in Germany, it was dyestuff manufacturers, prospective dyestuff manufacturers, or chemists chiefly interested in dyestuffs, who most frequently came to the Bureau. In the three years following business men connected with every branch of the chemical industry and the chemical equipment industries have had some occasion to deal with the Bureau of Foreign and Domestic Commerce. The detailed analysis of import statistics of dyestuffs which was made for the Bureau and the chemical industry by Dr. Thomas Norton, combined with his reports on atmospheric nitrogen and some minor Bureau contributions on particular sides of the chemical industry, put this government bureau in the minds of a great many men in the industry. The success of the dyestuff census led to the request by your Society for a survey of all chemical imports. Your Society, unlike many of the others, backed its convictions by raising funds to help cover the expense of the inquiry, so the Bureau was glad to pitch right into the work on such a survey. Dr. Pickrell will tell you more about that a little later. Naturally the fact that the Bureau was engaged in this study has had a tendency to interest others of your members in our work and visits to the Bureau by your members have been even more frequent. Not long ago these visits from chemists and others interested in chemicals became so numerous that the Chief of the Bureau remarked it would soon become necessary in our examination requirements for Bureau positions to specify a knowledge of chemistry.

Your committee has requested me to tell here to-night what the Bureau of Foreign and Domestic Commerce has to offer to the American chemical industry. As at present organized the Bureau came into existence in 1912 by Congressional action consolidating the Bureau of Manufactures and the Bureau of Statistics. The Bureau of Manufactures had been charged by law with the duty of fostering, promoting, and developing the manufacturing industries of the United States. The Bureau of Statistics had been charged with collecting and publishing the statistics of imports and exports and tonnage of the United States. Since the consolidation, Congress has laid all the emphasis on trade and the promotion of manufacturing industry by means of promoting trade. The appropriations for the Bureau have been made primarily with a view to enlarging our information about foreign markets. The great bulk of the work during these past six years has been the promotion of the export trade of the United States. The appropriations have related chiefly to the foreign field, and the Bureau has not been given any permanent organization for direct promotion of domestic commerce. In fact, the one little appropriation which we did have for collecting the statistics of the internal commerce of the United States was withdrawn. As matters stand to-day the Bureau of Foreign and Domestic Commerce is the official center of information for all questions pertaining to the movement of goods into the United States from abroad, the movement of goods from the United States to foreign countries, and the movement of goods between the main block of territory of the United States and our non-contiguous territory. Further the Bureau is the chief source of information in this country concerning the trade, industries, and natural resources of foreign countries. We get the information concerning the outward and inward movements of goods in the United States, as most of you know, through the United States customhouses. Declarations of value and quantity are required for statistical purposes in connection with exports, as well as imports. Returns from the customhouses are made to the Bureau of Foreign and Domestic Commerce, which takes care of final compilation and publication of returns. Information concerning the trade, industries, and resources of foreign countries comes through a variety of channels.

The Bureau receives the official statistics, official gazettes, principal trade papers, and other non-official publications, from practically every country and important colony on earth. There is a staff of trained readers, translators, and research statistical clerks working continuously on this incoming stream of printed matter from foreign countries.

Then there is the large number of reports that are constantly coming from the American consular offices which dot the world. Even at this time, when of course we have no consulates in Germany and the other enemy countries, we have over two hundred and fifty active consulates, and one hundred and fifty more consular agencies. A good many of our business men are apt to smile at mention of the consular service, but the really well-informed American business men who have had much contact with the consular service will tell you that it is a remarkably good organization. We need more consuls, and a larger staff in many of the existing consulates. The consuls have a multitude of duties, varying from really responsible representation of the Government to purely notarial functions. They are required to make commercial reports, both with regard to general commercial conditions at the places where they are stationed and with regard to market opportunities for the sale of American goods. The consuls have clearly defined local territories to cover in their reports. Some of our consuls are so pressed with other routine work that they are forced to neglect these commercial matters. Others give perhaps the bulk of their time to commercial matters. During the last couple of years, since our entry into the war, the consuls have had so many additional duties imposed upon them that matters of trade information

and trade promotion have of necessity pretty much gone by the board. But the importance of the consular service in our scheme and mechanism of trade promotion and trade information should be recognized and appreciated. For current reports on local matters of importance to American commerce it is to the consuls that we must look.

In addition to the consuls we have, at the principal embassies and legations, officers who are known as commercial attachés. Everybody now knows what military and naval attachés are. Well, the commercial attaché is the accredited representative of the Department of Commerce attached to the staff of the embassy or legation to report on commercial developments of national importance and look out for national commercial interests of the United States. He acts as commercial adviser to the ambassador and at the same time keeps the Department of Commerce, and through the Department the business men of this country, fully informed about developments of general significance to American trade. The commercial attaché is under the Department of Commerce and plays with regard to commerce a part corresponding to that taken by the military and naval attachés with regard to military and naval matters. Unlike the consul, the commercial attaché has as his field an entire country. Unlike the consul, also, the commercial attaché has no other functions beyond those of promoting the commerce of the United States. The commercial attaché is a resident trade representative and exclusively a trade representative.

Another very important part of this mechanism of keeping American business men informed as to the trade and industries of foreign countries is the staff of commercial agents. The commercial agent is a trained specialist in some particular line or phase of commerce who has a distinct assignment to visit certain foreign countries and report on things pertaining to his line of trade or industry which have interest for the American manufacturers and merchants. Thus, when we undertook to make a study of the subject of atmospheric nitrogen in Germany and the Scandinavian countries, we had the investigation made by a chemist of recognized standing and fitness for the work. Similarly, when we had a survey made of South American markets for drug products, patent and proprietary medicines, surgical instruments, and dental supplies, we picked a commercial agent who had had technical experience in connection with those lines. Our study of oils and seed products in foreign countries was made by a man who was known throughout the trade for the work which he had done in that connection. I have taken a few instances relating directly to the chemical industry. In like manner we have had specialists report on foreign markets for agricultural implements and machinery, machine tools, electrical goods, canned goods, cotton and other textiles, boots and shoes, and so on. For some of the more important industries we have had our commercial agents cover practically all countries.

I have described the sources of information of the Bureau of Foreign and Domestic Commerce. I will now touch briefly on the nature of our organization in Washington for handling information and making it available to the business men of the country. In the Washington office, where we have between 150 and 200 workers, we are organized partly on a geographical basis and partly on a subject basis. More interest has been taken in Latin America than in any other foreign field. This is reflected in our appropriations and in our organization. Our Latin American Division is one of the largest and one of the best informed and busiest parts of our organization. It is in charge of a man who has for years specialized on Latin American trade, and is personally familiar with the entire Latin American field. He has a number of assistants who have been in Latin America and the necessary translators and clerical assistants. There is undoubtedly in this Division more trade information with reference to the countries of Latin America than anywhere else in this country, and probably than in any foreign country. This year Congress gave us a special appropriation which made possible the creation of a Far Eastern Division. The Far Eastern Division has been organized, has developed its files, and correlated the available information with reference to the Far East somewhat after the fashion of our Latin American Division. As Russian commercial affairs have loomed so large in the past few years we have developed our Russian information files very largely. In addition to our geographical divisions we have a Division of Foreign Customs Tariffs, which supplies information with regard to tariff rates and customs requirements, consular regulations, and regulations affecting commercial travellers in any foreign country or colony. In this division we also have the information with regard to foreign patent and trade-mark requirements. In the past couple of years our little foreign trade-mark section has done yeoman service in helping American manufacturers to protect their trade-mark rights in foreign countries where German competitors were pirating them under foreign laws by which registration rather than use is the test of validity. We of course have our Division of Statistics, which is the central office for United States trade statistics. Foreign statistics in general are handled by our Division of Research, which also has our information files with reference to foreign countries not covered by specialized divisions. Our Division of Trade Information handles all the non-technical correspondence. We have lists of foreign buyers, classified, for practically every important foreign city. The value of the lists has been lessened, of course, recently by the ever-changing enemy trade prescriptions of the belligerent countries. We have a big collection of trade directories and a list of American manufacturers known to be interested in exporting what we call our Exporters' Index. Incidentally, we have our trade information files very thoroughly indexed and cross-indexed, in order that inquiries may receive the best possible attention. Then we have our Editorial Division, which gets out our daily paper, Commerce Reports, with which many of you are familiar, and the reports of the foreign representatives that I have mentioned. The organization of the Bureau in Washington is for service. The Divisions that I have talked about are arranging the material that comes in from abroad in order to make it helpful to American business men. The Chief of the Bureau's Editorial Division, Mr. Hopkins, will explain to you more in detail some of the aspects and possibilities of that work.

Whereas in former years most of our inquirers were interested exclusively in foreign markets for American manufactured goods, more recently a large percentage of inquirers have been interested in foreign sources of supply for materials to be used in manufacturing in this country. This has been strikingly true as the shortage of ship space has curtailed trade with the more remote parts of the world and has made necessary the use of nearer sources of supply and of new materials that are more readily available with less use of ship tonnage than the customary materials. Our representatives abroad pass on information about new industrial materials, new processes, and new uses of old materials. The Bureau of Foreign and Domestic Commerce is making such information available to manufacturers here.

In short, if there is any phase either of competition from foreign countries in foreign markets or from foreign countries in American markets or any information about needed supplies of old or new raw materials for manufacture in this country, the Bureau of Foreign and Domestic Commerce either has the information or the means and disposition to obtain it.

I have talked at some length and at the risk of going too much into detail in order to make quite plain to you the extent of the trade information and trade promotion service which the Bureau

carries on. Questions are sometimes asked as to whether this is all worth while, and both in Congress and elsewhere, occasionally questions are put as to whether there is an actual money return for the funds which are expended in this work. It is hardly a fair test to apply, but the work that the Bureau of Foreign and Domestic Commerce has done will stand even this test. The letters from American firms who have been helped by the Bureau and who have quite spontaneously expressed their gratitude run into thousands. The sales of American merchandise in foreign countries as a direct result of the trade opportunities that are pointed out to American manufacturers by the Bureau have from year to year run well into millions of dollars. There have been instances of single sales that have run up into seven figures. This tangible result is not counted by the Bureau as the main result of its work, however. The Bureau officials believe that they have accomplished more by keeping American manufacturers awake to the importance of foreign trade and of doing it on the best ethical and technical basis than by means of this trade opportunity service. The settling of commercial disputes between traders in the United States and traders abroad has been a line of service carried on by the Bureau which has produced remarkably good results. The good that was done by the American commercial attaché in Australia in the trying years between 1914 and 1917, before we entered the war, can never be calculated in dollars and cents. It was largely through the efforts of this representative of the Department of Commerce that American national good will in commerce was preserved there in spite of vigorous propaganda against the United States and its commercial methods. There is no calculating in dollars and cents the value to American foreign trade in general when individual American concerns are aided by the Bureau to change their export methods so as to conform to the best practice.

We are prone in this country to view our own Government as rendering less assistance to trade than the governments of foreign countries. I am inclined to believe that this is characteristic of business men everywhere. In England for years it has been the practice of business men to knock the Board of Trade, the organization in England which corresponds to our Department of Commerce. In Germany the average manufacturer has always professed to despise government assistance. Here we have pointed to Germany and England as examples of how governments help trade. In England they point to us and to Germany as examples of how government helps trade. In Germany they have pointed to England and to the United States as examples of how government helps trade. So it goes.

When I went to Germany to take part in an investigation of the German pottery industry I went somewhat with the idea that I was going to find government subsidies to trade, which, with starvation wages, had been proclaimed before our Ways and Means Committee as the reason for German success in foreign trade. I made a point of talking with German manufacturers on the subject of the help they received from the government. I never found a manufacturer who would concede that the government was helping him at all—instead he was usually growling at the burden of government taxation and interference. In this very industry that you gentlemen are engaged in in this country there is a disposition to point to Germany and to say that the German government is directly subsidizing the German manufacturing industries and that there is no hope of competing with German manufacturers under these conditions. The tradition that the government was backing all the German trading and manufacturing companies, and that to this was due the success of German industry in the world market, is a dangerous and regrettable thing. There are too many American manufacturers who without knowing the facts are inclined to cry, "Wolf, wolf," and demand government support or government protection on that false basis. In British countries in the course of the liquidation of German concerns there has been a direct effort to trace out the extent of government assistance. To date I have seen nothing as a result of the work of liquidators that has been at all convincing evidence that German success abroad was due to direct government help. In fact, one of the British official liquidators at Hong Kong who made a deliberate attempt to ferret out evidence of government participation in German trade in that colony admitted frankly that the books and papers of the liquidated concerns gave reason rather for the contrary conclusion. We do not know all the facts about the German methods of commercial penetration, and possibly we never shall. We do know that the German government has shown a very sympathetic attitude toward the big commercial interests, has encouraged them in many ways, has given material encouragement to German shipping, and has worked with pretty definite governmental commercial policies, all in the interest of increased national efficiency. Admit all this, however, and yet on the whole we have got to admit further that German commercial and manufacturing success has been chiefly attributable to energy and careful planning in private organization. It will be a bad thing for the American manufacturer to fool himself into abject dependence on government support in getting and holding his business. The American manufacturer in the long run, just like the manufacturer in any other country, must organize better, produce better, and sell better than his competitors. I am not going to enter into any discussion of the merits of government protection and government subsidies, each of which may have its place in carefully organized governmental commercial policy, but I do wish to mention the need of a cultivation of a spirit of self-reliance and confidence in manufacturing and selling ability among the American manufacturers. Our Government can help a manufacturer in a variety of ways. I have to-night pointed out some of the ways in which the Bureau of Foreign and Domestic Commerce can render assistance. I think that in the field covered by the work of the Bureau our Government has done as much and as effective work as any foreign government. Times and circumstances have been greatly changed as a result of the war. Other governments are reorganizing and preparing to spend large sums in promoting their interests in after-war trade. From all that we know of the past and present attitude of our own Government I should say that we have no reason to believe that our Government will not expand its own service, give it variety and new lines of activity, just as much as the national interests require. We must not look to the Government to do the business for us, but at the same time we cannot afford to ignore or underestimate the value of what the Government is prepared to do and is actually doing.

OUR PUBLICATIONS AND THEIR BEARING ON THE CHEMICAL INDUSTRY

By O. P. Hopkins

Chief, Editorial Division, Bureau of Foreign and Domestic Commerce

The recent wonderful development of the chemical industry in this country has awakened in our chemists a desire to be better informed on the relations of the American industry to that of the rest of the world. They have a vision of a permanent and self-contained industry here at home, but they now realize that this vision will never be made a reality by ignoring what is going on in other countries, by making themselves believe that the future is assured no matter what plans, what commercial campaigns, what trade tendencies may be attracting attention elsewhere. They realize, in short, that the time has come for the chemical industry, along with almost every other industry we have, to accustom itself to a much broader view of affairs, to adopt a world point of view.

This has led to the suggestion that the industry is now ready

to take a more serious interest than heretofore in foreign trade statistics and information in general bearing on the exportation and importation of chemicals, raw materials, and machinery and apparatus. The members of this Section will suspect at once that the suggestion comes from Dr. Herty and Dr. Hesse, and such suspicions are well founded. In response to their suggestion I am going to call attention to the wealth of material published by the Bureau of Foreign and Domestic Commerce and offer a few practical suggestions for making use of it.

I suppose the interested members may be divided into two classes: Those who intend to make a practical commercial use of our data, and those who simply wish to keep up with the times, to be well informed on all matters pertaining to their calling, whether or not it will ever mean dollars and cents to them. Both groups will be kept in mind as far as possible.

Our Bureau is the original source of all statistics relating to American foreign trade, and its figures are issued monthly, quarterly, annually, and bi-annually. If a chemist or chemical manufacturer wishes to keep his finger on the pulse of our foreign trade as it rises and falls from month to month, he will turn to the "Monthly Summary;" if he wishes to follow in considerable detail the ebb and flow of imports only, he will study the "Quarterly Statement of Imported Merchandise Entered for Consumption;" if he wishes to review the trade for a whole year as compared with previous years, he will examine the annual "Commerce and Navigation;" and if he wishes to go rather deeply into our trade with any particular country or countries, he will turn to "Trade of the United States with the World," which has been published every two years, but in the future will be published yearly.

MONTHLY STATISTICS

The "Monthly Summary" shows imports and exports by quantities and values for the latest month compared with the corresponding month of the previous year and also for the months of the current fiscal or calendar year ended with that month. For instance, the May number this year gave the trade for May as compared with May of last year, and also the total trade of the eleven months ended with May as contrasted with similar periods in 1917 and 1916. In June the total was shown for the twelve months of the fiscal year contrasted with the two fiscal years immediately preceding, although in much less detail than will be shown in the annual report when it is issued. In July, however, in addition to the statistics for the month, there is shown the total for the seven months of the calendar year, which plan will be followed until the calendar year is finished, when periods of the fiscal year will again be considered.

Countries of origin and destination are shown only for articles moving in great quantities, and this rule unfortunately affects a great many articles in which the chemical manufacturer is interested. Just recently, however, it was decided to show the destination of our rapidly growing dyestuff exports and this feature has attracted considerable attention. Countries are also shown for some of the oils, naval stores, rubber, and the most important metals and ores.

As already stated, these figures enable a manufacturer to keep his finger on the pulse of our foreign trade, but they are just the bald statistical facts. They are not analyzed in any way. Analysis is left to the reader, perhaps to a greater extent than is necessary. At any rate it will be a wise plan for the chemist who wishes to get the most out of the figures to devise some plan of his own for separating out the material in which he is most interested. An outline for a compact little continuous table can easily be made and filled in from month to month, for one article or for some logical group of articles. Percentages of increases or decreases can be shown conspicuously in a number of different ways. Personally, I think a graph is the most satisfactory way of tracing movements of this kind, and it is my understanding that chemists are pretty keen at devising things of that sort.

QUARTERLY STATISTICS OF IMPORTS

The quarterly statistical statement relates only to imported merchandise entered for consumption in the United States. It is designed primarily for Congress and such government officials as may be interested in tariff legislation, for it gives not only the rate of duty for each item imported, but the total amount of duty collected as well. It is not likely that many members of the AMERICAN CHEMICAL SOCIETY are interested in the tariff statistics, but there is one feature of the quarterly statistics that should not be overlooked. The classes are subdivided to a much greater extent than in the "Monthly Summary." For instance, under the heading "Chemicals" in the "Monthly Summary" only two acids are named, oxalic and carbolic, whereas in the Quarterly there are thirty-two. That is an important feature, and one that is very commonly overlooked. The Quarterly, however, does not indicate origin in any case, nor is any comparison made with quarters of previous years. The imports are simply set down in some detail for a quarter of the fiscal year, alongside the preceding quarters of the same year. If it happens to be the first quarter, then no comparison is attempted. If a person decides that he wants to keep his finger on the pulse of the import trade in a certain line of chemicals and finds that there is not adequate information available in the "Monthly Summary," he can turn to the Quarterly and if he wants to go to the trouble of keeping a graph he will soon be able to trace the important developments in his line over a considerable period. For the busy man it ought to be possible to assign the work of keeping the graph or compiling a continuous table to a secretary or clerk. It would take very little time in any event.

ANNUAL STATISTICS BY ARTICLES

The annual "Commerce and Navigation of the United States" is an imposing volume of nearly a thousand large pages of solid statistics. It is so formidable in appearance that many people hesitate to trust themselves to find in it the information they wish, and prefer to write in to the Bureau and have us look up the data. But it really isn't complicated at all. For the chemist, who is accustomed to prying into all sorts of mystifying secrets, this book ought to be a very simple matter. I am sure it has proved simple to any who have tried it.

The three annual tables of prime interest to the chemical industries are No. 3, "Imports of Merchandise," by articles and countries; No. 5, "Exports of Domestic Merchandise," by articles and countries; and No. 9, "Imported Merchandise Entered for Consumption," by articles.

Two features of the tables "Imports of Merchandise" and "Exports of Merchandise" make the volume invaluable to anyone who wishes to make a serious study of our foreign trade. In the first place, all of the countries of origin and countries of destination are given for each article—there are no baffling "other countries" to contend with. In the second place, a comparison is afforded with each of the four years immediately preceding the last. Another feature that deserves mention is the recapitulation under each article showing the imports or exports by continents.

The list of articles in these two annual tables is about the same as that in the "Monthly Summary," but not as detailed as in the Quarterly. Quantities are shown wherever possible, and values in all cases. The tables are used for the most part in making studies of the origin and destination of the goods that enter into our foreign trade. If the chemist wishes to find out where our quebracho imports originate, he turns to the index for the page he wishes and soon comes upon the quantity and value of the imports for each contributing country for the last five years.

The third annual table mentioned as being of interest to the chemist is No. 9, which is an annual compilation of the quarterly statistics already described. It has the same advantageous

feature of great detail and the same disadvantages of not furnishing a comparison with preceding periods and of not indicating the origin of the imports. If all the countries of origin were shown for all the articles given and comparisons made with preceding years, this table alone would be larger than the entire volume now devoted to the annual statistics. Possibly the day will come when such a table will be issued, but the demand from many industries will have to be much stronger than it is to-day.

There is also included in this volume a table showing our exports of foreign merchandise, that is, our re-exports of foreign goods. It may occasionally happen that items in that table will interest the chemist. There are twenty-one other tables that need not be described. A good index prevents any confusion that might otherwise result from gathering so many tables under one cover.

STUDIES OF COUNTRIES

The "Commerce and Navigation" is intended to facilitate commodity studies, and is not well suited for studies of countries. If a chemical manufacturer wished to study our trade in caustic soda he would find his information in "Commerce and Navigation;" but if he wished to survey our chemical trade with Argentina, say, he would be almost obliged to turn to our "Trade of the United States with the World," in which each country is taken up separately and its import and export trade with the United States shown in detail by articles.

This work has been published every two years in two volumes, one for imports and one for exports. There is no particular reason why it should not be published every year, and from now on it is going to be.

The statistics are for fiscal years and comparison is made with returns for the year immediately preceding the last.

COMMERCE REPORTS

For the chemist who wishes to have something more than just the statistics of our foreign trade in chemicals there is available the Bureau's daily "Commerce Reports," which relies for its material upon the American consuls, traveling special agents, commercial attachés, trade commissioners, and the experts in the Washington office.

The reports from these various sources cover practically all phases of foreign trade, but for the most part may be said to aim at promoting the sale of American goods in foreign markets. A fair proportion of them bear directly on markets for chemicals and allied materials and products, although there are not as many on heavy chemicals as there will be when the manufacturers of those lines go in for foreign trade on a large scale. When the demand for information increases, the supply will increase. Reports on the markets for such lines as medicinal preparations and pharmaceutical supplies are much more numerous, while on such allied products as paper there is no end of information.

The reports vary widely in character. There may be one on a pressing temporary shortage of caustic soda in Brazil, while another may review at some length the conditions that govern the use of caustic soda in that country, with an opinion as to future developments that will affect the market. Others may throw light on the subject of packing chemicals for certain markets or on tariff regulations.

Sources of raw materials also receive attention and not a few reports are devoted to the appearance of new products in the various countries and to new manufacturing processes.

Actual opportunities for selling goods or forming business connections are featured in a separate department, usually made up as the last page of the paper. Millions of dollars' worth of American goods have been sold through these trade opportunities, and a goodly share has been chemicals or allied products.

But of course this paper appears every day and if a busy man merely glances over it, and perhaps misses a number occasionally, he will not gain more than a very general impression of what is going on in the foreign trade. If he wishes to follow developments more carefully and get practical results, he must devise some way of getting together the material in which he is most interested and keeping it easily available. It is at that point that many manufacturers, chemists among them probably, decide not to see it through.

It happens that I do not know a chemical manufacturer with a working method for extracting the good metal from this mass of ore, but I do know of a system devised by one of our largest hosiery manufacturers. He, the president of the concern himself, spends two or three minutes each morning in marking material in Commerce Reports for filing. His stenographer then clips the marked passages and pastes them on colored paper. White paper is used for reports on hosiery, yellow for reports on miscellaneous wearing apparel, and green for any reports on general conditions that might possibly have a bearing on the demand for hosiery. These are filed by countries and take up very little room. When he wishes to brush up on the hosiery business in Argentina, there is his information right at hand in the most convenient form imaginable. There seems to be no reason why some scheme of this sort would not be just as convenient and valuable for the chemical manufacturer.

However, there is a quarterly index that simplifies matters greatly for those who do not care to establish a file, especially if a set of bound volumes is maintained.

Annual reviews of the trade and commerce of the various countries are printed separately as supplements to Commerce Reports, one for each country. These vary in size according to the commercial importance of the country, but the contents are rather uniform, as the business conditions of the year are reviewed and statistical and other information is given as to domestic production and foreign trade. Special attention is given to the progress American goods make in the market, and the prospects for the future. These reviews are really up-to-date little commercial handbooks and are extremely valuable in reviewing current commercial progress in any country. The chemical trade of course receives its share of attention in countries where it is comparatively important.

SPECIAL REPORTS

The Bureau issues a great many special reports, the majority of which are devoted to the markets for specified lines of goods in specified countries, or districts, although some are devoted to studies of basic economic conditions and some are on unusual but opportune subjects, of which Dr. Norton's reports on the dyestuff situation in this country and the census of dyestuff imports are examples.

The special reports on markets are written by consuls, commercial attachés, and traveling special agents, principally the last named. These traveling agents are specialists in certain lines, such as cotton goods, agricultural machinery, and shoes. Unfortunately, there has never been in the past a sufficient demand from the industry to warrant a special investigation of the foreign markets for American chemicals, but there is such a study on the program for Latin America for the present fiscal year and if sufficient interest is shown in that there will probably be others to follow. The pressure brought to bear on the Bureau for such investigations is the only index it has as to the attitude of the industry.

The catalog of the Bureau's publication will show what special publications of interest to the chemist have been published in the past, and announcements of new reports are printed in Commerce Reports.

SUMMARY

As already pointed out the foreign-trade information published by the Bureau of Foreign and Domestic Commerce can

be approached at two different angles by the chemist. He may not be after practical results, as figured in dollars and cents. He may simply wish to keep abreast of the new expansion of the industry in which he is engaged, to know what is going on. A great many people are going to take that sort of interest in foreign trade in the future, just as the average Frenchman or Englishman keeps himself fairly well posted on foreign investment markets, whether he has any money invested abroad or not. We ought to take at least a cultural interest in the great industrial and commercial developments of the country.

But many chemists are going to look at the matter in a very practical manner. To lay a sure foundation for future success they must familiarize themselves with conditions in foreign fields. They must come to look upon business with Argentina, or China, or South Africa, as they now look upon business in the Pittsburgh territory, or the Chicago territory, or the New England territory. It really is not much different when you become accustomed to the longer focus.

The practical minded chemist will also find it necessary to study the facts of our own import trade if he is to make sure progress in his efforts to manufacture here at home the chemicals we formerly purchased abroad. The forthcoming census of imported chemicals is being made to the order of the American chemists.

As the chemists get along in their studies of the Bureau's data they will soon be able to make suggestions for additional service, and I can assure them that the sooner they come the better the Bureau will like it.

THE METHOD OF PREPARATION OF THE CENSUS OF CHEMICAL IMPORTS

By E. R. Pickrell

Special Agent, Bureau of Foreign and Domestic Commerce

It was with pleasure that I accepted the invitation of Dr. Herty to state briefly for your information the method of preparation of the Census of Chemical Imports. As you gentlemen well know, the idea of this census was conceived by your fellow member, Dr. B. C. Hesse. Upon request of representatives of the American Chemical Society, the Department of Commerce undertook for the benefit of American chemical manufacturers this monumental statistical work. The Census of Dyestuffs which was published in 1916 by the Bureau of Foreign and Domestic Commerce was the initial undertaking of this kind by any branch of the United States Government. How well Dr. Norton accomplished this vital and timely task is shown by the fact that requests for copies of the dyestuff census have been received even from foreign countries. To-day the domestic dyestuff manufacturers have at their disposal information concerning the importation of dyestuffs into the United States which is of inestimable value for the development of a permanent domestic dyestuff industry.

The Census of Chemical Imports is a much greater and more difficult task than the dyestuff census, for it entails the procurement of information relating to a vast and varied number of articles. The statistical data presented by this census will be of value not only to chemical manufacturers but also to the drug manufacturers, synthetic medicinal manufacturers, perfumery manufacturers, paint and varnish industries, oil industries, and fertilizer industries.

During the fiscal year 1913–1914, chemicals, allied chemicals, drugs, and medicinals imported into this country totaled in value $176,000,000. This total was divided as follows:

Chemicals, drugs, dyes, and medicines	$95,000,000
Oils	46,000,000
Fertilizers	28,000,000
Tanning materials	2,000,000
Perfumes	2,000,000
Paints	2,000,000
Glue	2,000,000
Grease and oils	1,000,000
Soap	1,000,000
Oleostearin, dyewoods, beeswax, and blood (each)	500,000

Inasmuch as the object of the Census of Chemical Imports was to show the quantity, value, country of origin, and per cent of the quantity imported from each foreign country of every chemical, drug, allied chemical, and medicinal imported into this country for the fiscal year 1913–1914, the last normal year, and since there was no available statistical data in this country setting forth this information, it was necessary to examine every invoice filed at the different customhouses in this country during that one fiscal year.

In view of the fact that more than sixty per cent of all the articles imported into the United States come through the Port of New York and that probably seventy-five per cent of all the chemicals imported are entered here, it was deemed advisable that the clerical staff engaged on the census personally examine the New York entries.

The original request was made to the Secretary of the Treasury that all invoices, some 700,000, received in the United States for the fiscal year 1913–1914 be forwarded to the Port of New York for examination by the staff engaged on the census. That official was of the opinion this procedure would not be advisable because of the increased liability that some of these very valuable records might be lost or destroyed in transit. The alternative procedure was then adopted of sending circular letters of instruction, with an appended alphabetical list of 3500 chemicals, allied chemicals, drugs, and medicinals to the collectors of the headquarters ports of the forty-eight customs districts into which the United States and its territorial possessions are divided, requesting that invoices covering all these articles be forwarded to New York.

It is the aim of the census to amplify Schedule E of Imports, that is, Table 9 of the Commerce and Navigation Reports published by the Bureau of Foreign and Domestic Commerce, maintaining the same classification as closely as possible, but always keeping in mind that the purpose of the census is purely commercial. Consequently the commercial classification has had precedence over scientific terminology. It would have been a much easier task to have devised and employed a strict scientific classification and disregarded entirely Table 9, which follows more or less closely the Tariff Act of October 3, 1913.

This amplification is to show the quantity, value, and per cent imported from a foreign country of every chemical, allied chemical, drug and medicinal imported into this country during the fiscal year prior to the European war. In other words, the seventy-five classes covering these articles provided for in basket clauses in Table 9 are to be amplified into over three thousand articles. By means of this amplification each article will be specifically designated instead of being grouped together, as formerly, in general terms or basket clauses. For example, Table 9 now provides for 32 acids by name. The Census of Chemical Imports will show more than 60 acids by name. Every acid imported into this country in the fiscal year 1913–1914 will be provided for in the census. This same table lists 21 soda compounds. The census has already more than 52. There are an unlimited number of articles, many of which are of common chemical usage which will be provided for definitely in the census and which are at present hopelessly lost in the basket clauses. Table 9 does not show more than half a dozen synthetic medicinals; the census will show every synthetic medicinal imported during that year. Whereas in Table 9 medicinal compounds, preparations, and salts to a value in excess of $315,000 were grouped together in one general class, the census will completely subdivide this class so that probably more than 150 different medicinal preparations will be shown. Then again, crude drugs valued at over $1,000,000 were imported during the fiscal year 1913–1914. These drugs, which were divided into two general classes in Table 9, will be completely separated into over 250 different articles.

To gather this tremendous amount of detailed information a staff of 24 clerks has been employed, some since March 1918,

in translating and transcribing the necessary information from more than 35,000 invoices gathered from every customs district in the Union.

For every single article mentioned in each entry an individual card was made, stating thereon the country of origin, the quantity and value, and the English name as translated from the foreign language. More than 90,000 such cards were made out. These 90,000 cards were then assembled into groups containing the same articles, and the quantities and values, according to country of origin, were totaled. This information was then transcribed to larger cards and the foreign monetary and quantitative terms converted into American dollars and units of weight. The quantities from the various countries of exportation were ascertained and expressed in percentages employing the entire quantity imported as the equivalent of one hundred per cent. The following are examples of the information to be presented in the census and the manner of presentation:

	Value	Quantity Lbs.	Country of Origin	Per cent
Titanium Potassium Oxalate....	$839	4,859	Germany	53.9
			England	46.1
Carbon Tetrachloride.....	$32,616	657,409	Germany	97.9
			Italy	1.9
			Canada	0.2
Tartaric Acid.....	$218,856	906,614	Germany	39.1
			England	19.8
			Italy	17.1
			Austria	9.1
			Netherlands	7.8
			France	7.1

The mass of statistical data collected was so great it was deemed advisable to incorporate in the body of the census only those articles having a total value in excess of $100. At present there are over 3,000 articles having a value of over $100, as compared with 75 classes now provided for in Table 9. The number of articles is steadily increasing and will approximate about 4,000. Those articles having a total value less than $100 will be listed alphabetically as an appendix to the census. The grand total value of all these articles less than $100 will be shown in the census.

It is hoped that this Census of Chemical Imports will clearly present to domestic manufacturers of chemicals, allied chemicals, drugs, and medicinals what they may expect in the way of foreign competition when this world conflict is over; that this information will be in such detail and so definite that American production of these commodities will be stimulated; that every American manufacturer dependent upon these commodities will be able to obtain them as a result of American production; and that an American chemical industry brought into existence through extraordinary circumstances will remain and grow to be one of the bulwarks of American industrial progress and development.

Would it not be advisable to present to the American manufacturers in a series of half a dozen well-stated publications, covering the chief classes of materials provided for in the census, such as coarse chemicals, paints, perfumes, oils, fertilizers, and synthetic medicinals, the information contained in the census relating to these articles, the quantities and values of the same imported during the year 1917–1918, and the quantities and values produced and consumed in the United States during the same year, so that each manufacturer of a particular class of articles will be cognizant to a minute degree of all factors affecting his trade?

CURRENT INDUSTRIAL NEWS

By A. McMillan, 24 Westend Park St., Glasgow, Scotland

ANALYSIS OF WHITE METAL

As rapid analyses of white metal are frequently made, the following note on the subject, which appeared in the *Z. angew. Chem.*, for April 30, may be of interest. About 1 g. of the metal borings is dissolved in 10 cc. nitric acid, density 1.4, the solution being diluted with 50 or 100 cc. hot water, boiled for 5 min., and then filtered. The moist precipitate (consisting of oxides of tin and antimony) is washed into a conical flask, heated and diluted with water; about 2 g. of pure powdered iron are then dropped into the flask and the liquid is kept at 80° C. for about 1 hr., air being excluded. The tin will have dissolved as stannous chloride, which is estimated by ferric chloride, while the antimony is precipitated as metal on the excess of the iron which is extracted with hydrochloric acid. The original filtrate contains the lead, copper, iron, and zinc of the white metal. Sulfuric acid is added to the solution which is evaporated to dryness and redissolved in water. The lead remains insoluble as sulfate and the other metals pass into solution. The copper is precipitated by sulfureted hydrogen; the iron is oxidized by bromine water and precipitated as hydrate by caustic soda. The zinc is finally precipitated from the filtrate, previously made acid with hydrochloric acid, by soda.

LUBRICATING OIL

Oil of a quality suitable for aeroplane motors is being obtained in Russia largely from hempseed. The presses produce a yield of from 5 to 6 per cent of a dark gray colored oil. Refining and filtering processes give as a pure lubricating product, 30 per cent of a clear yellow oil. The crude residue is used for soap making. As the manufacture has been carried on mainly by Austrian prisoners of war, the processes will soon be made known in Austria and Germany where, consequently, large quantities of seed are already available.

VENEZUELAN TRADE INQUIRIES

The British Consul at Caracas reports that a firm of commission agents in that city desires to represent in Venezuela, firms dealing in drugs and medicines, hardware, etc., also that a firm at Barquisimets would be glad to get into touch with firms interested in importing castor-oil beans. These latter have recently, in not inconsiderable quantities, been shipped to the United States, and in view of the good market obtained, this plant, previously regarded as a weed, is now being assiduously cultivated in Venezuela. The oil furnished by these beans is said to be the only one which satisfies all the requirements for lubricating aeroplane engines.

POTASH SALTS IN CHILE

The existence of nitrate of potassium as a by-product of the nitrate of sodium industry has been engaging the attention of chemists and mining engineers in Chile for some time past. According to the *Canadian Weekly Bulletin*, one of the best known scientists in Chile claims to have discovered a process for its extraction by refrigeration and is proving the efficiency of the process by practical application. From his investigations he has ascertained that potash exists in all the nitrate regions, being most plentiful in the Tarapaca region, followed by Taltal, Antofagasta and Tocopilla in rotation of importance. Out of 165 oficinas, there are at least 100 whose caliches contain 1 to 2 per cent of potassium nitrate. He estimates that in the residues of the saltpeter industry, 600,000 tons of potash are thrown away yearly. Analyses made of saltpeter ready for shipment proved the existence in this of 0.7 to 3.6 per cent. If an average of 1 per cent be taken out of 3,000,000 tons of sodium nitrate exported, there are 30,000 tons of potassium nitrate given away. Of the 600,000 tons thrown away in the residues of the oficinas supposing that only 60 per cent is utilized, there remain for exportation 360,000 tons.

NEW CONCRETE MIXER

A machine recently brought out by Messrs. Winget, 25 Victoria St., London, says the *Times Trade Supplement*, is designed particularly for the efficient mixing of semi-wet concrete, though it is also adapted to the mixing of concrete of any consistency to the other extreme of wetness. It consists of six patent chain paddles rotating at 35 r. p. m. in a semi-circular trough. Paddles of this form, it is stated, increase the mixing by more than 100 per cent as compared with the solid spades previously used, and also present the advantage that no stone can wedge between them and the trough so that aggregate of any shape or description can be used. The cement and aggregate are fed into a hopper above the trough into which they are discharged by the depression of a lever, and water is added at any stage in any quantity by turning a tap in an overhead pipe, which insures even distribution. The mixed concrete is finally discharged by pulling a second hand lever, which rotates the trough on its trunnions. At present the machine is being made in one size only, with a capacity of 3 cu. ft. Through this 60 completely mixed charges can be passed in an hour, equivalent to 67 cu. yds. per working day of 10 hrs. The machine, which weighs $1^1/_4$ tons complete, is driven by a $2^1/_2$ h. p. paraffin engine. A larger size with a capacity of $^1/_2$ cu. yd. is now being tested and will, it is expected, be ready for commercial manufacture shortly; its weight complete is about 3 tons and it is driven by an 8 h. p. paraffin engine, which is arranged through a friction clutch also to rotate the trough on its trunnions for discharge.

COMBUSTION OF COAL

It has been shown by experiment, says the *Engineer*, that the sulfur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, but the oxidation of the sulfur in the coal may assist in breaking up the lumps of coal and thus may increase the amount of fine coal which is particularly liable to rapid oxidation. Even this opinion is not unanimously endorsed. In spite of experimental data showing that sulfur is not the determining element in spontaneous combustion, the opinion is widespread that, if possible, it is well for storage purposes to choose a coal with a low sulfur content.

BATIK DYEING PROCESS

A special display of textiles dyed by the Batik process was exhibited at the Leipsic Spring Fair this year and in a statement issued by the *Textil Zeitung* information was given that the use of the process was spreading rapidly among manufacturers and was likely to become a great and important branch of the textile industry after the war. "Batiking" is well known to United Kingdom manufacturers and United Kingdom firms were the first to offer to the Straits Settlements, where it was originally introduced from Java and is exceedingly popular, goods dyed either by the same or a modified batik process. The *Textil Zeitung* claims that the process has been amplified and perfected in Germany during the war. Certain tissues, which hitherto would not take certain colors, can now be dyed. Stuffs, blouses, stockings, hats, etc., can be redyed by it when they are old and can take a lighter color or be entirely changed. It has been possible to use apparently useless or faded goods. The following account of the batik process written by an authority in the Netherlands East Indies is of interest: To batik signifies to cover a cotton fabric with a thin ground of wax before plunging it into a bath of dye so as to preserve from the latter certain parts of the stuff thus forming a design. This operation, repeated several times in succession but with a dye of different color on each occasion, and with the stuff recoated so as to preserve different portions from the dye, finally produces a design which is often of real artistic value

LAMP TESTS

In the *Schweizerische Elektrotechnische Zeitschrift*, for January 5 last, is given a summary of the results obtained from tests of various lamps with the orthochromatic plates and silver eosin plates prepared by two German firms. The tables show wattage and candle power of various lamps and their actinic value, absolute and per watt and per Hefner candle power for both kinds of plates with and without yellow filters. The lamps tested in this way were the Hefner lamps, vacuum and gas filled, tungsten-wire lamps, arc lamps with solid carbons and yellow and white-flame carbons, enclosed arcs and quartz-enclosed mercury arcs.

NEW RADIOACTIVE ELEMENT

The *Chem. Trade Journal*, **62** (1918), 512, quoting from the *Münchener Newste Nachrichten*, says that after a number of unsuccessful attempts by several scientists to discover the mother substance of actinium, recent efforts have succeeded not only in isolating this substance but also a new radioactive element of great emissive power. L. Meitner states that the material taken as a starting point for the investigation was the residue, insoluble in saltpeter and acids of pitchblende, which forms the raw product of radium. This residue was subjected to treatment which finally left undissolved only the substance of the tantalum group, and this final residue showed a radiation, at first weak but afterwards increasing greatly though gradually, which mainly proceeds from the evolution of actinium, showing that the element contains actinium and must, indeed, be its mother substance. The new element has been named Protactinium. Its period of semi-integration, *i. e.*, length of time which elapses before half the atoms are separated from one another, probably fluctuates between 1,200 and 18,000 yrs. The production of protactinium requires large quantities of raw material; for about 1 kilo of the pitchblende residue insoluble in saltpeter and acids 73 milligrams of protactinium are obtained. The substance is obtained in the form of a white powder which contains the new element at first only in very small proportions and with a large admixture of earthy acids. Experiments for the separation of the element from the acids will be undertaken immediately.

RUBBER-SEED OIL

The report of the Federated Malay States Agricultural Department shows evidence of the growing tendency to apply scientific methods to the rubber industry. A description is given of the method of manufacture of rubber-seed oil and its residual product with a view to putting it on a commercial basis. It would seem, from the report, that this high-grade oil requires hardly any refining, is obtained from a waste product available in great quantity, easy to collect, transport and store and easy to crush. It would certainly pay in normal times to ship the seeds or kernels but, as the prospects of freight facilities for some years do not present a bright outlook, it would seem that shipping the oil is the better proposal. Oil keeps better than seeds and is more easily stored. Experiments with a consignment of 30 tons of seeds sent to England resulted in $250 per ton being obtained for the oil, while $40 per ton was realized for the residual cake. At the time linseed oil stood at $300 per ton. The difference of $50 per ton may be put down to the prejudice with which all new products have to contend. As far as can be foreseen, rubber-seed oil will occupy a place but little inferior to linseed oil as soon as the world's markets have acquired confidence in the new product. Finally, the production of rubber-seed oil would not interfere with the market for coconut oil or sesame, as these oils are used essentially as human foods in the form of margarine and cooking fats. These oils are never used as rubber-seed oil is likely to be) for paints, varnishes, red and white lead, packing compositions for joints, soft soap manufacture and the like

THE SCHOOP METAL-SPRAY PROCESS

According to a note by K. Matzinger in the *Anzeiger für Elecktroteknik und Maschinen-Bau*, April 28, 1918, by increasing the "atomizing pressure" in the pistol of the Schoop apparatus, metal deposits of very fine grain and high density and strength have recently been obtained. The pistol is a blow-pipe in which the metallic bead, fused by the flame, is torn away and atomized by the current of compressed air. The ordinary working pressure of the air is 3.5 atmospheres, but the pistol operates on the injector principle and the actual atomizing pressure was so far only 1.5 atmospheres. This pressure has recently been raised to 2.5 and 3 atmospheres without increasing the working pressure, with very promising results. A lead pipe, 1 mm. wall thickness, made by the improved process, was filled with hydrogen at 5 atmospheric pressure while lying in water; no hydrogen escaped while hydrogen bubbles forced their way through a lead pipe made by the old process. In another experiment plates of sheet iron were covered with lead, one or two coatings at pressures of 1.5 or 2.5 atmospheres. The one or two coatings of the old process did not prevent subsequent rustings of the iron, but both the one coating and the two coatings of lead deposited at the higher pressure kept the plates free from rust when they were placed in water.

CATALYTIC PROCESSES IN GERMANY

The Badische Anilin Company is developing some promising catalytic processes, says the *Gas World*. When a mixture of two volumes of carbon monoxide and one volume of hydrogen is passed over asbestos impregnated with cobalt or osmium oxide and some caustic soda, at temperatures from 300° to 420° C. and pressures from 100 to 120 atmospheres, the result is the production of water, carbonic acid, methane, higher hydrocarbons and oxygenated compounds such as aldehydes. The hydrocarbons are saturated and unsaturated with a boiling point above 250° C. If carbon dioxide is used instead of carbon monoxide, the yield of hydrocarbons is reduced. By adding nitrogenous or sulfur-containing components to the gas mixture employed, nitrogenous or sulfur-containing organic compounds are produced by the catalyzers. Catalyzers of higher heat conductivity, such as rods or wires of metals or carbides, especially those of the iron group, tend to prevent the reaction from hanging back.

CADMIUM IN BRASS

As much of the zinc now imported into France contains considerable proportions of cadmium, Léon Guillet (*Comptes rendus*, March 6, 1918) has investigated the influence of cadmium on the mechanical properties of brass. He prepared alloys containing 70 to 60 per cent copper, 28 to 40 per cent zinc, and up to 4.54 per cent cadmium. The high percentage of cadmium is accompanied by a relatively high percentage of lead to which Guillet does not draw attention. The other impurities were iron and tin, neither present in more quantity than 0.1 per cent. He found that cadmium had little influence on the properties of the brass, as long as cadmium did not exceed 1 per cent, and higher percentages are fortunately rare. The influence of cadmium was distinctly deleterious. It lowered the hardness and general strength and this was particularly noticeable in the impact tests which were made on notched bars. The elongation was hardly affected as long as the cadmium remained below 2 per cent. For low percentages the cadmium could be traced in fine lines surrounding the grains of alloy; when the percentage went higher the cadmium was seen to be isolated in round grains. It would appear that the cadmium enters into solid solution when present in small proportions. The detrimental effects of the presence of cadmium were more striking in an α than in an α-β brass.

ACID RESISTING FERROSILICONS

The publication by Camille Matignon in *Comptes Rendus* of May 21, 1918, of the results of corrosion tests of his comes somewhat late. He conducted tests in 1913 with the alloys then obtainable and the analyses and corrosion values are interesting. His alloys contained between 13 and 17 per cent silicon, nearly 1 per cent manganese and in addition to the usual phosphorus and sulfur only the constituents we mentioned. The métilluie of Adolphe Zouve contained 2.5 per cent aluminum; one of the two elianites (an Italian product) contained 2.2 per cent of nickel and seemed to be less corrodible, owing to this constituent; the other ferrosilicons were ironac and duriron. Matignon further tested a ferroboron containing 70 per cent iron, 15.4 per cent boron, 4.9 per cent silicon, and 3.3 per cent manganese; and Borcher's metal, a nickel chromium alloy containing 64.6 per cent nickel, 32.3 per cent chromium, 0.5 per cent silver, 1.8 per cent molybdenum. The corrosion tests were made in boiling nitric acid and in boiling acetic acid and butyric acids, concentrated and diluted. The ferroboron was easily attacked; the Borcher's metal differed from the other alloys by resisting diluted acids better than concentrated acids, but was not otherwise superior to them. The best métillure was a very homogeneous alloy. None of the alloys resisted hydrochloric acid, and there is no mention of sulfuric acid. Some of the tests were continued for a period of 360 hrs.

NEW NORWEGIAN INDUSTRIES

A recent exhibition in Christiania illustrating Norwegian industrial self-help shows that an extensive work has been undertaken to make Norway more independent of foreign supplies. A factory for the making of crucibles based on artificial graphite from the Arendal Smelting Company will soon commence operations at Langesund. Ferromanganese was formerly imported, but is now made at the Fiskaa Works, several concerns having taken up the manufacture of electrodes, of which 8,000 tons were formerly imported per annum. The requisite quantity of sulfate of aluminum, some 400 tons per year, is now being made within the country. Chloride of lime, soda lye, glue and various dyestuffs, red lead, etc., will be manufactured on a basis which will leave some for export, after the country's requirements have been met. Iodine, which formerly it did not pay to manufacture on account of the powerful Iodine Trust which the war has broken, will now be made on a scale large enough to supply all Scandinavia. A Holmestrand concern has worked out new methods for the preparation of bismuth and various preparations from it. Nitrocellulose and collodion cotton are now being made from ordinary cellulose, which seems to yield a suitable product. Formerly Norway imported her entire requirements of grinding materials, especially from America, Germany, and Austria, but now these are being entirely covered by home manufactures. The exhibition also comprised electric lamps, porcelain articles for electro-technical purposes, and material for the complete equipment of electric installations, electric cables, etc.

NEWFOUNDLAND COD-LIVER OIL

The Imperial Institute, London, is calling the attention of importers to Newfoundland cod-liver oil. Hitherto the bulk of the refined medicinal cod-liver oil used in the Empire has been of foreign origin, Newfoundland having devoted attention chiefly to the production of industrial cod-liver oil for currying leather. The oldest British colony has, however, now taken its cod-liver oil industry seriously in hand and is in a position to provide not only the industrial oil, for which it is famous, but also refined oil equal in quality to the finest medicinal oil produced in Norway. The Imperial Institute is prepared to supply analyses of Newfoundland oil, names of exporters and other information on the subject to importers interested in this branch of trade.

NATIONAL METAL AND CHEMICAL BANK

The directors of the National Metal and Chemical Bank have issued a circular, says the *Chemical Trade Journal*, detailing the objects of the bank. For the purpose of its business, it is to assist "in the coördination of British interests in the base metal, chemical and allied industries." It has already acquired extensive interests in undertakings producing iron ore, coal and the principal nonferrous metals and, through its associated concerns, is in a position to arrange for the smelting and refining of gold, silver, lead, bullion, lead ore, zinc ore, etc., and to supply all descriptions of manufactured lead, zinc and alloys. The bank is also largely interested in chemical undertakings, producing dyes of all kinds, sulfuric acid in large quantities, and in superphosphate works in course of construction.

DISCOLORATION OF WHITE PAINT

Zinc-white enamels frequently turn yellow and brown, especially in warm atmospheres both in the light and dark. In some cases this discoloration is merely a staining of the paint with atmospheric dust and dirt. In others it is not without reason attributed to the presence in the pigment or oil of traces of lead. Dr. D. F. Twiss discussed the question in the *Journal of Chemical Industry*, June 29, 1918, and found that lead cannot in all cases be responsible, since the discoloration sometimes proceeds in the absence of all sulfureted hydrogen and is not accelerated by its presence. The linseed oil and varnish themselves tend to turn brown when absorbed by dry filter paper and kept for a few hours at 60° C., and the brown color appeared quite as readily when this experiment was performed in sealed tubes, charged with pure carbon dioxide as under ordinary conditions; thus the presence of oxygen and the action of high temperature which would polymerize the oil, are not at all essential, contrary to expectation. On the other hand, it proved possible to bleach the brown tint again by the light rays from a quartz-mercury lamp. For this reaction the presence of oxygen is necessary as was expected, the real bleaching agent being the ozone. Dr. Twiss was able to repeat the discoloration and bleaching experiments several times with the same specimens. The effects might also be due to the presence of manganese or of alkalies, but the experiment in carbon dioxide is against the latter assumption and, even if radioactivity should be concerned in the phenomena, which is not unlikely, the color change would ultimately be the manifestation of a chemical change in the pigment or medium.

GAS IN GLASS INDUSTRY

At the annual meeting of the Society of Chemical Industry, Dr. Morris Travers gave an account of the establishment of one of the three large British glass works which have been brought into existence since the war began. Dr. Travers said that in the early experiments at one factory oil-fired furnaces were used, but eventually it was decided to put down a gas-fired furnace which was built and running in seven weeks and was capable of turning out 5 tons of glass per week. This was a non-recuperative furnace, but a later one was recuperative. The greater control and quicker working which gas gave opened up the prospect of knocking off the night shift which was now necessary in this industry. Discussing the requirement in regard to chemical glass, Dr. Travers commented on the fact that every chemist wanted an infinite range of beakers. That meant that blowing machines could harly be used in the industry because the large variety meant that only a comparatively few of each could be made. If it were possible, as he believed it was, to have beakers in three sizes only, between the liter and 50 cc., instead of eight, blowing machines could be introduced which would considerably reduce the cost of manufacture.

HEATING IN A LIQUID

There has been prepared by Messrs. J. Wright & Company, Birmingham, says the *Gas Journal*, a useful booklet on the "Use of liquids, consisting of fused salts or mixtures of salts for the heating, quenching and tempering of carbon steel and high speed steel." Attention is drawn to the advantages of heating in a liquid and there are brief descriptions of various kinds of melts that have been evolved for different purposes. There are numerous difficulties encountered in the use of a lead bath for heating, and these are pointed out. Barium chloride is used for heating high-speed steel and "Pyromelt" for carbon steel or carbonized work. The latter is so light that the trouble experienced in the case of lead of articles floating on the surface does not arise. Then there is "Feusalt" for quenching high-speed steel, for tempering and for heat treatment; "Tempermelt" for tempering and for heat treatment; and patent "Quenchoid" for tempering carbon steel and for heat treatment. The booklet also contains illustrations of Wright-Brayshaw furnaces for the various salts, and the final page is devoted to a comparison of the Centigrade and Fahrenheit scales. Copies of the booklet may be had on application to the firm.

SOURCES OF ORE

According to *Metall und Erz*, new sources of mineral wealth are to be found in European Turkey. Copper ore exists in great quantity in Turkish Rhodope in the neighborhood of Yardimli. In the Turkish Balkans, ores of nearly all the metals occur, while gold is found in Markova Reka, south of Uskub. In the neighborhood of Kratova, gold, and galena, containing a fairly high percentage of gold, have been found. Chromium ore in abundance has been discovered near Niausta on the Salonika-Monastin railway. The mountain range of Southern Macedonia is especially rich in chromium ore and there are also ores of iron, antimony and lead.

BOLIVIAN WOLFRAM INDUSTRY

According to the latest available figures, nearly 25 per cent of the output of wolfram in Bolivia is enemy-controlled. The total production in 1916 compiled from figures giving the output of the mines was: in non-enemy mines, 2,388 metric tons, of which 1,364 tons were sent to the United States and 1,360 to the United Kingdom; in mines belonging to the enemy, 658 tons were consigned to the United States.

GAS AND PETROL ENGINES

A series of vertical gas and petrol engines are described and illustrated in a catalog sent by the Keighley Gas and Oil Engine Company, of Keighley. They are made with one, two, or four cylinders, and while the one- and two-cylinder types are arranged for thermo-siphon cooling with radiator, water circulation is employed in the four-cylinder type, a centrifugal pump being driven from the cam shaft, as is the magneto, by a silent chain. In the two- and four-cylinder engines oil is forced under pressure to all the bearings by means of a geared pump driven from the cam shaft by skew gears, while in those with a single cylinder a pump of the plunger type is employed. A centrifugal governor, totally enclosed with all its connections inside the crank case, is coupled direct to the throttle value in the carbureter and varies the mixture to suit the load. A number of self-contained electric generating sets, with the engine, dynamo and all accessories mounted on a cast iron base plate, are illustrated in the catalog, which also describes similar self-contained air compressor and pumping sets, together with stationary, semi-portable and portable engines for farm and estate duty.

ANTIFRICTION METALS

A French report on new antifriction metals includes trials of alloys consisting chiefly of aluminum, cadmium, magnesium, and especially of zinc. Such alloys were designed to reduce as far as possible the use of copper, tin, lead, and antimony, and the most satisfactory results are stated to have been given by a compound of 63.3 per cent zinc, 21.3 per cent tin, 12 per cent lead, and 3.3 per cent copper.

HYDROSULFITES

At a meeting at King's College, London, Mr. F. Rogers said that the value of hydrosulfites in their application to industry seems to have been fully recognized by German chemists and that much labor had been expended in the problem of solidifying them. French and American chemists had also worked at the problems with the result that they were now obtainable in a stable form. Sodium hydrosulfite is extremely valuable as a reducing agent, one of its principal uses as such being in dyeing with indigo. It is also used for clarifying sugar, molasses, edible oils, soaps, etc. It is a valuable straw bleacher and is prepared in a convenient form for the removal of stains. Up to the present time, English chemists have never taken sufficient interest in the compound but now it can be obtained in large quantities, thus enabling industries to be carried on, which otherwise would have been crippled.

METALLIC LIQUIDS

A pamphlet received from Messrs. George Lillington & Co., of 40 Holburn Viaduct, E. C. 1., describes their "Metalo" liquid which in various forms is used for hardening concrete and cement, for waterproofing and hardening external and internal walls, roofs and old work, for waterproofing wood and preserving it from rot, decay and vermin, for hardening wood and plaster and rendering them waterproof and fire-resisting, and for preserving iron and steel work. Some tests are quoted showing the effect of the liquid, which is merely added to the water used in mixing, on the strength of concrete. Briquettes made of three parts of sand to one of cement, which gave under pulling tests 275 lb. per sq. in. after 14 days, and 345 lb. per sq. in. after 28 days, gave 316 lb. per sq. in. after 14 days and 388 lb. per sq. in. after 28 days when a 1 to 5 solution was employed. A 6-in. cube of concrete, containing three parts of aggregate to one of cement, together with 5 per cent of the liquid, had a crushing strength of 43.6 tons at the end of 28 days, whereas the crushing strength of a similar cube not treated with the liquid was only 33 tons after the same time.

STARTING RHEOSTATS

A list received from the British Thomson-Houston Company, of Rugby, describes two forms of starting rheostats for electric motors, in both of which the switch and resistance are enclosed in such a manner as to prevent access of dust and give complete protection to all live parts. In one form, intended for use with motors from 0.25 to 7.5 h. p., the contact brush is of the skate type, pressed on the contacts by means of a steel spring, and the starting period allowed is 30 seconds with normal full current. In the other form for motors of 3 to 40 h. p. the contact brush is made up of a carbon portion, which reduces sparking to a minimum, and of a brass portion which carries practically all the current; a starting period of 40 seconds is allowed. These rheostats comply with the Home Office Rules for the use of electricity in factories, and with the British Engineering Standard's Association's specification for normal duty rheostats. They can be used for starting and stopping motors as often as four times an hour, though this starting duty does not represent the limit since the resistance units are constructed to withstand excessive temperatures without damage.

AIR RAID SIGNALS

Engineering publishes some interesting particulars of the Challot rotating vanes and the series of horns forming the sirens now mounted on monuments in numerous French towns to give warning of the approach of hostile air craft. The siren consists of a casing or stator within which an aluminum rotor revolves on ball bearings. The stator and rotor each have a number of openings generally rectangular. Vanes for canalizing the air start from the center of the rotor and end at the rotor openings. When the rotor revolves centrifugal force drives the air through the openings and the flow is alternately permitted or interrupted according as the openings in rotor and stator coincide or not. The rotor is driven by an electric motor of 12 to 15 h. p. Conical horns of suitable shape and length are connected to each opening of the stator in order to amplify the sound. The Paris sirens have a total weight of 1,700 lbs. and in the city cannot be heard beyond a radius of 1.5 km. (under 1 mile), although in the open the range may be as high as 8 to 10 km. Hand-operated sirens have also been built for giving the alarm in small towns.

OXIDATION OF AMMONIA

At the British Scientific Products Exhibition held in London during August, a unit plant for the oxidation of ammonia to oxides of nitrogen was exhibited. Such a plant was not extensively used outside Germany before the war and there is reason to believe that the Germans have relied on it very largely for their output of nitric acid for explosives, as well as in the manufacture of sulfuric acid by the chamber process. The method is now in use in this country and several large firms such as Brunner, Mond and Company and the United Alkali Company are using apparatus similar to the plant shown at the Exhibition.

SYNTHETIC RUBBER

At a recent meeting of the German Bunsen Society held at Berlin, the question of synthetic rubber was discussed and its possibilities as a substitute for the natural product were considered. The world's requirements before the war amounted annually to some 145,000 tons. Since 1914, however, the demand apart from the needs of the Central Powers has increased to 220,000 tons. Of this quantity America takes the greater part. In the period 1910–12, according to the *Chem. Trade Journal*, 63 (1918), 162, attempts were made by Frantz Hoffman at Leverkusen to produce a substitute by synthetic processes. These were in large measure successful but the constant fall in prices of the natural product resulted in the partial abandonment of the experiments. The enormous demand brought about by war conditions and the shortage in Germany and Austria have given fresh impulse to this promising new branch of industry. In spite of the difficulty of obtaining materials 150,000 kilos of methyl rubber are produced monthly. It was not at first a wholly satisfactory substitute, for it became oxidized in air and was somewhat refractory in the process of vulcanization. These objectionable qualities have, however, been in large part removed by improvements in manufacture. By the addition of other substitutes a useful hard rubber, it is said, is now produced, equal in firmness and durability to the natural product, and 20 per cent better for electrical insulating purposes. The accumulator boxes used in submarines are made of this hard rubber. Soft rubber is more difficult to make. At ordinary temperatures the product is not elastic but leather-like. It becomes elastic as its temperature is raised. The addition of dimethyl aniline and toluidine increases the elasticity of the manufactured material. It is now used for tires for heavy road motors. A factory of large extent has been built at Leverkusen, capable of producing 2000 tons annually.

CORROSION OF BRASS TUBES

Two cases of condenser tubes of brass which had been badly corroded by electrolysis, says *Engineering*, were examined by the *Materialprüfungsamt*, near Berlin, in 1916. One of the brasses originally contained the following percentages of metals: copper, 70.5; zinc, 28.8; lead, 0.21; tin, 0.28; iron, 0.08. The corroded alloy contained copper, 97.4; zinc, 0.69; lead, 0.06; tin, 0.46; iron, 0.08. The other brass gave the following analysis: copper, 59.2; zinc, 40.37; no tin; iron, 0.32; lead, 0.24. The corroded alloy had the composition: copper, 96.76; zinc, 1.29; no tin; iron, 0.10; lead, 0.05. In both cases, hence, the corrosion had bleached out the zinc and had also diminished the small percentage of lead, while there was little or no change in the iron. That the ordinary water of the supply main may give rise to considerable differences of electric potential is shown by the water of Charlottenburg, a suburb of Berlin. In this water, couples of zinc and brass acquire a potential difference of 0.888 volt. In view of the actual wide uses of substitutes for metals and alloys, the Prussian government has drawn attention to this danger of electrolysis.

TOOL STEELS

Two varieties of tool steel are described in folders sent out by Messrs. Edgar Allen and Co., Sheffield. One of these, known as Red Label, is a tungsten crucible steel for twist drills, taps, milling cutters, and similar tools. It possesses the qualities of deep-hardening and density of structure, and, as compared with ordinary carbon tool steels, shows from 75 to 100 per cent more torsional resistance; and, though it is not a high-speed steel, it will take a much higher friction heat than ordinary carbon steel. After being heated carefully and thoroughly to darkish cherry-red, say 1400° to 1436° F., it is hardened in clear water at about 60° F. though small sections may be hardened at an even lower temperature. The second steel, K 90, is intended for tools in which extreme accuracy is required, and with it the expansion and contraction ordinarily set up in the hardening process are stated to be practically eliminated. It should be heated slowly and thoroughly to a cherry-red heat, say 1436° to 1472°, and quenched in oil. Both steels are sent out annealed and ready for machining.

COMPRESSION STRENGTH OF GLASS AND QUARTZ

Some new experiments on the crushing strength of glass and quartz conducted by G. Berndt, Berlin-Friedeman, were communicated last December to the *Deutsche physikalische Gesellschaft*. The experiments were made on the Amsle testing machine, maximum load 30 tons, first with cubes of the glasses and quartz and then with cylinders. It was observed that when cubes were used the strength decreased as the cube edge was increased, in steps from 5 mm. up to 15 mm.; the cylinders afterwards used had a diameter of 5 mm. and the same height. The faces were either all polished or only those faces were polished to which pressure was applied; this made little difference and the rate of applying the load had likewise little effect on the results. With stained glass, but well annealed, the strength was smaller by 10 per cent with quick loading than with slow loading. The final crushing to powder took place with almost explosive violence. A borosilicate glass showed an average strength of 15,200 kg. per sq. cm. when strained and a higher average of 16,900 kg. (maximum, 18,400 kg.) when well annealed. In the case of quartz the crushing strength was smaller by 25,000 kg. per sq. cm. when compressed parallel to the optical axis than when the pressure was at right angles to the axis (25,000 kg. to 27,000 kg.). These values for quartz are somewhat higher than those found by Winkelmann, but lower than those found for glass.

FATS AND OILS IN GERMANY

Before the war, says the *Zeitschrift für angewandte Chemie*, the annual production of vegetable oils in Germany was about 20,000 tons of animal fats, exclusive of cheese, about 1,000,000 tons, of mineral oil some 150,000 tons. To meet the demand there were imported 270,000 tons of animal fats, 570,000 tons of vegetable oil and 1,000,000 tons of mineral oil. The demand for animal fats may be satisfied by home production which in times of peace may be greatly increased. Among the imports of animal fats, American produce figures largely. Vegetable oil came for the most part from overseas, but largely in the form of fruit from which the oil was extracted in Germany, such as linseed, rapeseed, cottonseed, palm kernels, soy beans, sesame, etc. These have been imported from Africa, South and East Asia, and the Argentine. In recent years, oil instead of soy beans has been imported from East Asia. The chief source of mineral oil has formerly been the United States; in future it is likely to be Roumania.

DAMASCENE STEEL

In the Middle Ages, Indian steel, famous under the name of damascene steel, was a product of great importance. A note on the subject by Col. N. T. Belaieus appears in the *Journal of the Royal Society of Arts*. The Hindoos, particularly, seem to have excelled in the manufacture of iron and steel, and the famous wrought iron pillar at Delhi and other instances of their skill still exist. In some of the specimens high carbon crucible steels were undoubtedly used. Small cakes of the steel were examined by Réaumur and also by Faraday whose investigations led to useful results. The fine watering of these Damascus blades shows the great amount of mechanical treatment to which they were subjected, the Oriental maker never exceeding a temperature of about 700° C. From the point of view of after-war trade, the damascene process is of considerable interest.

CHINESE PENCIL FACTORY

An Anglo-Chinese enterprise has been started in Shanghai to manufacture lead pencils. This is the first undertaking of this character in China though there are several such factories in Japan. The raw materials used at present are American wood and graphite, while the machinery was made in Japan. Though the factory is at present on a very moderate scale, the possible output is estimated at 100 gross pencils per day and there seems to be no reason why these China-made pencils should not compete successfully with the foreign-made articles chiefly imported from enemy countries before the war It will, at any rate, be possible to turn out a very cheap article and the quality promises to be sufficiently good to satisfy the needs of the China market.

JAPANESE-CHILEAN NITRATE ENTERPRISE

It is reported by the *Japan Advertiser* that efforts are being made to undertake an enterprise for the working of niter deposits in Chile under Japanese and Chilean joint management. There has been a steady increase in the import of Chilean niter into Japan. In 1914 it amounted to no less than 24,000 tons, but the figure for last year increased to 53,000 tons. At present, the total consumption of niter in Japan amounts to about 60,000 tons. It is said that to obtain this quantity by working deposits in Chile requires a capital of no more than $1,000,000 and some Tokyo business men are making efforts to undertake the enterprise in coöperation with Chilean business men. The Chilean government sold 15 niter concessions by tender on August 1, 1918.

DRYING OVENS

Gas-heated drying ovens for enameling, lacquering, core drying, armature drying, and other operations carried out at temperatures up to 500° F. are described in a list published by the Davis Furnace Company, of Luton, England. The most usual types are the double-cased, with two casings, the intervening space being packed with 2 in. of non-conducting material and the products of combustion circulating through the heating chamber on their way to the flue outlets; and the treble-cased, in which the space between the two outer casings is packed with non-conducting material and the products of combustion circulate round the inner casing, so that the burnt gases do not come in contact with the work to be heated. Natural draft burners consuming gas at ordinary main pressure are employed for heating, though the burners can be modified to use producer gas when necessary in places where town gas is not available. A thermometer is provided in each oven for temperature regulation which can be accurately effected. To facilitate handling and reduce transport charges, the ovens, the double-cased type of which are made in various standard sizes ranging up to 9 ft. by 6 ft. by 6 ft. over all and the treble-cased up to 6 ft. by 5 ft. by 7 ft., are supplied in sections to be bolted together on arrival.

RIVETING RECORDER

There is danger in riveting steam boilers by hydraulic pressure that the pressure on the cup may be released before the shank of the rivet has had time to cool. In such an event the plates may spring apart to such an extent that the shrinkage of the rivet in cooling is not sufficient to ensure a tight seam. In a German technical paper a description was recently published of an automatic recorder designed to overcome this possible defect of hydraulic riveting. Pressure upon the warm head of the rivet is transmitted through piping to clockwork and sets a pointer in motion until the required pressure is reached. This pressure is kept constant until a predetermined number of seconds has passed when a red pointer indicates that the pressure may be released and the pointer returns to zero. This result is graphically recorded upon a traveling paper band from which the pressure and the period of compression can easily be read.

PLATINUM SUBSTITUTE

A platinum substitute tested, according to the *Chemical Trade Journal*, in Amsterdam, was an alloy of 89 per cent of gold with 11 per cent platinum. This material, called *platino*, withstood sulfuric, hydrochloric, and nitric acids, and other reagents used in chemical work and was unaffected by heating for 1/2 hr. in a smoky petroleum-gas flame. It proved equal or superior to platinum in ware for the chemist's laboratory except for the large loss by corrosion when used in contact with a mixture of sulfuric and nitric acids.

NEW SOUTH AFRICAN INDUSTRIES

During the year 1917, the following new industries, according to the Report of the Industries Advisory Board, are known to have been initiated in the Union of South Africa and, in many cases, to have commenced production: manufacture of calcium carbide, chloride of lime, alcohol motor fuel, shoe and floor polishes, sulfate of ammonia, asbestos, arsenic, starch from maize, paints and distempers from local materials, glue and size, wax, also tin and antimony, smelting, wattle bark extraction, and detinning of scrap tin. In addition, a cement factory capable of manufacturing 720,000 bags of 188 lb each has commenced work near Mafeking.

AEROPLANE CONSTRUCTION

A catalog issued by Messrs. Accles and Pollock, Birmingham, gives full-size illustrations, with equivalent diameters of the special sections of weldless steel tubing they make for aeroplane construction and other purposes. The sections are to be numbered in hundreds and are of all forms—square, rectangular, round-end oval, pointed oval, D, half-round stream line, etc. There are tables giving the areas of sections of circular tubes and the approximate weight in lbs. per ft. of all outside diameters from 1/16 in. up to any size in 16ths for Imperial standard gauges No. 6 to No. 26, and illustrations are added of wire strainers and other ferrules made from solid drawn weldless steel tubing and of various polished aircraft parts manufactured by the firm.

NEW STEAM MOTOR

A new form of steam motor which is expected to supersede the internal combustion motor has been invented according to the Danish press, by a well-known Danish engineer. The new motor is mobile and the steam is supplied by pumping water intermittently into a spiral where it is vaporized by a blowpipe flame. The water circulates and is used again as in a motor cooler and in much the same quantity. The motor has three cylinders but has the same effectiveness as a six cylinder internal combustion motor. It does not weigh more nor occupy more space than an ordinary benzene motor. It is capable of using the most inferior crude oils as fuel. It is simple in working, can be easily controlled, and is said to be specially suitable for use in fishing boats. Patent rights have been sold both in Norway and Sweden.

A NEW PLASTIC COMPOUND

The noninflammable and odorless plastic material described in a late French patent is made from gelatin, glue, or other animal product by the action of suitable chemicals. After melting the gelatin or glue on a water bath at about 200° F., a decoction of hop flowers is prepared and added in a mixture with dilute oxalic acid. Impurities are thus caused to settle at the bottom. The liquid gelatin is poured into sheets or strips, dried in cold air, and then colored with natural or artificial dyes. The sheets are then treated with a bath of 25 to 30 per cent or more each of formaldehyde, water, and alcohol, with a little oxalic acid, tannin, and glycerin, after which they are dried in hot air.

IRON AND STEEL TRADE OF ADEN

The iron and steel trade of Aden can not be considered as large nor as offering a growing opportunity for manufacturers, but, due to the cessation of practically all civilian building, owing to the difficulty in getting material, a field will be open to manufacturers who can make prompt after-war deliveries. The iron and steel used at Aden is principally for construction of lighters and buildings, for the repair and maintenance of small plants used for manufacture of ice and condensing of water, and for repairs to ships. The slight increase noted recently in imports of nails, rivets, washers, etc., is due largely to the fact that as no material is obtainable for construction of new lighters it is necessary to make extensive repairs to the present lighters. The decrease in imports of "bar and channel iron" and "beams, pillars, etc.," indicates how the normal demand for building materials have fallen off. Several builders have expressed a desire to import iron and steel for building purposes from the United States, but have been deterred by the high freight rates and the cost of material.

SCIENTIFIC SOCIETIES

RESOLUTION CONCERNING ORGANIC NOMENCLATURE

Editor of the Journal of Industrial and Engineering Chemistry:

The following resolution was passed unanimously by the Division of Organic Chemistry at the meeting of the AMERICAN CHEMICAL SOCIETY, held at Hotel Statler, Cleveland, Ohio, September 12, 1918:

WHEREAS, *The Journal of the American Chemical Society* and *Chemical Abstracts* have adopted and consistently employ the pure English terms "benzene," "toluene," and "xylene," including all of their derivatives, in place of the hybrid forms "benzol," "tolуol," "xylol," etc.; and

WHEREAS, these English terms alone are to be found in publications devoted to pure organic chemistry, both in this country and Great Britain; and

WHEREAS, industrial and technical journals have become lax in their use of these strictly correct English forms; and

WHEREAS, the one-time confusion between the words "benzene" and "benzine" now no longer exists, owing, primarily to the discontinuance of preparation of this latter named product, and, again, to a recent and well-made suggestion of the term "benzolene" for this same petroleum benzine fraction, if later to be placed on the market;

Therefore be it Resolved, that the members of the Division of Organic Chemistry of the AMERICAN CHEMICAL SOCIETY shall hereafter encourage the use of these English terms exclusively, where and whenever opportunity permits.

It is requested that a copy of this resolution shall be sent to the Editor of the *Journal of Industrial and Engineering Chemistry*, with the hope that the German terms aforementioned may be replaced by the English throughout the pages of the Industrial Journal, both in its editorial and advertising matter. By this means we shall maintain a consistency in organic nomenclature throughout all publications of our Society.

As stated herein, it is the wish of our Division that you and your associate editors immediately consider our resolution and transmit the same to other journals of the industrial chemical world.

WILLIAM J. HALE,
Secretary

The above resolution was unanimously endorsed by the Division of Industrial Chemists and Chemical Engineers at the Cleveland Meeting (see page 866, October issue), and has also been endorsed by the Advisory Committee of the AMERICAN CHEMICAL SOCIETY. In view of this unanimous expression of opinion we shall endeavor to carry out the recommendation contained in this resolution in the editorial columns of THIS JOURNAL.—[EDITOR.]

AMERICAN ELECTROCHEMICAL SOCIETY
34TH GENERAL MEETING, ATLANTIC CITY
SEPTEMBER 30 TO OCTOBER 2, 1918

The meeting at Atlantic City, September 30–October 2, 1918, was another demonstration of the feasibility and desirability of war-time scientific meetings. Eighty-two members and thirty-two guests constituted an interested body which listened attentively to the papers, started lively discussions, and gave an air of attention-to-business to all the proceedings.

Princeton had been selected for the meeting place, and a full and interesting program had been arranged to the last detail, but the commandeering of colleges and universities by the Government on October first made Princeton unavailable, and a quick change to Atlantic City was effected at the last moment.

Headquarters were at the Hotel Traymore, and many members attending the Chemical Exposition at New York the previous week found a welcome relaxation in spending Sunday at the shore. The sessions were held in the convenient Belvedere room, whose windows command a spacious view of the island and surf-edged beach.

Monday morning's program included papers on "An Apparatus for the Separation of Radium Emanation and its Determination Electroscopically" by J. E. Underwood and Prof. Schlundt, of the University of Missouri; "Notes on the Heterogeneous Equilibrium of Hydrogen and Oxygen Mixed with Radium Emanation" by S. C. Lind, of the Bureau of Mines, Denver; "Processes Within the Electrode which Accompany the Discharge of Hydrogen and Oxygen," by Prof. Donald P. Smith, of Princeton; "The Sign of Potential," by Prof. O. P. Watts, of the University of Wisconsin. The discussion of the latter paper was particularly lively, Prof. Watts pleading for the retention of the usual designation of the stronger metals as the more electropositive and the retention of the parallelism between chemical activity and electrical potential. His main argument was the uniformity thus introduced in the signs of the electrodes and the direction of the current in consonance therewith, in electrolytic and battery cells.

In the afternoon session F. C. Kelley read a paper on "The Hardness of Soft Iron and Copper Compared," in which he showed that annealing in hydrogen gave unexpected softness to pure iron. E. Kilburn Scott described at length "Nitrogen Fixation Furnaces," touching on the salient and characteristic features of various types of arc furnaces in a masterly manner. W. R. Mott, of the National Carbon Company's research laboratory, contributed a remarkable paper on "The Relative Volatilities of Refractory Materials," in which he tabulated ten different methods or lines of observation which give data on the volatilities of various refractory metals and oxides in the electric arc. The long paper contained a mass of new and interesting observations and data, from which perhaps only a fraction of the possible conclusions and inferences were drawn by the author; a number of such were brought out in the discussion.

In the late afternoon, at a meeting of the Board of Directors of the Society, the 1919 Spring Meeting was scheduled for New York City, the Fall Meeting for Chicago, coincident with the Fifth National Exposition of Chemical Industries, and a $2000 subscription to the Fourth Liberty Loan was voted.

The evening gathering in the beautiful Rose Room (which happened to be lined with an exhibit of the wonderful Farré airplane pictures) furnished relaxation in the form of moving pictures: "The Fixation of Atmospheric Nitrogen at Niagara Falls," by courtesy of the American Cyanamid Co.; "Canadian Shawinigan Falls Power Development and Electrochemical Industries," by courtesy of the Shawinigan Water and Power Co.; and "The Triplex (Bessemer–Open Hearth–Electric) Steel Process at South Chicago," by courtesy of the U. S. Steel Corporation. The pictures formed a very satisfactory substitute for the usual visits to industrial plants; such exhibitions are valuable adjuncts to a scientific meeting.

Tuesday was given, morning and afternoon, to discussing "Electrochemistry After the War." A. H. Hooker, of Niagara Falls, discussed the chlorine and alkali industry; Van R. Kokatnur, of Niagara Falls, the multitudinous uses of chlorine; W. I. Landis, of the American Cyanamid Co., air nitrates; F. A. J. FitzGerald, of Niagara Falls, the electric furnace; J. A. Mathews, of the Holcomb Steel Co., Syracuse, electric steel; Robert Turnbull, of St. Catherine's, Canada, electric furnace pig iron (the low-phosphorus pig made in steel-melting furnaces from steel scrap); C. A. Winder, of Niagara Falls, the power situation; J. W. Beckman, of San Francisco, the same topic, from the Pacific Coast standpoint; Grinnell Jones, of the U. S. Tariff Commission, tariff problems of the electrochemical industries; Lt. Col. W. D. Bancroft, U. S. A., scientific research; Dr. Mees, of Rochester, the question of coöperative industrial research. The general note in all these discussions was optimism, tempered by a realization of the magnitude of the tasks and the necessity of scrapping old ideas and facing bravely the new situations which have arisen.

In the evening Dr. E. F. Northrup, of Princeton, gave an informal account of how he came to devise his interesting and potentially important "Oscillatory Current Induction Furnace." His non-mathematical presentation, giving a direct and clear insight into the characteristics of the furnace, held the attention of the gathering for nearly two hours. The next morning the meeting of the Society adjourned direct to Trenton, N. J., where Dr. Northrup, at the works of the Pyroelectric Instrument Company, concluded his lecture by demonstrating the furnace in operation, melting a charge of nickel. A visit to the Thermoid Rubber Company plant, after lunch, concluded a meeting which was a pleasure and an inspiration to everyone fortunate enough to be in attendance.

J. W. RICHARDS

LEHIGH UNIVERSITY
SOUTH BETHLEHEM, PA.

THE MILWAUKEE MEETING OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

On October 7 to 12, 1918, Milwaukee was host to the American Foundrymen's Association, the American Institute of Mining Engineers—the Institute of Metals Division and the Iron and Steel Section, and the American Malleable Castings Association. In addition to the joint and separate meetings of these bodies, the huge auditorium hall was filled with an industrial exhibition of metals and metal-working accessories which was worth going a long way to see.

All the Societies joined in an opening session on Tuesday morning, at which President Backert, of the Foundrymen's Association, presided; Governor Philips, of Wisconsin, welcomed the visitors in a patriotic speech; a long and interesting letter from Captain R. A. Bull, a former president of the Association and now in France, was read, and a ringing resolution was passed, to be telegraphed to President Wilson, pledging anew to the Government every resource of the allied metal trades until "the abject and unconditional surrender of the enemy."

Following this, the gathering resolved itself into various sectional meetings, unfortunately scheduled simultaneously, thus rendering it impossible to hear all the papers in which one might be interested. Several in this predicament were heard drawing a parallel between this convention and a four-ring circus. The criticism was a valid one; the program should have had the sectional meetings arranged consecutively, using both mornings and afternoons, so as to prevent the keen disappointment felt by those forced to choose between one meeting and another.

The Foundrymen's Association had a schedule of papers on various subjects, from moulding sands to core ovens, electric furnaces, and pyrometers. Owing to the impossibility of being in three places at once, the writer can only report what was verbally reported to him, *viz.*, that the attendance on these technical sessions was poor and the discussion of the papers tame, excepting the discussion on casting semi-steel shrapnel shells. Evidently the foundrymen are stronger in action than they are at talking, a virtue which, we will readily admit, has its commendable features.

The Institute of Metals Division of the Mining Engineers (W. M. Corse, *Chairman*), on the other hand, held well attended sessions at which discussion was lively and the interest so great that they extended an hour or more beyond the normal closing hours. Almost all the papers on the program had been printed in advance in the Bulletin of the Institute, giving ample opportunity for preparation of careful and well-considered discussion. Professor Zay Jeffries described "The Metallography of Tungsten," attempting therein to show the causes of its brittleness; Sir Robert Hadfield, of Sheffield, England, communicated some discussion mainly bearing on the explanation of the effect of tungsten on the electrical properties of steel. S. L. Hoyt discussed in a new way the ever-present problem of "The Constitution of the Tin Bronzes;" his conclusions did not find unanimous approval. Jesse L. Jones, of the Westinghouse Company, considered "Babbitt and Babbitted Bearings," his main point being that the genuine "Babbitt" was improved by reducing its tin content by the addition of 1 per cent of lead. Two papers by S. Skowronski treated of "Oxygen and Sulfur in the Melting of Copper Cathodes" and "The Relation of Sulfur to the Over-Poling of Copper;" N. B. Pilling discussed "The Action of Reducing Gases on Copper."

Another session was devoted to a "Symposium on the Conservation of Tin." A dozen men prominent in the white metal industry read carefully prepared addresses, and a general discussion of a most interesting nature followed, the session lasting from 10 A. M., to 1.30 P. M., and being continued into the afternoon session at 3 P. M. The savings possible by reducing the tin in solders, using substitutes for tinfoil, packing dry foods in cartons instead of tin boxes, using copper-coated iron for boxes intended to be printed, saving the fumes from melting down old tin scrap to sash-weight-iron, making dry tin skimmings, etc., etc., almost *ad infinitum*, were thoroughly considered. It was a unique session of absorbing interest.

At the concluding session, Dr. John Johnston read an interesting résumé of the existing data on "The Volatility of Zinc from Brass," and discussed the figures in an able manner. Although the data are scanty, yet they allow some definite conclusions to be drawn as to the vapor tension of zinc from these alloys at various temperatures, and the consequent liability to loss of zinc in melting and pouring them. Dr. J. W. Richards discussed the question from the thermodynamic standpoint, pointing out that the vapor tension curve of pure zinc was well known, and that if the heats of combination of zinc with copper to form these various brasses were determined calorimetrically, the vapor tension of zinc from these alloys could be calculated with precision; further, if their latent heats of fusion were also determined, the vapor tension of zinc from the solid brasses could be calculated. The further discussion emphasized the advisability of *coöperative industrial research*, subsidized by the brass manufacturers, to determine such lacking data and make them available to the industries. G. C. Stone, of the New Jersey Zinc Co., described "The Effect of Impurities on the Hardness of Cast Zinc;" C. A. Hansen's paper on "Electrolytic Zinc" was, in the absence of the author, read by title; Prof. C. H. Fulton's paper on "The Condensation of Zinc from its Vapor," was a valuable contribution towards the explanation of a difficult problem; G. F. Comstock discussed the important question of "Non-Metallic Inclusions in Bronzes and Brasses;" Dr. G. K. Burgess and L. J. Gurevich, of the Bureau of Standards, "Fusible Plug Manufacture." Dr. Arthur W. Gray had a long and painstaking paper on "Dental Alloys," principally the amalgams and their properties. Hill and Luckey described how minute quantities of lead can be determined in copper by boiling off the lead from a weighed sample, in an electric arc, and noting with a stop-watch the time required until the spectroscope shows the absence of the lead lines—a most interesting and novel method of quantitative chemical analysis.

The Iron and Steel Section (Dr. J. W. Richards, *Chairman*) was scheduled for two sessions, one dealing principally with iron and steel and the other with coal and coke. The first session opened with an exhibit of moving pictures of the Triplex Steel Process (Bessemer–Open Hearth–Electric) at the South Chicago works of the Illinois Steel Company, Dr. Richards furnishing explanations of the process and the pictures. Dr. John Johnston, of the National Research Council, read a paper on the work of the Council, written by H. M. Howe. Papers on "The Limonite Deposits of Mayaguez Mesa, Porto Rico," and "Recent Geologic Development on the Mesabi Iron Range," were read by title. "The Manufacture of Ferro-Alloys in the Electric Furnace," by R. M. Keeney, was an up-to-date pre-

sentation of a very important topic, containing particularly new information concerning ferro-uranium. "The Manufacture of Silica Brick," by H. LeChatelier and B. Bogitch, was mostly a detailed discussion of the microscopic characteristics and the constituents of bricks burned at different temperatures—it should have brought out an active discussion, but it did not. Two interesting papers followed on partly distilled coal—carbo coal and semi coke, by C. T. Malcolmson and G. W. Traer, respectively. The discussion was lively and brought out very clearly the fact that such products are looked to, in the Middle West, to replace anthracite coal for household use—an object of great national importance. W. H. Blauvelt's paper on "The By-product Coke Oven and its Products," dealt with nearly the same topic. H. R. Collins, of the Fuller Engineering Company, discussed "The Use of Coal in Pulverized Form," which led to considerable discussion, in which Mr. Adams, of Milwaukee, described the installation of powdered coal firing in locomotive boilers in Southern Brazil, using coal with 4 to 5 per cent sulfur. Mr. Adams also invited all present to visit the Milwaukee Power Station, where a steam boiler was running regularly on powdered coal, at high thermal efficiency. Those accepting his invitation saw a very simple and effective installation, which will doubtless soon be copied in power plants all over the country.

The meeting as a whole was a great technical success and fulfilled admirably its function of instructing and stimulating to greater industrial and scientific achievement the metallurgists and engineers in attendance. J. W. RICHARDS

LEHIGH UNIVERSITY
SOUTH BETHLEHEM, PA.
October 15, 1918

REPORT OF THE COMMITTEE ON RESEARCH AND ANALYTICAL METHODS, FERTILIZER DIVISION, AMERICAN CHEMICAL SOCIETY

Cleveland, September 11, 1918

Two subjects have been under consideration by this Committee:

The first was the report of Mr. H. C. Moore, who was appointed to work out a suitable method for the determination of sulfur in pyrite to replace the faulty Lunge method. His work developed the value of a modification of the Allen and Bishop method and has been under way for several years. The coöperative work this year has given results which are even more satisfactory, if anything, than those of previous years and are being reported by Mr. Moore in a paper to be read before the Division at this meeting, with the recommendation that the method be adopted.

The other was the DeRoode method for determining potash, which was brought to the attention of the Committee from several quarters. A modification of this method was published by T. E. Keitt and H. E. Shiver in the *Journal of Industrial and Engineering Chemistry* for March 1918

The results obtained by this method are, in general, considerably higher than those obtained by the official method and the results of preliminary work do not indicate that this is due to impurites or other sources of error.

PAUL RUDNICK, *Chairman* C. H. JONES
F. K. CAMERON J. M. MCCANDLESS
A. J. PATTEN

NOTES AND CORRESPONDENCE

THE CENSUS OF CHEMISTS

Editor of the Journal of Industrial and Engineering Chemistry:

General Sibert directs me to extend to you the thanks of the Chemical Warfare Service of the United States Army for your assistance in the census of American chemists recently made by this arm of the service. Without the aid of your Journal it would have been impossible to have gained such wide publicity for the enterprise, or to have obtained such a prompt and altogether satisfactory response from the great body of loyal chemists of this country. Well over half of the questionnaires have been answered, and the rest are daily being received in such numbers as to indicate the completion of the task at a not far distant date. The War Department is thus put in possession of an invaluable set of records at extremely small expense.

While the purpose of the questionnaire has been understood by nearly all of those who have replied to it, there have been a few instances in which it has been mistakenly interpreted as a call to immediate service. In order to avoid any misunderstanding it should be explained that the purpose of the census is primarily to put the War Department in control of complete information as to the chemical man power of the country, not to gain immediate recruits for the Chemical Warfare Service. At the present time the vacancies in the Service are comparatively few in number. When vacancies occur in the future, reference will be had to the tabulated information gleaned from the present census, and appointments will be made from the names on file, attention being paid to the applicant's technical qualifications, desire to serve, etc.

The great majority of American chemists will undoubtedly never be called upon to serve in a military capacity in the present war. The Government, however, must have complete information concerning all chemists, in order that it may select those best fitted to perform its work, and at the same time interfere as little as possible with established essential industries. The chemist who, after returning his complete questionnaire, receives no call to service, may take it for granted that the Government cannot, for the time being, utilize his services. In the meantime three things are asked of him:

1—To keep the Chemical Warfare Service informed of any change in his address, his employment, his draft status, or anything else which might have a bearing on his case.

2—To notify the Chemical Warfare Service at once if he is drafted *and called to camp*. In such a case he should give his complete military address.

3—To help stabilize the industry of the country by continuing steadily at essential work until the Government notifies him that his services are needed elsewhere.

In addition it is requested that all persons send to the Chemical Warfare Service the names and addresses of any chemists of their acquaintance who have not already received the questionnaire. Chemists who have already received the questionnaire but who have not yet returned it should do so *at once*, in order that the Government may not be put to the trouble of sending out a large number of "follow up" letters. Any chemist who has not received the questionnaire should write for a copy, addressing his request to the Personnel Section, Administration Division, Chemical Warfare Service, U. S. A., 7th and B Streets, N. W., Washington, D. C.

F. E. BREITHUT
Major, Chemical Warfare Service, U. S. A.
Chief of Personnel

WASHINGTON, D. C.
September 30, 1918

DEFERRED CLASSIFICATION AND FURLOUGHS FOR GOVERNMENT AND STATE CHEMISTS

The Chemical Warfare Service has been duly authorized, by order of the Secretary of War, to make the necessary arrangements through the Adjutant General's Office, to secure the furlough, without pay or allowances, of such chemists as are necessary in such government bureaus as the Bureau of Standards, Bureau of Chemistry, Bureau of Mines, United States Patent Office, where such chemists are engaged in chemical work for the government or state bureaus concerned, essential to the prosecution of the war. At the same time they are advised that the new Selective Service Regulations, to be published shortly, will emphasize to the draft boards the fact that skilled employees of war industries should be placed in deferred classification. The induction into the military service of skilled men necessary to essential industries or occupations, to be subsequently furloughed back to their industries or occupations, involves an expense to the Government, and the men concerned lose time from their necessary work. The bureaus concerned are authorized by the Selective Service Regulations to submit to the draft boards affidavits and written proof to maintain their contention that their employees should be placed in deferred classification and it is believed that they should be encouraged in securing deferred classification rather than securing the furlough of the men after they have been inducted into the military service.

All communications in regard to information from those desiring any details should be addressed to Major Victor Lenher, Chemical Warfare Service, U. S. A., Chief, Governmental and State Relations Branch, Unit F, Corridor 3, Floor 3, 7th and B Sts., N. W., Washington, D. C.

CHEMICAL INDUSTRY IN THE NETHERLANDS

In a recent number of the Dutch publication, *In- en Uitvoer*, Mr. Jan Straub gives a brief history of the chemical industry in the Netherlands. The writer points out that the present backwardness of the industry is the natural result of the lack of minerals in the country and of the fact that in the Netherlands, agriculture and trade have for ages been the principal sources of wealth. In Germany, on the contrary, the great mineral wealth furnishes valuable opportunities for the employment of the growing population. The chemical industry in the Netherlands owed its origin to the needs of agriculture, but its progress was retarded by the ease with which chemicals could be imported from Germany and from oversea countries, as well as by the limited demand at home. The Dutch simply followed the practical maxim according to which it is better to buy cheaply than to produce dearly. In recent years, however, the demand for chemicals has increased greatly in Holland, particularly for export to the colonies, and the war has induced the Dutch to make extensive investigations in order to ascertain what chemicals and preparations could be made at home just as cheaply as elsewhere. The methods and processes of production have been studied during the war in various establishments, and the factories are ready to begin production as soon as peace returns and the raw materials become available.

The manufacture of essential oils is a comparatively new branch of the chemical industry which is always certain of a market for its products. It supplies soap factories, manufacturers of artificial fruit flavorings, and distillers with the means for the refining of their products. The manufacture of toilet soaps, fruit syrups, and fine liquors is on the increase, and the demand for essential oils and compound ethers is growing. The oils and the salts are prepared under scientific supervision, and the manufacturers are profiting by the experiences of their customers. They will be in a position to compete with foreign producers after the war.

The production of pure chemicals and drugs has developed rapidly under the stimulus of the war. The increasing demand for all sorts of inorganic and organic preparations both for industrial and medicinal use will provide a market for these products also in times of peace, both at home and in the Dutch East Indies. It may well be that many of these preparations, when peace returns, will be obtainable from abroad at a price below the domestic cost of production. In that case, even if domestic production shall be discontinued, some good will have been accomplished nevertheless; the Dutch purchasers will know the limits of the prices which may be demanded of them.

Only a few of the coal-tar dyes were formerly manufactured in Holland here and there, but the necessary intermediate products had to be imported. During the war, steps have been taken to build up the industry systematically from the simplest raw material to the finished product. The increased production of the Limburg mines, the new coke ovens, and the expansion of the tar-distilling industry promise to furnish a sufficient quantity of intermediates. For the present the intermediate products are given the chief attention, as they have their own markets, and the production of finished dyes, one after the other, will follow later. The first products will doubtless be taken by the Dutch textile factories, which will thus become independent of foreign or rather German producers. The Dutch factories are also getting ready to produce various perfumery articles, drugs, and tar distillates, but refrain from making known the results achieved until the time comes when they may begin deliveries.

PORTRAIT OF CHARLES M. HALL FOR THE CHEMISTS' CLUB

On the evening of October 11, 1918, previous to the regular meeting of the New York Section of the AMERICAN CHEMICAL SOCIETY, a portrait of the late Charles M. Hall, presented to the Chemists' Club by the Aluminum Company of America, was unveiled. Mr. Ellwood Hendrick, President of the Chemists' Club, in his introductory remarks, spoke briefly of the life of Mr. Hall and of his work on aluminum. He then called upon Mr. Duggan, Chairman of the House Committee, to unveil the portrait, after which the artist who painted the portrait, Mr. Rood, was asked to tell something of the process of making a likeness of a man whom he had never seen. This, Mr. Rood explained, he had done by means of various photographs of Mr. Hall and of talks with men who had known him.

In the absence of Mr. Arthur V. Davis, President of the Aluminum Company of America, who had expected to be present to give personal recollections of Mr. Hall, Mr. Hendrick called upon Dr. C. F. Chandler, who told the story of Mr. Hall's discovery, at the age of twenty-two, of the solubility of alumina in fused cryolite and all that this discovery has meant industrially.

The portrait of Mr. Hall now hangs in the Lounge Room of the Chemists' Club. He is the third Perkin Medalist whose portrait has been hung on the walls of the Club, and Dr. Chandler said that he hoped to live to see a portrait of each one of them hanging in the Club.

COÖPERATION REQUESTED BY THE ALIEN PROPERTY CUSTODIAN

Editor of the Journal of Industrial and Engineering Chemistry:

I will greatly appreciate it if you will call the attention of the readers of your publication to the provision of the "Trading with the Enemy Act," which provides that all money or other property held by, for, or for the account of, or the benefit of, an enemy or ally of enemy, should be immediately reported to this office. This includes patents, trade-marks, copyrights, prints, labels, and designs.

In connection with the last named, the following persons are required to make report to this office:

All persons who are in any manner interested in the use or operation of any enemy-owned patent, trade-mark, copyright, print, label, or design, including joint inventors, where one of the inventors is an enemy within the provisions of the "Trading with the Enemy Act."

Assignees of an undivided part or share of an invention, or right to carry on a process or operate under a trade-mark, copyright, print, label, or design, within and throughout a specified portion of the United States, when such patent or process is enemy-owned.

Mortgagees and licensees of enemy-owned patents, trade-marks, copyrights, prints, labels, or licenses.

The above includes guardians, executors, and administrators.

Any information regarding the enemy interests in any patents trade-marks, copyrights, prints, labels, or designs, should be forwarded immediately to Francis P. Garvan, Director of the Bureau of Investigation, Alien Property Custodian's Office, Washington, D. C., even if the information is only gossip or rumor. Oftentimes a clue to important enemy interests is obtained in this way. I feel sure than I can count upon your coöperation in the work of uncovering money and property of enemy character. The money thus obtained is invested in Liberty Bonds, and is made to fight for our country, instead of against it.

SIXTEENTH AND P STREETS, N. W.
WASHINGTON, D. C.
October 1, 1918

A. MITCHELL PALMER
Alien Property Custodian

AN ALINEMENT CHART FOR THE EVALUATION OF COAL—CORRECTION

In the article of the above title, THIS JOURNAL, 10 (1918), 627, the 4th line in "Directions for Use" under the cut should read "Price per dry ton" instead of "Cost per million B. t. u."

September 12, 1918 A. F. BLAKE

PERSONNEL, RESEARCH DIVISION, CHEMICAL WARFARE SERVICE—CORRECTION

It is regrettable that in the rush of assembling the names of the men engaged in work for the Research Division of the Chemical Warfare Service, for publication in the September issue of THIS JOURNAL, the name of Professor Treat B. Johnson, of Yale University, was omitted from the list.

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

No hedging against the end of the war is being done by the Government. Contracts are being let, plants are being built, and all plans are being made as if it were sure that the war will last two years more. While this is no more true of chemical activities of the Government than of any of its other war activities, it can be stated on the best of authority that the apparent collapse of the Teutonic fighting machine has in no way been reflected in the activities of the agencies conducting the chemical work being done by the Government. Incidentally, the ban on publicity, which has been clamped over this work since the beginning of the war, remains in place. Matter, which would be 90 per cent useful to the chemists of the United States and 10 per cent useful to Germany, is withheld with all rigorousness, along with much information which apparently would not be of value to the enemy.

The War Minerals Bill became a law at 2 P.M., Oct. 5. This Act, which affects importantly nearly every chemical industry, must await the issuance of regulations before its effects are felt generally. At this writing (Oct. 16) the President's proclamation, which will designate the agencies to administer the Act, is being expected daily. It is regarded as probable that power will be divided between the Bureau of Mines and the War Industries Board. Certainly price fixing and allocation of materials will go the the War Industries Board as it already is handling all such matters for the Government.

Prices for sulfuric and nitric acids have been agreed upon by the War Industries Board and the Committee on Acids of the Chemical Alliance, effective until the first of the year, as follows:

Sulfuric Acid, 60°	$16.00 per ton (2000 lbs.)
Sulfuric Acid, 66°	25.00 per ton (2000 lbs.)
Oleum, 20 per cent	28.00 per ton (2000 lbs.)
Nitric Acid, 42°	8½ cents per lb.

The same provisions for shipment in drums, carboys, in carload and less than carload lots as were made effective for the quarter ending September 30 are to continue for the last quarter of the year, but with these new prices fixed for bulk shipment used as a base for package prices.

Senter, Mich., has been selected for the site of a new Government tetryl plant. The value is to be $250,000, which is to be divided between the cost of buildings and equipment.

A $1,000,000 addition to the Frankford Arsenal has been authorized.

The Federal Trade Commission continues to insist on the discontinuance of what it terms unfair methods of competition when prices are offered which are "unwarranted by trade conditions and so high as to be prohibitive to small competitors." The American Agricultural Chemical Co., of Connecticut, and the Brown Co., Inc., of Trenton, N. J., manufacturers of fertilizers, are among the latest concerns to be accosted by the Commission. The Commission states that it found that the American Agricultural Chemical Company is the owner of all the capital stock of the Brown Company and that prices were being offered at Philadelphia and at Atlantic City for raw materials which were "calculated and designed to, and did, tend to destroy certain small competitors."

Licensing of the platinum industry is proceeding more rapidly than had been expected. The fact that the same plan has been applied to other materials, as well as the wide publicity given the regulations, is responsible for most of those concerned being conversant with the steps they are required to take. It is estimated that 150,000 licenses will be issued.

That gas masks being used by the American Army give twenty times the protection afforded by German gas masks is a fact attested to in a formal statement issued by the War Department. It is stated further that there is not a single case on record of an American soldier falling victim to a gas attack when protected by the mask that is now being manufactured in the United States on a vast quantity basis. This fact has been so thoroughly established by repeated experiences that military authorities place the blame for gas poisoning on the carelessness of the victim. A great many officers in the United States Army insist that in most cases the men who get gassed should be court-martialed, not decorated.

It is an interesting fact that American gas masks stand up under tests that German masks cannot meet. German masks will not give protection against a high concentration of gas. This was demonstrated recently when the British assembled a sufficiently large battery of projectors to put seventy tons of phosgene into the air at once, with consequences quite well known to the German General Staff. There is no concentration of gas that American masks will not defy. This has been proved, not only on the battlefield, but in the experimental stations in this country, where determined attempts to break down the resistance of United States Army masks by heavy gas concentrations were absolutely unsuccessful.

Importation of French optical glass is to be controlled by the War Industries Board. Orders for the French product must

pass through the hands of the War Industries Board and the War Trade Board. Regulations for the importation of French optical glass adopted following conferences between the Military Optical Glass and Instruments Section of the War Industries Board, of which George E. Chatillon is chief, and the Bureau of Imports of the War Trade Board, provide:

1—All import orders for French optical glass should be placed with the Service Geographique, who will distribute them among the various French manufacturers.

2—The order, together with the application for import licenses, should be forwarded to the War Trade Board, Bureau of Imports, to the attention of Mr. Reardon.

3—The applications should state in detail the purpose for which the glass is intended.

4—The War Trade Board will in all cases consult with the Military Optical Glass Section of the War Industries Board before applications are granted.

5—Orders placed direct will not have the approval of the Military Optical Glass Section nor the necessary endorsement of the War Trade Board to allow the glass to be imported from France.

6—If glass of a special manufacturer is desired, it may be noted on the order.

Drugs and medicines used by the Army Medical Corps are being tested by the Bureau of Chemistry of the United States Department of Agriculture at headquarters here and at its offices in other cities. Several chemists have gone from the Bureau to accept commissions in the Army and perform the work directly for the War Department. Chemists and inspectors are being instructed for Army and Navy work and special investigations are being conducted on problems concerning foods, leather, fabrics, paper, and other products in military and naval demand.

In a new ruling of the War Trade Board (W. T. B. R. 254), the importation into the United States of varnish gums (Kauri, Copal, Damar, Zanzibar, Manila, Congo, Fentiansk, Bengurlla, Sandarao, and East India or Borneo gum) is restricted as to shipments made after October 10, 1918. All outstanding licenses have been revoked as to ocean shipment after that date and no new licenses will be issued except to cover the following: (1) Shipments made from abroad on or before October 10, 1918, (2) shipments for the use of the United States Government, (3) shipments from Mexico or Canada by other than ocean transportation, (4) shipments from Europe or Mediterranean Africa when coming as return cargo from convenient ports where loading can be done without delay, (5) shipments of Copal or Manila gum when shipped from the Philippine Islands, and (6) shipments of Kauri gum not to exceed a total of 3,000,000 lbs. during the calendar year 1918.

Licenses for the amounts of varnish gums permitted to come forward, pursuant to the foregoing, will be allocated by the Bureau of Imports of the War Trade Board in accordance with the recommendations, as to distribution and price, of the War Industries Board. Varnish gums are accordingly added to the list of commodities excluded from the terms of license PBF 27.

A voluntary increase in the price of castor beans has been announced by the War Department. This action will save serious loss to the majority of those who embarked in the new enterprise of growing castor beans, it is believed, and will make for a continuance of the industry in the South. The War Department's statement in this connection is as follows:

In order to procure an adequate supply of castor oil for use in connection with the War Department aviation program, numerous contracts were let last spring for the raising of castor beans in the Southern States, at a price of $3.50 per bushel. With the harvesting of the crop it has been found that this price does not provide sufficient remuneration to the grower.

After careful consideration of the matter by a board of the Bureau of Aircraft Production, Mr. W. C. Potter, the Acting Director of Aircraft Production, has established a price of $4.50 per bushel of 46 lbs. As specified in the original contracts, beans are to be delivered hulled and sacked, in carload lots, f. o. b. the nearest railroad station to the land on which they are grown.

Most of the planting of castor beans was done under sub-contracts with the general contractors. The price of $4.50 now established is to be paid to the actual growers of the beans. The remuneration of the general contractors for their services in connection with the crop is in addition to this sum.

Hope had been expressed that the shipping situation would be sufficiently relieved this winter to allow increased importations of nitrate of soda. While the shipping situation has improved, in so far as additional tonnage is concerned, beyond expectations of a year ago, the demands on that tonnage also have increased beyond all estimates. For this reason, it is improbable that any large amount of nitrate of soda for other than Government use will be brought in this winter.

The list of restricted imports No. 1, item 64, issued by the War Trade Board, provided that prior to October 1, 1918, licenses might be issued for the importation of 125,000 long tons of pyrite. Since licenses have not been issued for the full amount so permitted, the War Trade Board has authorized the issuance of licenses during the remainder of the present calendar year, when the applications are otherwise in order, for the importation from Spain of the unimported balance of the amount originally authorized, which is approximately 56,400 tons.

To provide for more prompt chemical analysis of food products for use by the Army and Navy, a new arrangement has been made by the Bureau of Chemistry, which is described in the following announcement:

Arrangements have been made by the Subsistence Division of the Quartermaster Corps whereby the laboratories of the Bureau of Chemistry, Department of Agriculture, throughout the United States are to be more fully utilized by the Army. Through this arrangement the inspection of food products which requires chemical analysis will be made to a greater extent under the direction of the general supply depots at the source of manufacture. Delays occasioned under the former procedure of having inspection made at the delivery point will thus be avoided. At times cars of greatly needed food products have been held up pending report of analyses. Under the new system such products will have been completely inspected at point of purchase.

The new system will be particularly effective in handling canned milk, putting milk upon the same basis of inspection as canned meat products in large packing houses. Further arrangements have been made whereby, if it develops that any stations of the Department of Agriculture are too remotely situated to afford the proper service, stations will be promptly established by the Bureau of Chemistry to give the required service. This arrangement is another of the steps which the Quartermaster Corps is taking to coördinate all government departments in securing the best supplies and service for the troops.

In the recent reorganization of the Ordnance Department, Lt. Col. W. C. Sprunance has been placed in charge of chemicals.

PERSONAL NOTES

Dr. Ernest G. Genoud died at his home in Dorchester, Mass., on October 12, of pneumonia following Spanish influenza. Dr. Genoud was born in Boston, February 23, 1886. After graduation from the Massachusetts Institute of Technology in 1908, he studied abroad, receiving the degree of doctor of engineering at Charlottenburg in 1911. He had become a recognized specialist on fermentation processes and was a member of the staff of A. D. Little, Inc.

The College of the City of New York announces the following additions to the department of chemistry: Henry T. Coles, formerly of Rose Polytechnic Institute, assistant professor of industrial chemistry; Herman C. Cooper, formerly of the University of Syracuse, assistant professor of physical chemistry; Carl R. McCrosky, formerly of Oregon Agricultural College, and T. R. Le Compte, formerly of the Department of Agriculture, as instructors in chemistry.

Mr. Carleton B. Edwards, formerly head of the chemistry department at Guilford College, is now doing chemical engineering work in smokeless powder with E. I. du Pont de Nemours and Co., at the Hopewell Plant, City Point, Va.

Mr. Benton Dales, formerly head of the chemistry department of the University of Nebraska, is now research chemist for the B. F. Goodrich Co., Akron, Ohio.

Miss Jessie E. Minor has resigned her position as associate professor of chemistry at Goucher College to accept a position as chief chemist for the Hammerschlag Paper Mills, Garfield, N. J.

Mr. Seward G. Byam, formerly chemist for the Revere Plant of the United States Rubber Co., Providence, R. I., is now employed as aeronautical chemist at the General Laboratories, Bureau of Aircraft Production, Pittsburgh, Pa.

Mr. Ralph Brown, formerly employed in the laboratory of the Eagle-Picher Lead Co., Joplin, Mo., is now running a small lead smelter for the estate of James Robertson, Galletta, Ont., Canada.

Mr. R. R. Henderson, formerly chief chemist of the Vreeland Chemical Co., has resigned his position with that firm in order to devote his whole time to consulting practice. Mr. Henderson specializes in the development of chemical processes and the application of automatic machinery to chemical productions. His headquarters are at Little Falls, N. J.

Mr. Richard L. Wing, formerly chief chemist for the Holmes Mfg. Co., New Bedford, Mass., is now Engineer, Area "E," U. S. Government Explosives Plant "C," Nitro, West Virginia.

Mr. Paul J. Carlisle, who for the past two years has been engaged in research for the Roessler and Hasslacher Chemical Co., Perth Amboy, N. J., has been transferred to St. Albans, W. Va., and placed in charge of a new department which the company is adding to its plant in that city.

Mr. Arthur P. Harrison, formerly chemist and bacteriologist with the National Soil Improvement Co., Charlottesville, Va., is now supervising the synthetic preparation of certain dye intermediates for the du Pont Dye Works, Wilmington, Del.

Mr. Philip G. Wrightsman, formerly instructor in chemistry at Iowa State College, is now in the Chemical Warfare Service working on toxic gases in the Research Division, American University, Washington, D. C.

Mr. H. M. Freeburn has resigned as assistant engineer of the Pennsylvania State Department of Health to become associated with the engineering staff of Wallace and Tiernan Co., Inc., New York City, manufacturers of chlorine control apparatus and sanitary engineering specialties.

Dr. Arthur M. Pardee has resigned his position as professor of chemistry at Tarkio College, Tarkio, Mo., and has been appointed professor of chemistry at Washington and Jefferson College, Washington, Pa.

Mr. H. L. Walter, formerly of the U. S. Bureau of Chemistry, has been appointed chief chemist of the State Food and Drug Department of Tennessee.

Mr. Harry L. Barnitz, consulting engineer on oxygen and hydrogen, has severed his connection with the International Oxygen Co. and is conducting business under his own name at 617 West 152 St., New York City.

Mr. A. G. Frericks, formerly chief chemist for the Palmer Tire and Rubber Co., St. Joseph, Mich., is now doing chemical inspection work in the Explosives Section of the Ordnance Department.

The Association of British Chemical Manufacturers has elected officers as follows: *President*, The Right Honorable Lord Moulton, K. C. B., G. B. E., etc.; *Chairman*, Mr. Robert Grosvenor Perry, C. B. E.; *Vice Chairman*, The Right Honorable J. W. Wilson, M. P.

Mr. L. S. Munson, who for the past eleven years has been with the Ault and Wiborg Co., Cincinnati, O., has recently accepted the position of assistant superintendent of the Deepwater Point, N. J., plant of the du Pont Dye Works.

L. D. Sale, Los Angeles, Cal., has been named chairman of the chemical, oils, and paints section of the Los Angeles district of Sub-Region No. 14, Region No. 19, of the resources and conversion division of the War Industries Board.

Dr. Walter Taggart has been appointed consulting chemist at-large for the Ordnance Department.

Mr. Alex H. McDowell, formerly with Wiley and Co., is now chemist at the Ashepoo Fertilizer Works, Charleston, S. C., of the American Agricultural Chemical Co.

Mr. Lawrence C. Stahlbrodt has been appointed by the Pfaudler Co., Rochester, N. Y., to take charge of its publicity department.

Mr. F. W. Bruckmiller, formerly assistant professor of chemistry at the University of Kansas, is now chemist for the Standard Oil Co. (Indiana), at Sugar Creek, Mo.

Mr. C. C. Vogt is on leave of absence from the industrial fellowship on dental supplies of the Lee S. Smith and Son Mfg. Co. in order to engage in gas investigations at the American University Experiment Station.

Professor H. F. Moore, of the Engineering Experiment Station of the University of Illinois, has been appointed by the National Research Council chairman of the committee to investigate the fatigue phenomena of metals.

Mr. S. M. Evans, vice president of the Eagle-Picher Lead Co., with headquarters in N. Y., has been relieved of duty with his company for the duration of the war and is now with the U. S. Fleet Corporation, with headquarters at Philadelphia, as chief statistician.

Dr. C. A. Brautlecht, professor of chemistry in the Florida College for Women, has been called into the Sanitary Corps as First Lieutenant. He is stationed at the Rockefeller Institute for Medical Research in New York City.

Mr. James K. Lawton, formerly chemist with the J. H. Pratt Laboratory, Tampa, Fla., has been commissioned Second Lieutenant in the infantry, United States Army, and assigned for duty with the Chemical Warfare Service, Edgewood Arsenal, Edgewood, Md.

Dr. Frank T. F. Stephenson, past president of the Detroit Section of the AMERICAN CHEMICAL SOCIETY, has been commissioned Captain in the Medical Corps.

Mr. Max L. Towar, formerly of Parke, Davis & Co., Detroit, Mich., is now with the National Aniline Company, of Buffalo.

Mr. Chas. H. Jumper, formerly secretary of the Detroit Section of the AMERICAN CHEMICAL SOCIETY, and chief chemist with the General Motors Co., Detroit, is now connected with the Calco Chemical Co., Bound Brook, N. J.

Mr. S. B. Chadsey, chairman of the Toronto Section of the Society of Chemical Industry and formerly assistant to the general manager of the Massey-Harris Company, has been appointed manager of the Massey-Harris Company's plant at Brantford, Ont.

Mr. G. Hallberg, formerly with the Riordon Pulp and Paper Company, Limited, Hawkesbury, has been appointed chemist at the Mattagami Pulp and Paper Company's sulfite mills at Smooth Rock Falls, Ont.

Mr. Harold B. Gammell, formerly stationed at Indian Head, Md., has been assigned to duty under the inspector of powders, East Coast, as sub-inspector at the plant of the Standard Textile Co., Glens Falls, N. Y. This work is under the Navy in which he enlisted in April 1917.

Mr. Wm. Garratt, formerly chief chemist for the Latrobe Electric Steel Co., Latrobe, Pa., now has a similar position with the Fulton Steel Corporation, Fulton, N. Y.

Mr. James S. Curry for some time supervising chemist for the du Pont Company at Wilmington, Del., died of pneumonia on October 12, 1918.

Mr. W. W. Jones, formerly manager of the New York office of Frederick Stearn and Co., has accepted the appointment of manager of the Essential Oil and Gum Department of the National Aniline and Chemical Co., Inc., 21 Burling Slip, New York.

Mr. Charles Crew has resigned his position with the Central Testing Laboratory and has taken charge of the consulting work on chemical engineering for The Stillwell Laboratories, Inc., New York.

Miss Elvira Weeks, formerly with the New Jersey Zinc Co., Franklin, N. J., is now in the Research Department of the Carborundum Co., Niagara Falls, N. Y.

Mr. Harold W. Baldwin, formerly with the National Aniline and Chemical Co., Inc., Boston, Mass., is now in the Army and doing research work at the American University Experiment Station.

Dr. J. Bishop Tingle, professor of chemistry at McMaster University, Toronto, died on August 6, in Ottawa, Ont. He had been a prominent figure in the scientific world for many years. For three years he was at Johns Hopkins University where he did organic research work and edited sections of the *American Chemical Journal*. Since the outbreak of the war, recognizing the part that chemistry was to play, he had laid special emphasis on training students for laboratory positions in war industries.

In addition to the silver service which was given to Dr. M. C. Whitaker on his retirement from the presidency of the Chemists' Club, an exquisite illuminated memorial, designed by Mr. Edward B. Edwards, has also been presented to him. The center is a Latin text written by Professor McCrea of Columbia University and the border decoration consists of portraits of Gerber, Bacon, Lully, and Paracelsus in the four corners and alchemistic symbols interestingly worked into a decorative design.

Mr. Arthur Given, formerly chief chemist for Morris Herrmann and Company and recently chemical engineer with Stevens-Aylsworth Company, has been appointed First Lieutenant in the Ordnance Department and is stationed at Picatinny Arsenal.

Mr. Edward W. Weiler has given up his position as research chemist for the United States Industrial Alcohol Co., Baltimore, Md., to enter the Chemical Warfare Service.

Mr. B. A Dunbar has recently been made head of the chemistry deparment at the South Dakota State College.

Mr. M. Cannon Sneed, formerly assistant professor of chemistry at the University of Cincinnati, is now head of the division of general and inorganic chemistry at the University of Minnesota.

Professor J. B. Rather, formerly head of the department of agricultural chemistry in the University of Arkansas, has accepted a position as chemist with the Standard Oil Company, New York.

Dr. M. L. Crossley, associate professor and acting head of the department of chemistry at Wesleyan University, Middletown, Conn., has resigned to accept the position of chief chemist for the Calco Chemical Co., Bound Brook, N. J.

In addition to those noted in the February issue of THIS JOURNAL, the following members of the staff of the department of chemistry of the College of the City of New York have gone into war work: Martin Meyer, 2nd Lieutenant, U. S. A.; Benjamin Rayved, Ensign, Paymaster Division; Leon J. Smolen, Nathan Rauch, Moses Chertcoff, Martin Kilpatrick, Hyman Storch, Joseph L. Guinane, Samuel Yachnowitz, Privates, Chemical Warfare Service; Julius Leonard, Alexander Lehrman, Yeomen, U. S. N.

Mr. E. J. Quinn, formerly research chemist at the Montana Agricultural Experiment Station, has accepted an appointment as assistant professor in the department of chemistry at the State College of Agriculture and Mechanic Arts, University of Montana, Bozeman.

Ricketts & Co., Inc., formerly of 80 Maiden Lane, have moved their offices to 280 Madison Avenue. Mr. Charles E. Wagstaffe Bateson, Dr. M. L. Hamlin, and Mr. T. A. Shegog, formerly assistant professor of chemistry and metallurgy at the Royal College of Science, Dublin, and professor of chemistry and metallurgy for the County of Monmouth, are associated with them.

Mr. F. W. Bunyan has resigned his position as testing chemist for the Southern Pacific Railway Company to accept a position as assistant chemist with the Noble Electric Steel Company, Heroult, Shasta Co., Cal.

Mr. H. A. Noyes, research associate in horticultural chemistry and bacteriology at the Purdue Agricultural Experiment Station, has resigned to accept an industrial fellowship with the Mellon Institute, University of Pittsburgh.

Mr. Edward P. Bartlett, formerly assistant professor of chemistry at Pomona College, Claremont, Cal., has been commissioned Captain in the Military Intelligence branch of the Army.

Dr. Arthur L. Day has resigned as director of the Geophysical Laboratory, Carnegie Institution of Washington, to do research work for the Corning Glass Works, Corning, N. Y.

Dr. H. C. McNeil, of the chemical department of the Bureau of Standards, has been appointed professor of chemistry at George Washington University, as successor to Prof. C. E. Munroe, who is giving all his time to the investigation work of the Committee on Explosives of the National Research Council.

Professor Moses Gomberg, professor of organic chemistry at the University of Michigan, has been commissioned Major in the Ordnance Department and is stationed in Washington.

Dr. H. S. Washington, of the Geophysical Laboratory, has been appointed chemical associate to the scientific attachés at the American embassies in Paris and Rome.

Professor M. F. Coolbough, of the department of chemistry, Colorado School of Mines, is in Washington on leave of absence and is engaged in war work at the Bureau of Mines.

Dr. H. M. Loomis, formerly of the Bureau of Chemistry, Department of Agriculture, has been made chief inspector of the sardine canneries of Maine and Massachusetts, for the Food Administration.

Mr. F. C. Teipel, recently associated with Bush, Beach and Gent, Inc., has rejoined Dana and Co., Inc., N. Y., as manager of their chemical department.

Lieutenant Colonel Charles F. Craig, who until recently has been stationed at Fort Leavenworth, Kansas, has been placed in charge of the Yale Army Laboratory School, the new school for bacteriologists and chemists.

Dr. Joseph C. Bock, formerly instructor at Cornell University Medical School, has been appointed professor of physiological chemistry in the school of medicine of Marquette University, Milwaukee.

Dr. F. Mollwo Perkin has been elected president and Mr. H. A. Carwood secretary of an association, which has been organized in England, of chemists engaged in the oil, color, and allied trades.

Mr. Charles L. Raiford, head of the department of chemistry at Oklahoma Agricultural and Mechanical College, Stillwater, Okla., has been elected associate professor of chemistry at the University of Iowa.

Dr. E. B. Spear, professor of inorganic chemistry at the Massachusetts Institute of Technology and consulting expert to the Bureau of Mines, delivered an illustrated lecture on "Some Problems of Gas Warfare" at the Brooklyn Institute of Arts and Sciences on October 19.

INDUSTRIAL NOTES

Alfred I. du Pont, the owner of the Grand Central Palace, N. Y., has announced that, notwithstanding the fact that the Government is to take over the building for the period of the war as a base hospital for the Army and Navy, he intends to proceed with his plans for creating there a center for world commerce after the war in an Allied Industries Corporation.

Japanese manufacturers have well developed their dyestuff industries since the war. They have more than 100 factories and an investment of more than $7,470,000. It is hoped that some plan may be devised whereby they may be able to resist invasion of foreign products after the war.

The Labor Department announces that the chemical industries of Niagara Falls, N. Y., are in great need of women employees. The survey of the plants was made by representatives of various Federal Departments acting under the direction of the Women in Industry Service of the Department of Labor.

American dyestuffs are gaining a hold on the Japanese market, which has heretofore been dominated by German products obtained through neutral countries. This gain is clearly shown by the figures of imports of dyestuffs into Japan for the first quarter of 1918. Japan is now a permanent factor in the manufacture of cotton and silk piece goods and the importance of building up a market there for American dyestuffs cannot be overemphasized.

Reorganizers of the Federal Dyestuff and Chemical Corporation, of Kingsport, Tenn., have decided to call their new company the Union Dyestuff and Chemical Corporation. It is understood that the company anticipates some large orders from the Government for chemicals.

The War Department has awarded a contract to the American Phosphorus Co., Philadelphia, for the construction of a $50,000 phosphorus plant at Fairmont, W. Va.

LIST OF APPLICATIONS MADE TO THE FEDERAL TRADE COMMISSION FOR LICENSES UNDER ENEMY-CONTROLLED PATENTS PURSUANT TO THE "TRADING WITH THE ENEMY ACT"

YEAR	PAT. NO.	PATENTEE	ASSIGNEE	PATENT	APPLICANT
1908	896,807	Karl Dieterich, Helfenberg, Saxony, Germany.	.....	Improvement in agar agar-cascara products and processes of making same.	Reinschild Chemical Co., 47-49 Barclay St., New York City.
1909	943,163	Adolph Schmidt, Dresden, Germany.	Chemische Fabrik Helfenberg, A. G., formerly Eugen Dieterich.	Improvement in agar agar-cascara products.	Reinschild Chemical Co., 47-49 Barclay St., New York City.
1905	782,739	Emil Fischer, Berlin, Germany.	E. Merck, Darmstadt, Germany.	C,C-Dialkylbarbituric acid and process of making same.	Fellows Medical Manufacturing Co., Inc., 26 Christopher St., New York City.
1906	812,554	Alfred Einhorn, Munich, Germany.	Farbwerke vorm. Meister, Lucius & Brüning, Höchst - on - the - Main, Germany.	Alkamin esters of para-aminobenzoic acid.	Fellows Medical Manufacturing Co., Inc., 26 Christopher St., New York City.
1903	718,340	Otto J. Graul, Ludwigshafen - on - the - Rhine, Germany.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the Rhine, Germany.	Process of making cyanmethyl derivatives of aromatic amids.	National Aniline & Chemical Co., Inc., 21 Burling Slip, New York City.
1917	1,216,612	Otto Schmidt, Ludwigshafen - on - the - Rhine, Germany.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany.	Producing soluble tanning agents	E. C. Klipstein & Sons Co., 644 Greenwich St., New York City.
1916	1,191,480	Otto Schmidt, Ludwigshafen - on - the - Rhine, Germany.	Badische Anilin & Soda Fabrik, Ludwigshafen-on-the-Rhine, Germany.	Tanning.	E. C. Klipstein & Sons Co., 644 Greenwich St., New York City.
1909	943,578	Rudolf Tambach, Ludwigshafen - on - the - Rhine, Germany	Knoll & Co., Ludwigshafen-on-the-Rhine, Germany.	Digitalis extract.	Merck & Co., 45 Park Pl., New York City.
1907	62,521	Ichthyol Gesellschaft Cordes, Hermanni & Co., Hamburg, Germany.	.....	Trade-mark "Ichthyol" for medicated soap.	Takamine Laboratory, Inc., 120 Broadway, New York City.
1907	61,011	Ichthyol Gesellschaft Cordes, Hermanni & Co., Hamburg, Germany.	.....	Trade-mark "Ichthyol" for plasters and certain medicinal preparations.	Takamine Laboratory, Inc., 120 Broadway, New York City.
1907	62,603	Ichthyol Gesellschaft Cordes, Hermanni & Co., Hamburg, Germany.	.....	Trade-mark "Ichthyol" for medicinal sulfonic acids and their salts.	Takamine Laboratory, Inc., 120 Broadway, New York City.
1906	54,088	Vereinigte Chininfabriken Zimmer & Co. Ges. mit beschrankter Haftung, Frankfort - on - the - Main, Germany.	.....	Trade-mark "Euquinine" for derivatives of cinchona alkaloids.	Takamine Laboratory, Inc., 120 Broadway, New York City.

The Pacific Electro Metals Company is now operating a silicon-manganese furnace and will in the very near future be operating another furnace making ferromanganese. Each of these furnaces has a capacity of 3,000 kilowatts. In addition, three 300 kilowatt furnaces are being installed in which ferronickel, ferromolybdenum, ferrochrome, and ferrotungsten will be made as the raw materials are available. To make the plant self-contained and independent of outside sources for electrodes, an electrode plant has been erected and local raw materials have been applied to the manufacture of electrodes. The directors of the company are C. D. Clarke, San Francisco, *President;* J. M. Kroyer, Stockton, Cal., *Vice-President;* Henry Koster, San Francisco, *Treasurer;* C. F. Potter, San Francisco, and J. W. Beckman, San Francisco.

A new chemical firm financed by Des Moines, Iowa, capital has entered the field. It is known as the Consolidated Chemical Products Co., of Alton, Ill.

To encourage the production and distribution of manganese used extensively in production of munitions, steel, and other war supplies, the Railroad Administration has ordered a reduction of about 20 per cent in rates on manganese ore from western producing fields to eastern manufacturing centers.

The Puerto Cortes consulate has been advised by residents that they have discovered and denounced a rich deposit of manganese within 2 miles of the Honduras National Railway. They claim that this ore is mixed with graphite, gold, and copper.

The New Jersey Zinc Company has issued a series of pamphlets explaining the composition and uses of zinc dust, zinc pigments, rolled zinc, spelter and other zinc products, and will send the booklets free to those interested.

The West End Mining Co., San Francisco, is preparing to install equipment and begin the development of potash beds in the Searles Lake district along lines endorsed by the Government.

The Isle of Pines promises to become an important producer of iron, copper, and other ores. Eleven mines have already been located, though only two are being actively developed as yet. The Cuban government is taking a most active interest in the development of these mines.

Kemico, Inc., has incorporated under the laws of Delaware to manufacture dyes, chemicals, and colorings of all kinds; capital, $10,000; incorporators, C. I. Rimlinger, F. A. Armstrong, B. A. Spangler.

Two sulfuric acid plants are to be erected in Pennsylvania, one at Emporium, the other at Mt. Union, under the supervision of the Construction Division of the Army. The estimated cost for both plants is $3,000,000. The Emporium plant will consist of eight units on a site on Driftwood Creek, close to the plants of the Aetna Explosives Company and the Emporium Iron Company. The Mt. Union plant will be erected adjacent to the plant of the Aetna Explosives Company. Twenty acres of land have been purchased at $56 an acre. The contract has been awarded to the Leonard Construction Company. The preparation of all plans and specifications, in addition to the supervision of the work, will be under the direction of the Construction Division.

At Copenhagen, Denmark, there is being held an exhibition of products made from the nettle plant, which, in these times of great shortage of raw material for the textile industry, is of considerable interest. In the department for readymade stuffs are to be found tablecloths, napkins, and towels in most diverse patterns. The nettle cloth is snow white, pliable, and pleasant. The exhibits show that practically all of the material is used, as, in addition to that consumed in making textiles, some is ground for fodder and some used in the paper industry. This is an entirely Danish industry and the people in the different districts are taught how to prepare the nettles for delivery to the factories.

Since 1916 the cane sugar industries around Lake Maracaibo, which formerly produced for local markets, have been exporting large quantities to England and the United States owing to the present high prices and scarcity of sugar.

Linoleum manufacturers have been asked by the Conservation Division of the War Industries Board to cut down the styles from 3 patterns to one and to do away with inlay linoleum. In addition to this they have been asked to cut down their use of chrome.

The large chemical companies manufacturing sulfuric acid and the powder manufacturers who depend upon the American production of sulfur for use in making explosives were considerably disturbed by reports that the Louisiana plant of the Union Sulfur Co., at Lake Charles, had been partly destroyed by a cyclone the latter part of August. Repairs are in progress and the plant will soon be restored to its normal condition.

M. Lechner Co., Manhattan, N. Y., has incorporated to deal in dyes, dyestuffs, powder, oils, etc.; capital, $10,000; incorporators, R. Lechner, A. Schmidt, B. Schneir, 200 Fifth Ave.

John R. Rettig and Co., Stockholm, has started to manufacture the electric-insulating material, micanite.

In order to increase the domestic supply of bromine, the Government had additional brine wells drilled in Michigan early in 1918. A large part of the output is marketed in the form of potassium bromide, sodium bromide, and other salts.

Peach pit and coconut hull charcoal are said to be more efficacious than ordinary charcoal in the soldier's gas mask and the United States has undertaken to furnish the special charcoal to the Allies. A nation-wide campaign for the collecting of this material is in progress.

A process for making a substitute for leather out of cotton is now being used by a company formed for that purpose. Machines have already been designed for making shoe laces, belts, and straps, and it is hoped that material several inches wide may soon be made.

At a recent meeting of the House of Commons a vote on the supplementary estimates for the Board of Trade of £1,000,000 ($4,866,500), the first installment of an advance for the development of the British dye industry, was agreed to. The object of this advance is to establish the dye industry on a sound basis within a reasonable time after the end of the war.

Plans are under consideration by the Solvay Process Co., Syracuse, N. Y., for the construction of a large plant in Grand Rapids, Mich., for the manufacture of picric acid.

The New England Chemical Co., Boston, has been incorporated with a capital of $500,000 to manufacture, export, and deal generally in dyestuffs and chemicals.

An explosion occurred in the chemical plant of the Barrett Manufacturing Co., Philadelphia, on September 17, 1918. Two men were killed and the blaze which followed the explosion threatened at one time the Government munition plant at the Frankford Arsenal.

The so-called Krayseska method, a new means of drying eggs, fruit juice, and blood, has been found worth while in Germany. The drying is done in a large iron cylinder, 5 meters in diameter, in which a pair of large metal wings rotate rapidly, driven by a steam turbine. The fluid is lashed to foam and dried by the aid of a current of hot air which is continually passed through the cylinder. The dried product is in the form of a powder, which will keep for a long time and can be most economically transported.

The Florida Fertilizer Milling Company has been incorporated with a capital of $100,000. The incorporators are F. D. M. Strachan, Geo. F. Armstrong, and Clarence Camp.

Dr. Richard B. Moore of the United States Bureau of Mines has announced that mesothorium is an excellent substitute in many ways for radium. He believes that this substance should be used instead of radium in luminous paints, gun sights, and the dials of watches, compasses, and airplane instruments.

From recent experiments it has been shown that worth while extracts of potash may be obtained from the common wild desert grease-wood shrub growing in Texas.

The American Indian Oil and Gas Co., Poteau, Okla., is to install machinery for the manufacture of carbon from natural gas.

A new fertilizer called tetraphosphate is being manufactured in Italy, which is considered equally as good if not better than superphosphate. It was invented in 1914 by Professor Stoppani, of Bologna, and the process was patented and purchased by an Italian company. Considerable progress has since been made notwithstanding the present difficulties in obtaining the phosphate rock and necessary reagents. From the eleven plants now in operation there is a yearly output of 500,000 quintals and four new plants are under construction.

Extensive phosphate deposits on Nauru or Pleasant Island and Ocean Island, located northwest of New Zealand, are said to be the most valuable deposits of the kind in the world The quantity of phosphate available is estimated at 500,000,000 tons, and as fertilizer the deposit is said to rival the famous nitrate fields of Chile.

Production of toluene has been commenced by the Hiram Walker and Sons Chemical Co., Walkerville, Canada The aim of the corporation is to furnish toluene for war purposes and to develop an after-the war trade in dyes and chemicals.

Swift and Co., Chicago, have let a contract for the construction of a salad oil plant at Charlotte, N. C., costing $75,000.

Fire occurred on September 21 at the plant of the Ames Chemical Laboratory, Glens Falls, N. Y., manufacturers of nitrate of silver.

On October 5 fire completely destroyed the Charleston Chemical Plant, at Bello, near Charleston, W. Va. The plant had been operated by the Government for several months.

The natural steam and water of the "soffioni" of the volcanic area of Tuscany contain large quantities of boric acid and are being used as a source of the acid which is produced about 99 per cent pure. The acid is treated with sodium carbonate to obtain borax which is manufactured in the form of crystals and powder. Ammonium carbonate is also manufactured and research work is being done to determine the radioactivity of the gases and the possibility of the separation of helium which is also present.

The Bureau of Mines has requested an elimination of wheat flour from the manufacture of high explosives other than "permissibles." This flour has been used in making dynamite and other explosives employed in mining and engineering operations. It is estimated that this will save more than 16,000 barrels.

Several factories are being built for extracting wax from candelilla weed, which grows in great profusion upon many thousands of acres of land bordering the Rio Grande in Texas. An important feature of this industry is that it has recently been discovered that the ash residue contains probably the highest percentage of potash of any known species of vegetation. The dried bagasse of the candelilla is used for fuel in the factory, and from the ashes, it is claimed, enough potash may be obtained to pay the entire expense of operating.

The Medical Research Board of the Division of Military Aeronautics, after recent experiments with lenses for air pilots' glasses, has announced that it has been able to effect the casting of certain substances in thin sheets which, while not glass, can be used as such and may afford a practical substitute for goggles. Thin sheets of the material have been produced which can even be ground and polished. The substance is hard and non-inflammable and insures practically a non-shatterable lens for the protection of the pilots' eyes.

The manufacture of calcum carbide is being resumed near Germiston, South Africa, as the difficulty of producing a suitable electrode has been overcome. It is expected that after a few changes are made $2^1/_2$ tons of carbide will be produced per 24 hrs.

The British Minister of Munitions has issued an order prohibiting the purchase, sale, or delivery of any radioactive substances, luminous bodies or ores without a permit.

A ruling of the War Trade Board restricts the importation into the United States of dyewoods and vegetable dye extracts as to shipments made after Oct. 10.

The Southern Acid and Sulfur Co., East St. Louis, Ill., is planning the development of sulfur properties and the manufacture of sulfuric acid at Port Arthur and Texarkana, Texas.

The Porterite Efficiency Products Corporation, New York City, manufacturers of paints, oils, and varnishes, has been incorporated with a capital of $500,000. The incorporators are W. J. Eldredge, P. J. Dobson, and J. A. Martin.

As a result of the increasing lemon crop, a plant has been built at Corona, Cal., for manufacturing citric acid and also for making and experimenting with other products.

The Hercules Powder Company, Landing, N. J., has recently engaged about fifty women from various colleges throughout the United States to act in the capacity of chemists.

The business of the New England Paint, Oil, and Varnish Co., Everett, Mass., has been purchased by the du Pont Company.

As the result of a terrific explosion of T N T at the T. A. Gillespie Loading Company's plant at Morgan, N. J., nearly one hundred persons were killed and 325 of the 700 buildings were destroyed.

The volcanic island of Santorini, in the Aegean Sea, produces a natural cement called "portselana," which, mixed in certain proportions with lime and sand, makes an excellent substitute for the best cement. The high price of imported cement has brought this product into prominence.

The gathering of moss in Sweden is now organized on a large scale. About 50,000 school children will be occupied in this work during the next three months and it is estimated that they can gather 17,500 tons of moss, to be used as cattle feed.

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

PUBLIC HEALTH SERVICE

Official Control of Antipneumococcus and Antimeningococcus Serums. G. W. McCoy. Public Health Reports 33, 1313–1316. Issued August 9.

GEOLOGICAL SURVEY

Gravel Deposits of the Caddo Gap and De Queen Quadrangles, Arkansas. H. D. Miser and A. H. Purdue. Bulletin 690–B. From Contributions to Economic Geology, 1918, Part I. 15 pp. Published June 14

New Determinations of Carbon Dioxide in Water of the Gulf of Mexico. R. C. Wells. Professional Paper 120–A, from Shorter Contributions to General Geology, 1918. 16 pp. Published June 20.

The Upper Chitina Valley, Alaska. F. H. Moffit. With a Description of the Igneous Rocks by R. M. Overbeck. Bulletin 675. 82 pp. Paper, 25 cents.

The only minerals yet found in this district that may be of possible economic importance are copper, gold, and molybdenum. No copper ore has been mined nor is any likely to be mined in the near future, for practically no work has been done on the copper deposits except the assessment work necessary to hold a few claims. The present price of copper, however, should stimulate the search for that metal in this district.

A little gold has been produced, but it is doubtful if the quantity recovered has been sufficient to pay more than a small part of the cost of production.

A vein of molybdenite is reported by a prospector who spent part of the summer of 1915 in the upper Chitina Valley. The vein, which is about 8 miles from the lower end of the largest of the Canyon Creek glaciers, is in granite and is reported to be 8 feet wide and to consist of quartz and molybdenite. The molybdenite forms a solid vein, 12 in. thick, between the quartz and the hanging wall and occurs in stringers and bunches through the quartz and in disseminated flakes in the quartz. There is no timber near the property, and the best source of supply would be Young Creek, which is separated from Canyon Creek by a low, flat divide that could be easily traversed. Sleds afford the only method of transportation now available in winter, and any ore produced from the vein will have to be brought out over the glacier ice to Canyon and Young Creeks and carried thence to the railroad at McCarthy.

Some Manganese Deposits in Madison County, Montana. J. T. Pardee. Bulletin 690–F. Being a Separate from Contributions to Economic Geology, 1918, Part I, pp. 131–143. Published July 8, 1918.

Platinum and Allied Metals in 1917. J. M. Hill. Being a Separate from Mineral Resources of the United States, 1917, Part I, pp. 11–21. Published June 21, 1918.

Crude platinum was produced in Alaska, California, Oregon and Washington in 1917. Buyers and refiners report purchases of 608 ounces from producers in these States, which, at the average price ($90 an ounce), would have a value of $54,450. Incomplete returns from placer mines that produce crude platinum indicate that the production in 1917 fell off about 100 ounces from that of 1916, when it was 710 ounces. In view of the high prices for crude platinum in 1917 this decrease is rather difficult to understand, but part of it may be due to the fact that some of the miners held their platinum for higher prices.

Dealers and refiners reported sales in 1917 of 72,186 ounces of secondary platinum metals derived from refining scrap and sweeps. The figures that make up this total probably represent some duplication, as the same metal may be handled as scrap several times in a year. The large increase in the sales of scrap metals indicate clearly that, owing to the greatly decreased imports of crude platinum and the high prices paid for scrap, much attention was given to the collection and refining of all kinds of scrap containing platinum metals.

The imports of platinum and allied metals for consumption in 1917, exclusive of the 21,000 ounces of Russian platinum received in December, which do not appear in the reports of the Bureau of Foreign and Domestic Commerce for 1917, were about 57 per cent of the imports in 1916 and about 25 per cent of the pre-war imports.

The quoted price of refined platinum in the New York market was $80 to $82 a troy ounce in January 1917, but it increased to $102 to $105 in February and remained nearly stationary throughout the year. The average price for the year was $102.80 a Troy ounce.

After the War Department had commandeered all crude and refined platinum on March 2, 1918, a maximum price of $105 an ounce for all imports was set by the War Industries Board.

Refined palladium was quoted at $70 to $85 a troy ounce at the beginning of 1917, but prices advanced continuously throughout the year, being $115 to $125 for the period from August to November and reaching a maximum of $130 to $135 the last of December. Refined iridium was apparently sold only by special bargaining, and no very definite information is available concerning its price. Apparently $110 was the nominal quotation in January, but sales in the last months of 1917 are said to have been made at $180 to $185 an ounce.

Quicksilver Deposits of the Phoenix Mountains, Arizona. F. C. Schrader. Bulletin 690–D. Being a Separate from Contributions to Economic Geology, 1918, Part I, pp. 95–109. Published June 26, 1918.

Cadmium in 1917. C. E. Siebenthal. Being a Separate from Mineral Resources of the United States, 1917, Part I, pp. 49–53. Published July 12, 1918.

Cadmium was first produced in the United States by the Grasselli Chemical Company in 1917. One by one other companies began the recovery of cadmium until there are now six producing companies, as follows: American Smelting & Refining Co.; Grasselli Chemical Co.; Krebs Pigment & Chemical Co.; Mammoth Copper Mining Co.; Midland Chemical Co.; and United States Smelting, Refining & Mining Co. As cadmium residue resulting from the production of electrolytic spelter is accumulating at several plants there will doubtless be other producers before long.

Cadmium is produced in the United States in two forms—metallic cadmium and the pigment, cadmium sulfide. The domestic production of metallic cadmium in 1907 was nearly sufficient to supply the home demand, a fact shown by the small imports for that year, but in 1908 the quantity of cadmium imported was almost doubled, and in 1909–1912 the imports were

back at the figures that prevailed before cadmium had been produced in the United States. Since 1912, however, the domestic production has made great strides, and as a result the imports of cadmium are again small. As the imports came largely from Germany they have been practically stopped for the last four years.

Complete statistics of the exports of cadmium are not available, but it is known that domestic cadmium has been largely exported during the war. According to the Bureau of Foreign and Domestic Commerce the following quantities of cadmium were exported through the port of New York in the last quarter of 1916: In October, 33,244 pounds, valued at $55,259; in November, 4,900 pounds, valued at $5,100; and in December, 1,044 pounds, valued at $1,530. Of the exports in October, 23,210 pounds went to France, 9,984 pounds to Italy, and 50 pounds to Dutch Guiana.

Unrefined cadmium in cadmium residues has also been exported, as noted above.

The price of stick cadmium throughout the first half of 1917 was listed in retail lots as nominal at $1.50 a pound. During the last half of the year the quotations remained practically stationary at $1.40 to $1.75 a pound. The average price for 1917 as calculated from sales was $1.47 a pound, as compared with an average of $1.56 a pound in 1916. The price in London during the first four months of 1917 was 7s. 7½d. ($1.75) a pound; during the next five months it was 8s. 1½d. ($1.90) a pound, and for the remainder of the year it was from 7s. 3d. to 7s. 7½d. ($1.70 to $1.75) a pound.

The average selling price of cadmium sulfide in the United States in 1917 was $1.41 a pound, as compared with $1.26 a pound in 1916.

The value of the output of cadmium in the United States in 1917, calculated at the average selling price, was $305,097, as compared with $210,931 in 1916, and the value of the cadmium sulfide produced was $70,939, as against $27,942 in 1916.

The total value of the output of metallic cadmium in the United States since the beginning of production in 1907 is $830,673 and of cadmium sulfide $151,389, both together equal to nearly a million dollars.

Manganese and Manganiferous Ores in 1916. D. F. Hewett. Being a Separate from Mineral Resources of the United States, 1916, Part I, pp. 731–756. Published July 18, 1918.

As an indication of the condition of the domestic manganese industry during 1916 it may be said that probably in no other mineral industry has there been the same inducement for change in source of supply, price, and manner of utilization. The continued elimination of established foreign sources of manganese ore and ferromanganese has caused the country to depend almost entirely on the ore deposits in Brazil. As prices of ore and ferromanganese more than doubled within the year, there has been strong incentive to utilize less desirable domestic supplies of ore. As a result, domestic production of each grade of ore in 1916 was nearly three times that of 1915. Although this is still only a small part of the country's needs as expressed in terms of manganese metal, the production is much larger than many competent observers thought possible several years ago.

The domestic shipments of manganese ore in 1916 were 26,997 gross tons; of ferruginous manganese ore, 176,130 tons; and of manganiferous iron ore, 372,673 tons. Most of this material is used in the iron and steel industries.

Gems and Precious Stones in 1916. W. T. Schaller. Being a Separate from Mineral Resources of the United States, 1916, Part II, pp. 887–899. Published June 27, 1918.

Talc and Soapstone in 1917. J. S. Diller. Being a Separate from Mineral Resources of the United States, 1917, Part II, pp. 81–84. Published July 12, 1918.

The sales of talc in 1917 amounted to 198,613 tons, valued at $1,889,672, a gain, as compared with 1916, of nearly 3 per cent in quantity and of more than 7 per cent in value. Thirty-seven producers reported to the Geological Survey, of whom 7 were in California, 6 in Georgia, 1 each in Maryland, Massachusetts, and New Jersey, 4 in New York, 6 in North Carolina, 2 in Pennsylvania, 5 in Vermont, and 4 in Virginia.

The highest average priced talc, including that which was cut for gas tips, pencils, and insulators, was sold from Georgia, North Carolina, and Vermont, and the highest prices ranged from $50 to $200 a ton. The lowest priced material was sold as rough talc (crude) at prices ranging from $3 to $8 a ton, or on an average of $5.58 a ton. Its value was greatly increased by grinding and ranged, when ground, according to quality, from $5 to $20 a ton, although the general average was only $9.11 a ton.

Magnesite in 1917. C. G. Yale and R. W. Stone. Being a Separate from Mineral Resources of the United States, 1917, Part II, pp. 63–69. Published July 19, 1918.

Until 1917 practically all the domestic magnesite was produced in the State of California, but in that year the newly developed deposits in Stevens County, Wash., yielded nearly one-third of the domestic output. Formerly this county imported from 250,000 to 350,000 tons of magnesite (stated in terms of crude material), mostly from Austria-Hungary and Greece. Practically all the California output was consumed on the Pacific Coast, mainly as a digester for wood pulp in paper mills, but to some extent as plastic material for flooring, plaster, and cement. The freight rate to eastern points from California was prohibitive, in view of the cheapness of the imported material. Since the opening of the war, however, and especially since the United States became involved in it, the importation from Austria-Hungary has ceased, and, except for a comparatively small quantity derived mostly from Greece and Canada, the country has been compelled to rely upon the domestic product. The natural result of this condition has been renewed activity in the larger mines and the opening and development of numerous new properties.

At the beginning of 1917 the crystalline magnesite from Washington was new on the market and untried. It so quickly proved its value that the market consumed all that the new quarries could produce. Toward the end of the year, however, embargo against shipments into the freight-congested district east of Chicago and north of Ohio and Potomac Rivers began to delay and limit shipments from both California and Washington, for many of the plants that make refractory products from magnesite are east of Chicago. In spite of this embargo the continued demand caused an increase of more than 100 per cent in production in 1917 over 1916, the previous record year.

The crude magnesite produced and sold or treated in the United States in 1917 amounted to 316,838 short tons, valued at $2,899,818, as compared with 154,974 tons, valued at $1,393,693, in 1916. In 1917 California produced 211,663 tons, valued at $2,116,630, and Washington 105,175 tons, valued at $783,188. California's increase in quantity over the production of 1916 was 37 per cent. Washington began production in December 1916, 715 tons being shipped by the end of the year.

The Nesson Anticline, Williams County, North Dakota. A. J. Collier. Bulletin 691–G, from contributions to Economic Geology, 1918, Part II. 6 pp. Published August 15. As it is generally recognized that the highest parts or crests of anticlines or arches in the rocks are the most likely places to find accumulations of natural gas, it would seem advisable that one or more wells be drilled about four miles east or southeast of the Nelson well in search of a larger gas flow.

The Santo Tomas Cannel Coal, Webb County, Texas. G. H. Ashley. Bulletin 691–I, from contributions to Economic Geology, 1918, Part II. 19 pp. Published July 25.

Gold and Silver in 1916. (General Report.) H. D. McCaskey and J. P. Dunlop. Separate from Mineral Resources of the United States, 1916, Part I, pp. 679–721. Published May 7.

Chromite in 1917. J. S. Diller. Separate from Mineral Resources of the United States, 1917, Part I, pp. 37–47. Published August 8.

The domestic production in 1917, so far as may be judged from reports already received by the Geological Survey, was 43,725 long tons. It came mainly from California, where the output was more than 36,700 long tons. Oregon ranks second, with a production of about 6,700 long tons. Alaska produced nearly 1,000 tons, and the remainder, less than 300 long tons, came from Washington, Maryland, and North Carolina. As a considerable number of supposed producers have not yet reported, it is possible that the total production may turn out finally to be somewhat greater. It seems probable that the total domestic production in 1917 was about 3,000 tons less than in 1916. If so, the decline deserves special consideration in view of the constantly increasing demand.

To discover, if possible, the causes of decline in the production of chromite in 1917, the United States Geological Survey sent out a questionnaire to all the chrome producers on its list, asking for statements of the maximum possible production of the mine during the last quarter of 1917 and the actual shipments of chromite from the mine during the same period, the difference being the deficiency in production due to one or more causes, of which the following may be noted: Bad weather, poor roads in winter, lack of funds, lack of shipping facilities, especially lack of cars as the result of the freight embargo, low prices, and uncertainty of market, particularly for low-grade ore. The last two are the most potent causes affecting small producers.

The price of 40 per cent chromite at the beginning of 1917 was $15 a ton, that is, 37½ cents a unit of chromic oxide, but at the end of the year the price had been raised to 70 cents a unit, or $28 a ton. The actual price reported to the Geological Survey ranged from $10 to $50 a ton and the average price of the ore sold during the year by producers was a little more than $24 a ton. Early in 1918 the price for 40 per cent ore reached 85 cents a unit ($34 a ton). The impending crisis resulting from lack of ships to import the ore needed for war purposes has impelled the principal consumer, the Electrometallurgical Co., of New York, to advance prices greatly in the hope of increasing domestic production.

The block chrome ore sold on the Pacific Coast in the summer of 1917 ranged in composition from 30 to 55 per cent chromic oxide and the average composition was 42 per cent.

Of the chromite mined and sold in the United States in 1917, 22 per cent of the total quantity contained from 45 to 50 per cent of chromic oxide, 32 per cent contained from 41 to 45 per cent of chromic oxide, 36 per cent contained from 38 to 41 per cent of chromic oxide, and 10 per cent contained from 30 to 38 per cent of chromic oxide.

Of the ore marketed on the Pacific Coast in 1917 nearly nine-tenths contained 38 per cent or more of chromic oxide and fell within the price of $1.25 a unit now offered. Important contracts for chromite ranging from 30 to 35 per cent chromic oxide have recently been signed, but the prices for that grade of ore have not yet greatly increased. It is hoped, however, that the large consumers of chrome ore for refractory purposes, as well as for ferrochrome, may further stabilize prices not only by adopting this scale of prices but by establishing a corresponding minimum price for ore below the grade of 38 per cent chromic oxide and thus contribute greatly to the increased production of low-grade ores and incidentally aid in promoting concentration.

The most striking feature of the imports in 1917 is the great decrease in the total from 115,045 long tons in 1916 to 72,063 long tons in 1917. This decrease is due wholly to restricted shipping facilities on account of the war and affects particularly imports from South Africa and New Caledonia, which require long overseas transportation. On the other hand, the imports from Canada have greatly increased and those from Guatemala appear for the first time. Only 17 tons have come from Cuba, but recent developments indicate that Cuba and also Brazil will soon be large contributors to our needs of chromite.

The measure of normal annual consumption of chromite for all the various uses before the war may best be expressed by the sum of domestic production and imports in 1913, about 65,000 long tons. On account of the greatly augmented demands of war conditions it has been estimated by the committee on mineral imports and exports of the Shipping and War Trade Boards that the needs of the United States in 1918 will be equivalent to about 130,000 long tons of 50 per cent ore, of which 67,500 tons will be needed for ferrochrome, 40,000 tons for making bichromates and other chemicals for tanning, etc., and 22,500 tons for refractory purposes.

Gold, Silver, Copper, Lead, and Zinc in the Eastern States in 1917. J. M. Hill. Separate from Mineral Resources of the United States, 1917, Part I. 7 pp. Published July 29.

Slate in 1917. G. F. Loughlin. Separate from Mineral Resources of the United States, 1917, Part II. 17 pp. Published July 30.

The total value of the domestic slate sold in 1917—$5,749,966—was an increase of nearly 8 per cent over that for 1916, which was an equal increase over the value in 1915. This increase was common to all the slate products recorded but was most marked in slate for "other uses." The increase in value, however, is in marked contrast to the prevailing decrease in quantity of the different products sold and only indicates the degree to which prices have been advanced to offset increased cost of production.

Feldspar in 1917. F. J. Katz. Separate from Mineral Resources of the United States, 1917, Part II. 5 pp. Published August 7.

The marketed production of domestic feldspar in 1917 was the largest ever recorded. It was an increase of nearly 7 per per cent in quantity as compared with 1916, 35 per cent as compared with 1915, and 5 per cent as compared with 1914. As reported prior to 1916, the values of the yearly production have expressed the combined sales of crude and ground feldspar and have, therefore, shown wider fluctuation than the quantities because of changes from year to year in the proportions sold as crude or ground. The value of the combined production in 1913 was the largest in the decade, and the production in 1915 dropped almost to the low level of 1908 and 1909. The industry rallied markedly in 1916 and 1917, making productions substantially as large as in the best years.

The average price for feldspar sold crude in 1917 was $3.40 a long ton, as compared with $3.34 in 1916 and $3.40 in 1915, the range in prices during 1917 reported to the United States Geological Survey being from $2 to $7 a long ton. The average price of ground feldspar in 1917 was $10.15 a short ton, compared with $9.30 in 1916 and $8.33 in 1915, the range in 1917 in prices reported to the Geological Survey being from $5.70 to $17 a ton.

Of the total marketed production about 70 per cent was sold crude and 30 per cent ground in 1917, compared with 63 per cent and 37 per cent, respectively, in 1916, and 69 per cent and 31 per cent in 1915.

Sand-Lime Brick in 1917. J. Middleton. Separate from Mineral Resources of the United States, 1917, Part II. 1 p. Published August 20.

The sand-lime brick industry, contrary to indications at the beginning of the year, showed decrease in both output and value

in 1917 compared with 1916. The causes for the decrease in output are not difficult to find. The principal cause was the general decrease in building activities; the scarcity of labor, likewise a general condition, was another cause, and transportation conditions may be cited as a third reason for this decline. The increase in the cost of production was reflected in the increased cost to the consumer of the principal product—common brick—of $1.11 per thousand, compared with 1916. Notwithstanding the decrease in the value of the sand-lime brick marketed in 1917 the value in that year was the greatest in the history of the industry with the exception of 1916.

The decrease in the quantity of sand-lime brick sold in 1917 compared with 1916 was 39,798,000 brick, or nearly 18 per cent, but the decrease in value was only $53,743, or 4 per cent.

Gems and Precious Stones in 1917. W. T. SCHALLER. Separate from Mineral Resources of the United States, 1917, Part II. 23 pp. Published July 29. This article contains a very complete glossary of gem names.

Mica in 1917. W. T. SCHALLER. Separate from Mineral Resources of the United States, 1917, Part II. 12 pp. Published July 29.

Although the total value of all mica produced and sold in the United States in 1917, as reported to the United States Geological Survey, was the highest on record, the total quantity was smaller than that for any preceding year since 1908, with the exception of 1912. This was due in part to the fact that a good deal of the scrap mica mined was not sold.

The prices paid for mica in 1917 continued, with minor fluctuations, to increase throughout the year. The prices paid for domestic mica in the South in 1917 were from 10 to 20 per cent higher than the prices for similar mica in 1916. The greatest increase was for the smaller sizes, especially for the 1½ by 2, 2 by 2, and 2 by 3 in. The largest sizes showed no increase in price.

The average price per pound of sheet mica produced in 1917 was 58 cents, a price lower than for either 1916 (61 cents) or 1915 (68 cents), but higher than for any other preceding year. A very large amount of punch or washer mica was produced in 1917, and as this averaged only 5 cents a pound it materially lowered the average value of all sheet mica with which it was combined.

Graphite in 1917. H. G. FERGUSON. Separate from Mineral Resources of the United States, 1917, Part II. 29 pp. Published July 26.

The increase in metal manufacture incident to the progress of the war has brought a greatly increased demand for crucible graphite, and the amount of graphite suitable for crucible use, both domestic and imported, consumed during the year was approximately 30,000 short tons, as against 13,500 short tons in 1913. The domestic production has responded to the greater demand and during the last three years has shown a steady increase.

Estimates furnished by the producers of crystalline graphite show that out of the total sales of 10,584,080 lbs., 6,816,913 lbs., valued at $982,336, or about 64 per cent by weight and 90 per cent by value of the total, was flake graphite containing from 80 to 90 per cent graphitic carbon, in large part suitable for crucible use. The remainder, 3,767,167 lbs., valued at $112,062, was dust or low-grade flake probably averaging under 50 per cent graphitic carbon. The proportion of flake produced is higher than in previous years, owing in part to improved milling methods, whereby a larger proportion of the graphite was saved as flake, and in part to the fact that because of the freight embargo during the latter part of the year such shipments as the Alabama producers were able to make consisted mainly of the better grade material.

The production of amorphous graphite during 1917 was 8,301 tons, valued at $73,481, as compared with 2,022 tons, valued at $20,723 in 1916. As amorphous graphite is not suitable for use in crucible manufacture, war conditions have no increased the demand for it to so marked a degree as for crystalline graphite. Moreover, the production of flake graphite for crucible use yields a large amount of dust as a by-product, and this dust is available for practically all uses.

Graphite is manufactured chiefly by the International Acheson Graphite Co., which utilizes electric power generated at Niagara Falls. The output has increased greatly in recent years and now forms an important element in the country's graphite supply. The bulk graphite is made either from anthracite or from petroleum coke and is utilized mainly in lubricants and paints and for foundry facings, boiler-scale preventives, and battery fillers.

Besides the graphite products that enter into competition with natural graphite, there are a large number for which artificial graphite is particularly adapted. Chief among these is graphite electrodes, the demand for which has greatly increased during the last three years on account of the remarkable growth in certain electrochemical industries.

Domestic flake graphite brought slightly higher prices in 1917 than in 1916. The prices received at the mines for the best grades ranged from 12 to 18 cents a pound for No. 1 flake, according to its grade; from 6 to 10 cents a pound for Nos. 2 and 3; and from half a cent to 5 cents a pound for dust. Flake graphite containing 90 per cent or more of graphitic carbon sold for considerably higher prices than the usual product containing 85 per cent carbon or less.

Salt, Bromine, and Calcium Chloride in 1917. R. W. STONE. Separate from Mineral Resources of the United States, 1917, Part II. 12 pp. Published August 10.

Salt is so abundant and so widely distributed in the United States that the industry can meet domestic requirements in spite of unfavorable conditions. At some plants in 1917 there was shortage of labor, difficulty in obtaining fuel, and an inadequate supply of freight cars, yet the total production for the country was a notable increase over that of 1916. The salt produced and sold in the United States in 1917 was 6,978,177 short tons, valued at $19,940,442, an increase of 9.7 per cent in quantity and 46.1 per cent in value over the production of 1916.

From the itemized figures in the table it is determined that the increase in production of manufactured or evaporated salt in 1917 was 1.1 per cent, of brine salt 13.8 per cent, and of rock salt 17.3 per cent. The much larger increase in rock salt is a measure for the readiness with which the production of salt by mining can be expanded in comparison with the production by evaporating brine.

The average price increased 33 per cent and was $2.86 per ton in 1917, as compared with $2.14 in 1916. This great increase in price was caused by higher wages paid for labor and higher cost of fuel and all other supplies.

The quantity of bromine marketed in 1917 increased nearly 23 per cent over the production in 1916.

The production of bromine was retarded in 1917 by steadily falling price and increasing cost of production, by railroad freight congestion, by embargo on shipments which hindered the movement of salt, by shortage of labor and fuel at some plants, by needed repairs, and by the extremely cold weather in December.

The wholesale price of bulk bromine in New York was 25 to 35 cents a pound in 1913, 30 to 35 cents from January to August 1914, and 40 to 50 cents from September to December 1914.

The following table shows a large increase in consumption and a very large increase in value of calcium chloride in 1917:

CALCIUM CHLORIDE PRODUCED AND MARKETED IN THE UNITED STATES, 1915–1917

YEAR	QUANTITY Short Tons	AVERAGE PRICE per Ton
1915	70 [illegible]	$ 6.37
1916	[illegible],009	8.12
1917	40,803	14.80

Sulfur, Pyrites, and Sulfuric Acid. P. S. SMITH. Separate from Mineral Resources of the United States, 1917, Part II. 43 pp. Published July 10.

Although precise statistics are not given, it may be said that the domestic production in 1917 was nearly 50 per cent greater than in 1916—a year during which several hundred per cent more sulfur was produced than in any year before the war.

According to reports received from the Bureau of Foreign and Domestic Commerce, the quantity of crude sulfur or brimstone exported from the United States in 1917 was 152,833 tons, valued at $3,504,661. This was the greatest export of sulfur by this country in a single year, exceeding by nearly 20 per cent the previous record quantity exported in 1916. The exports in 1917 exceeded by more than 70 per cent the exports in 1913, which may be taken as fairly representative of normal conditions immediately before the war.

Up to 1900 the annual domestic production of sulfur was relatively insignificant and about 175,000 long tons of sulfur were imported each year. With the commercial development of the deposit in Louisiana the importation of sulfur suddenly decreased, and in 1907 the imports amounted to only about 20,000 tons. Since that year up to and including 1916 the imports of sulfur each year have been between 20,000 and 30,000 long tons. In 1917, however, owing to the restrictions imposed by certain of the foreign governments, the difficulty of obtaining ships, and the quantity of domestic sulfur available, less than 1,000 tons of foreign sulfur were received in this country.

The domestic production of pyrites in 1917 was 462,662 long tons, valued at $2,485,435, an increase of about 39,000 long tons in quantity and of about $520,000 in value, as compared with the production in 1916. The consumption of pyritic ore in 1917—that is, the domestic production plus imports—amounted to about 1,430,000 long tons and was about 240,000 long tons less than the consumption in 1916. This decrease was largely attributable to the great falling off in imports.

In addition to the pyritic ores reported here, returns from manufacturers of sulfuric acid show that 708,500 long tons of domestic copper-bearing sulfide ores, 147,531 long tons of foreign copper-bearing sulfide ores, 594,100 long tons of domestic zinc-bearing sulfide ores, and 152,911 long tons of foreign zinc-bearing sulfide ores were treated in 1917 for their sulfur as well as for their metallic content.

The production of sulfuric acid in 1917 was nearly twice as great as the production in 1913, which may be taken as a normal pre-war year. The expansion in the industry to meet the conditions imposed by the war had been begun in 1916, so that the increase in 1917 over 1916 was much less than the increase in 1916 over 1915.

The production of sulfuric acid in 1917 expressed in terms of 50° Bé. was 5,967,551 short tons valued at $71,505,536, to which must be added 759,039 short tons of acids of strengths higher than 66° Bé., which cannot be converted for purposes of calculation into acid of 50° Bé., valued at $16,034,645. The total value of all the sulfuric acid produced in 1917 was therefore $87,540,181. This production shows an increase in 1917 over 1916 of the acid expressed as of 50° Bé. of more than 325,000 short tons in quantity and of about $8,800,000 in value and an increase in stronger acids of more than 315,000 short tons in quantity and $5,225,000 in value. The value of the total production of sulfuric acid in 1917 was therefore more than $14,000,000 greater than the value in 1916.

The totals given above include by-product acid—that is, acid produced at copper and zinc smelters. The production of acids from this source in 1917, expressed in terms of 60° acid, was 1,336,209 short tons, valued at $14,516,104, to which must be added 119,048 short tons of acids of strengths higher than 60° Bé., which can not be calculated in terms of acid of 60° Bé., valued at $2,374,441. None of the stronger acids are reported to have been produced at copper smelters, and no 50° acid was reported to have been produced at either the copper or the zinc smelters.

BUREAU OF CENSUS

Chemicals and Allied Industries. Census of Manufacturers, 1914. 85 pp. One of a series of bulletins being issued by the Bureau, presenting statistics of industries, concerning which inquiries were made at quinquennial census of manufacturers in 1914. Statistics are presented in three sections: Summary and analysis, giving general data compiled for industry; special statistics relating to materials, products, and methods of manufacture; and State tables, giving comparative summary, by States, for 1904, 1909 and 1914, and detailed statistics for industry, by States, 1914.

Leather Industry. Census of Manufacturers, 1914. 63 pp.

Wool Manufacturers. Census of Manufacturers, 1914. 48 pp.

Patent and Proprietary Medicines and Compounds and Druggists' Preparations. 18 pp.

BUREAU OF MINES

Bibliography of Petroleum and Allied Substances, 1915. E. H. BURROUGHS. Bulletin 149. 111 pp. Paper, 15 cents.

Oil Storage Tanks and Reservoirs. With a brief discussion of losses of oil in storage and methods of prevention. C. P. BOWIE. Bulletin 155. 68 pp. Paper, 25 cents.

Mining and Concentration of Carnotite Ores. K. L. KITHIL AND J. A. DAVIS. Bulletin 103. 77 pp. Paper, 25 cents. Prepared under a coöperative agreement with the National Radium Institute.

Initial Priming Substances for High Explosives. G. B. TAYLOR AND W. C. COPE. Technical Paper 162. 20 pp. Paper, 5 cents.

The Use of Permissible Explosives in the Coal Mines of Illinois. J. R. FLEMING AND J. W. KOSTER. Bulletin 137. 103 pp. Paper, 20 cents. This report was prepared under a coöperative agreement with the Illinois State Geological Survey and the engineering experiment station of the University of Illinois.

Metal-Mine Accidents in the United States during the Calendar Year 1916. A. H. FAY. Technical Paper 202. 78 pp. Paper, 10 cents.

Quarry Accidents in the United States during the Calendar Year 1916. A. H. FAY. Technical Paper 193. 55 pp. Paper, 10 cents.

Siliceous Dust in Relation to Pulmonary Disease Among Miners in the Joplin District, Missouri. E. HIGGINS, A. J. LANZA, F. B. LANEY AND G. S. RICE. Bulletin 132. 108 pp. Paper, 25 cents.

Recovery of Gasoline from Natural Gas by Compression and Refrigeration. W. P. DYKEMA. Bulletin 151. 117 pp. Paper, 25 cents. "This report treats of the compression and refrigeration process for the recovery of gasoline from natural gas from the viewpoint of the practical engineer and businessman. Conditions of actual operation and the equipment in use are cited and described so that operators, and others interested, can compare the variations in methods of treating natural gas for its gasoline content in the different fields and also the conditions encountered and the features that control the methods used."

The Quick Determination of Incombustible Matter in Coal and Rock-Dust Mixtures in Mines. A. C. FIELDNER, W. A. SELVIG AND F. D. OSGOOD. Technical Paper 144. 29 pp. Paper, 10 cents. "An investigation of the specific-gravity method of determining the percentage of rock dust, ash, or dry incombustible in mixtures of coal and rock dust such as are

found in the entries and rooms of mines showed that this method was rapid and sufficiently accurate for use in controlling the application of rock dust in mines."

Effects of Moisture on the Spontaneous Heating of Stored Coal. S. H. KATZ AND H. C. PORTER. Technical Paper 172. 19 pp. Paper, 5 cents. "The only recommendation of practical import to be made as a result of the matters considered in this paper is to prevent the segregation of the fine coal in building a pile for shortage. This has been proposed before as a means of reducing the danger of spontaneous combustion. The consideration of moisture now gives it further support."

Weights of Various Coals. S. B. FLAGG. Technical Paper 184. 7 pp. "A study of the foregoing table indicates that heavier weights may be expected for coals of high fixed carbon content than for those of low. Increased ash content seems to lower the unit weight. It is also true, in general, that the coals high in moisture are lighter than those low in moisture and the younger coals are lighter than the older coals."

Use of the Interferometer in Gas Analysis. F. M. SIEBERT AND W. C. HARPSTER. Technical Paper 185. 12 pp. Paper, 5 cents. This paper describes the outcome of some of the investigations made by the Bureau of Mines in connection with work on mine gases and natural gas.

Physiological Effect of Different Gases on Man. G. A. BURRELL. Large chart unnumbered. This chart shows the pertinent physical properties and easily recognized characteristics of mine gases in a form that can readily be understood by miners.

Temperature-Viscosity Relations in the Ternary System CaO–Al_2O_3–SiO_2. A. L. FEILD AND P. H. ROYSTER. Technical Paper 189. 36 pp. Paper, 5 cents.

Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1913 to 1916. A. C. FIELDNER, H. I. SMITH, J. W. PAUL AND SAMUEL SANFORD. Bulletin 123. 478 pp. Paper, 50 cents.

Measuring the Temperature of Gases in Boiler Settings. H. KREISINGER AND J. F. BARKLEY. Bulletin 145. 72 pp. Paper, 15 cents. "This book is one of a series of publications being issued by the Bureau of Mines for the purpose of disseminating information in regard to the methods by which the fuels in this country may be used most efficiently."

A Convenient Multiple-Unit Calorimeter Installation. J. D. DAVIS AND E. L. WALLACE. Technical Paper 91. 48 pp. Paper, 15 cents.

The Diffusion of Oxygen through Stored Coal. S. H. KATZ. Technical Paper 170. 47 pp. Paper, 10 cents.

Slag Viscosity Tables for Blast-Furnace Work. A. L. FIELD AND P. H. ROYSTER. Technical Paper 187. 38 pp. Paper, 5 cents. The purpose of this report is to make available to the operator the results of the slag-viscosity measurements made in the laboratories of the Bureau. This information, if used intelligently, should help the blast-furnace operator to reduce losses caused by off-grade pig iron; to improve fuel economy; to promote operating efficiency; and to extend present-day practice to meet the increasing need of smelting lean and complex ores.

Methane Accumulations from Interrupted Ventilation. H. I. SMITH AND R. J. HAMON. Technical Paper 190. 46 pp. Paper, 10 cents. This report was prepared under a coöperative agreement with the Illinois State Geological Survey and the Engineering Experiment Station of the University of Illinois.

BUREAU OF STANDARDS

Wave Lengths in the Red and Infra-Red Spectra of Iron, Cobalt, and Nickel Arcs. W. F. MEGGERS AND C. C. KIESS. Scientific Paper 324. 14 pp. Paper, 5 cents.

The Properties and Testing of Optical Instruments. Circular 27. 2nd Ed. 41 pp. Paper, 10 cents. In recent years many types of optical instruments have been developed and have come into more or less common use. At the same time, a great deal has been written in the English language on optical subjects, but there is no general discussion of optical instruments in nontechnical language for the benefit of the average person who owns, for example, opera glasses or a camera. The primary purpose of this circular is to correct this deficiency by giving a simple description of the principal features of optical instruments, to explain the causes and correctness of various imperfections, and to indicate methods of testing for the presence of imperfections which mar the ideal performance of optical instruments. This information, for the most part, can be found in various textbooks and treatises on optical subjects, but the fact that it is inaccessible to many people, because it is widely scattered and generally couched in mathematical language, is the reason for this presentation. This circular should not be mistaken for a complete treatise on optical instruments. It is intended first of all to serve the public who use optical instruments but who have had little opportunity to study the physical theory of such instruments.

DEPARTMENT OF AGRICULTURE

Commercial Bordeaux Mixtures: How to Calculate their Values. E. WALLACE AND L. H. EVANS. Farmers' Bulletin 994. 11 pp.

Tests of the Absorption and Penetration of Coal Tar and Creosote in Longleaf Pine. C. H. TEESDALE AND J. D. MCLEAN. Department Bulletin 607. 43 pp. Paper, 15 cents. Published June 6.

Digestibility of Some Seed Oils. A. D. HOLMES. Department Bulletin 687. 20 pp. Paper, 5 cents. Published June 28. This bulletin records studies of the digestibility of corn oil, soy-bean oil, sunflower-seed oil, Japanese mustard-seed oil, rapeseed oil, and charlock oil. It is primarily of interest to students and investigators of food problems.

Articles from the Journal of Agricultural Research

Influence of Gypsum upon the Solubility of Potash in Soils. P. R. MCMILLER. 14, 61–66 (July 1).

Mineral Content of Southern Poultry Feeds and Mineral Requirement of Growing Fowls. B. F. KAUPP. 14, 125–134 (July 15).

A Comparative Study of Salt Requirements for Young and for Mature Buckwheat Plants in Solution Cultures. J. W. SHIVE AND W. H. MARTIN. 14, 151–175 (July 22).

Composition and Digestibility of Sudan-Grass Hay. W. G. GAESSLER AND A. C. MCCANDLISH. 14, 176–185 (July 22).

Soil Reaction and the Growth of Azotobacter. P. L. GAINEY. 14, 265–271 (August 12).

Effect of Different Oxygen Pressures on the Carbohydrate Metabolism of the Sweet Potato. H. HASSELBRING. 14, 273–284 (August 12).

COMMERCE REPORTS—AUGUST 1918

Special efforts are being made in Australia to increase the production of industrial denatured **alcohol** by diverting plants engaged in the manufacture of potable spirits. (P. 441)

Over one hundred **dyestuff** factories are in operation in Japan. In order to protect them in the future, a high tariff is suggested. (P. 454)

Owing to the cutting off of foreign supplies of **salt**, steps are being taken in Holland to develop extensive salt beds, the existence of which has long been known. (P. 499)

In Mexico, it is proposed to manufacture **alcohol** and a cattle food, from "sotol," a plant which grows wild in unlimited quantities. (P. 503)

Large deposits of **lignite** of good quality have been discovered in Greece, where they will be especially valuable owing to lack of coal deposits. (Pp. 512 and 667–71)

The Canadian Research Council has urged the formation of "industrial guilds," to be made up of firms or companies in the same or allied industries, for the purpose of conducting **research** laboratories for the benefit of the members of the guild. In some cases government aid, in the form of grants or laboratory space, may be furnished. (P. 580)

The syndicate which controls the **sulfur** industry of Sicily, has been granted an extension of 12 years, in view of the present unsettled condition and the increased competition of American, Japanese and African sulfur. (P. 623)

Plans are being made for extensive development of the **iron ore** deposits of Brazil at the close of the war. (P. 636)

Owing to the shortage of **adhesives** in Germany, glue is being extracted from bones by treatment with sulfur dioxide, removal of fat by benzene extraction, and then boiling the bones under pressure. Various vegetable juices are also being used in the manufacture of adhesives. (P. 680)

Detonation caps are being made in Sweden with an explosive containing copper, and no mercury. (P. 685 and 808)

Arrangements have been made for the first installment of £1,000,000 on the British loan for the development of the **dye** industry, in order to promote the manufacture of those dyes which are essential, but cannot now be produced on a commercial basis. (P. 705)

A plant is to be erected in Colon for the manufacture of **coconut oil** and **palm oil**, and **soap**, and by-products. (P. 709)

A new process for the production of **salt, magnesium salts, sodium sulfate, iodine** and **bromine**, from seawater, is being installed in Norway. (P. 820)

Bids received in Brazil for the erection of **caustic soda** plants, all specified the electrolytic process, except one which proposes to use the Solvay process. (P. 828)

SPECIAL SUPPLEMENTS ISSUED DURING THE MONTH

DENMARK—4*a*
FRANCE—5*c*
ITALY—8*b*
SPAIN—15*b*
LIVERPOOL AND SHEFFIELD—19*f*
BRADFORD, ENGLAND—19*g*
SCOTLAND—19*h*
CANADA—23*c*
FRENCH WEST INDIES—28*b*
HONDURAS—31*a*
CHINA—52*f* and *g*

STATISTICS OF EXPORTS TO THE UNITED STATES

MEXICO—712
Antimony
Arsenic
Bones
Copper
Gold
Silver
Cottonseed cake
Guayule rubber
Hides
Horn
Ixtle fiber
Lead
Mercury
Sarsaparilla
Tin
Candelilla wax
Zinc ore
DENMARK—Sup. 4*a*
Chalk
Diamonds
Flint pebbles
Hides
Paper
Porcelain
Rennet
FRANCE—Sup. 5*c*
Dye extracts
Photographic paper
Antimony sulfide
Hides
LIVERPOOL—Sup. 19*f*
Bones
Wool grease
Crude gums
Hides
Rubber
Ferromanganese
Palm oil
Rapeseed oil
Fish oil
Paper stock
Ammonium sulfate
Ammonium chloride
Cochineal
Cutch
Gum tragasol
Sodium silicate
Sodium sulfate
China
Artificial silk
Tin
CHINA—Sup. 52*f*
Antimony
Beeswax
Albumen
Cantharides
Camphor
Aniline dyes
Indigo
Gall nuts
Musk
Rhubarb
Sodium benzoate
Tumeric
Hides
Pig iron
Tungsten ore
Bean oil
Castor oil
Cottonseed oil
Peanut oil
Rapeseed oil
Wood oil
Linseed
Sesame
Zinc ore

BOOK REVIEWS

Sulfuric Acid Handbook. By THOMAS J. SULLIVAN. McGraw-Hill Book Company, Inc., New York City, 1918. Price, $2.50, net.

This book owes its chief value to the fact that it contains the unusually complete set of sulfuric acid tables adopted by the Manufacturing Chemists' Association of the U. S. A.

These tables are indispensable in working out problems connected with the manufacture and use of sulfuric acid, and placed together in a convenient form, fill a long-felt want.

J. B. F. HERRESHOFF

Treatise on Applied Analytical Chemistry. By VITTORIO VILLAVECCHIA AND OTHERS. Translated by THOMAS H. POPE. Pp. 475. P. Blakiston's Son & Co., Philadelphia, Pa. 1918. Price, $6.00.

The author of this book has endeavored to present those subjects which have to do with the purchase of raw materials for manufacturing processes. He has also given attention to the analysis of finished products from the standpoint of impurities and adulterations. The book is well arranged and the subjects are presented in a very pleasing manner. It is a commendable volume and should be of value to those interested in the problems of analytical chemistry.

ALLEN ROGERS

Cellulose. An Outline of the Chemistry of the Structural Elements of Plants. By CROSS AND BEVAN. New Impression with Supplement. 348 pp. with 14 plates. Longmans, Green & Co., New York and London, 1918. Price, $4.50.

This is a reprint of the third edition of this classical work which is familiar to all students of cellulose chemistry. The new impression is extended, however, by a supplementary chapter, pp. 311–331, which contains brief paragraphs on pure cellulose, ester anhydrides, reactions of decomposition, physical properties and lignocellulose, while the summary of technical progress since the edition of 1916, is compressed into less than two pages. This is the more to be regretted since the authors state that owing to "the persistent international complications" they have not been able to complete the records which would justify publishing a No. 4 of their series of Researches on Cellulose. In view of the colossal importance which cellulose and its compounds have acquired as war materials, and the noteworthy special applications of paper to war purposes, it is unfortunate that the authors have been unable to bring the subject more nearly up to date.

A. D. LITTLE

The Chemist's Pocket Manual. By RICHARD K. MEADE. 3rd Ed. 530 pp. The Chemical Publishing Company, Easton, Pa., 1918. Price, $3.50.

The author's extensive experience as an engineer and chemist has enabled him to produce a book which should appeal particularly to chemical engineers, works chemists, and superintendents. It differs from other manuals in its practical character. The customary lengthy tables of the properties of inorganic and organic compounds are condensed and the space saved is devoted to matter on fuels and combustion, electricity, mechanics, steam, steam engines and boilers, hydraulics, power transmission, elevators and conveyors. There are a number of useful conversion tables for analytical chemists and a suggestive article on graphic methods for saving calculation. Methods for standardizing weights and calibrating glassware are described.

The last half of the book is taken up by a description of the methods used in the examination of iron, copper, lead, zinc ores, etc., the analysis of iron, steel, alloys, coal, flue gases, clay, lubricating oils, asphalts, soap, mixed paint, fertilizers, water, and Portland cement. In the reviewer's opinion a better selection of methods, both practical and accurate, could scarcely be made. At the end of each part there is an excellent bibliography of the more important magazine articles and books.

The manual is seriously marred by the number of errors. Even a casual examination will disclose quite a few. In the section on mineralogy the proofroom eluders "carnalite, proutsite, pyroxine" may be found. The newspaper atrocity "analine" is discovered on p. 310. "Sulfuric anhydried" appears on p. 205. Sadtler is misspelled Sartler on p. 260. Mohr is Moh on p. 261. One year has 265.24 days on p. 10. The atomic weights of 1917 are used, but the table is titled 1916 on p. 28. Many other errors might be cited.

By this time the reader's confidence in the reliability of the tables is somewhat shaken. To investigate this point the reviewer examined carefully three of the tables. The first of these, the table of logarithms, has two mistakes in the logarithms corresponding to the numbers 110 and 540. The second, the table of molecular weights on pp. 32–35, has eight incorrect formulas. The extinct symbols Al_2Cl_6, $Fe_2Cl_6.K_6Fe_2(CN)_{12}$ are used in this table, whereas the modern ones are listed in the table of reagents on p. 303. The third table, factors on pp. 36–41, contains a number of slight errors. The factors NH_4Cl to NH_3, $BaSO_4$ to SO_3, $Zn_2P_2O_7$ to Zn are seriously in error.

The reagents used in analysis on p. 303 might preferably be made up to a concentration bearing some relation to the molecular weight, as described in A. A. Noyes' "Qualitative Analysis," instead of a haphazard percentage basis. Methyl red is missed from the table of indicators.

In the directions for the determination of the specific gravity of liquids with a pycnometer, the bottle is immersed in water a "little above or below" the standard temperature. The pycnometer is removed as soon as its thermometer shows the proper temperature. This procedure can scarcely give accurate results, since the only guarantee that the temperature of the liquid in the pycnometer is uniform is to have a thermometer in the bath as well as in the bottle, and both thermometers must register the identical temperature before the pycnometer can be removed for weighing.

The book is of handy size, is free from advertising matter, and is well printed on strong paper. It should be in the hands of every chemical engineer and analyst.

A. C. LANGMUIR

Chemical French. An Introduction to the Study of French Chemical Literature. By MAURICE L. DOLT, Ph.D., Professor of Chemistry in the North Dakota Agricultural College. viii + 398 pp. The Chemical Publishing Co., Easton, Pa., 1918. Price, $3.00.

Whether or not chemistry was once a French science, in later times its language has had a decided German accent. Nowadays, however, our interest in French chemists and French chemistry is happily increasing and this book is opportunely timed. It is a companion volume to the well known *Chemical German* of Professor Phillips, being similarly arranged, printed and bound.

French does not present so many new words to the speaker of English as does German, but it is full of troublesome idioms; these the author, who had his birth and early education in France, is well equipped to handle.

Part I consists of four exercises reviewing in chemical language the essentials of French grammar, and of twenty exercises covering the various fields of chemistry. At the head of each is a little vocabulary of new words and phrases occurring in the exercise. Part II comprises classic selections from the French journals, such as that of Pasteur on racemic acid and Moissan on fluorine. The book concludes with a useful table of irregular verbs and a dependable vocabulary of about 5500 terms (which, however, by no means includes all the words that appear in the text).

Chemical French has been carefully prepared and is excellently adapted to its purpose. It will no doubt meet with a cordial reception.

AUSTIN M. PATTERSON

The Science and Practice of Photography. By JOHN R. ROEBUCK, Assistant Professor of Physics, University of Wisconsin. D. Appleton & Co., New York, 1918. Price, $2.00.

The sub-title of this book is "An Elementary Textbook of Scientific Theory and a Laboratory Manual" and for the purposes of a class textbook the sharp division between theory and practice thus indicated is perhaps well adapted. The first part, on general theory, consists of the following chapters: Historical Development, Properties of the Gelatin Dry Plate—Exposure and Development, Properties of the Gelatin Dry Plate—Color Sensitiveness, Latent Image Theories, Negative Defects, Positive Processes, Lenses, Color Photography, Good Pictures, with an appendix on Plate Speed Numbers and Development. The second part consists of a Laboratory Manual of exercises for students, taking them through the principal operations and processes; also appendices on apparatus, chemicals, record slips, and photometers.

The book has the outstanding merit of putting the crux of photographic science in the forefront of the argument. This is of course the dependence of the density and character of the negative upon exposure and development, and bound up with this, the relationship of subject, negative, and positive. It is of interest to industrial chemists that two of their number, Hurter and Driffield, were the first to eliminate non-essentials here, to give acceptable definitions of such photographic quantities as density and contrast, and to standardize their measurement. The principles which they derived, and their mathematical and graphic exposition of these, have formed the basis of most subsequent quantitative work.

This has indeed shown that these principles are limiting ones, completely true only under simplified conditions, and actually subject to many deviations in the denser detail of practice. It is, however, their great merit that they discerned an essential reference framework through the fog of practical variations. The author's account of these fundamental matters, in the second chapter, is adequate and lucid. One may venture a hope, rather than a criticism, that a future edition will show an even more extended application of the characteristic curve, for example, in connection with intensification and reduction methods, for positive processes, and also for color sensitizing and color photography. Without some illustration of the influence of color (or wave length) upon the form and gradation of the characteristic curve, the sensitizing curves given are apt to be misleading.

The chemical side of photographic processes receives a less satisfactory treatment. Equations are given somewhat baldly, without any reference to mass action, to reversibility, or other elements of the mechanism of the reactions. In the equation as printed for wet plate development,

$$FeSO_4 + AgBr = Ag + Fe(SO_4)Br,$$

the ferric bromo-sulfate is surely a questionable species, while the part played by restraining organic acids is not indicated. The treatment of development and organic developers seems rather brusque in a work emphasizing the desirability of scientific foundations, failing which, the process of development becomes only a subject of empirical rules or individual guess-work.

The chapter on the latent image stands out favorably by contrast. It is an excellent and concise piece of work in which the author concludes in favor of the colloid silver theory. It may then be suggested that the chemical aspect of the book would be strengthened if this occasion were used to bring forward the basic principles of colloid chemistry as central to photographic processes. A sufficient claim for an elementary statement will be allowed on considering such facts as these. The modifications of silver bromide described by Stas and others are chiefly colloidal changes due to interrelated adsorption and subdivision. Practically all photographic images are colloidal,

their physical texture and color, as well as their chemical reactivity and stability, largely depending upon control of the colloid condition. And virtually all photographic processes are carried out in or upon a colloid medium.

These criticisms must be understood as made from the standpoint of the photographic chemist. As an introduction to photography, the book as a whole strikes one as very readable, well balanced, and admirably adapted to its purpose as a class textbook. This is assisted in no small measure by the well chosen experiments of the Laboratory Manual.

There are some minor errata and misstatements requiring correction. Jean Servias Stas was an eminent Belgian chemist, not a "famous German." H Cl, incorrectly typed H C I on p. 15, is not a desirable acid in gelatino-bromide emulsions. Dr. Scheffer's name is misspelt, pp. 68 and 107, and in the index. Under the carbon process, the alkaline chromates are given as sensitizers, which is misleading, since it is only as dichromates (or bichromates) that sensitizing is effected. Also, the coloring matters used are pigments, not dyestuffs as stated, which are only used to shade them. And in the article on wet collodion in the Laboratory Manual there is no explicit statement of the necessity of saturating the silver sensitizing bath with silver iodide.

The book is well printed on non-glossy paper, with numerous clear illustrations, and has a good index. The footnote advices that articles such and such may be obtained from firms so and so of Berlin, München, Dresden, etc., seem somewhat superfluous at this date.

S. E. Sheppard

The American Fertilizer Handbook for 1918. Edited by John D. Toll. 11th Annual Edition. Ware Brothers Company, Philadelphia, 1918. Price, $1.50.

The American Fertilizer Handbook has become a valuable reference book in the fertilizer industry, and should be found very valuable to anyone connected with this industry. It is classified in the following sections: Fertilizer Materials, Directory of Allied Industries, Phosphate Rock, Fertilizer Machinery, Fertilizer Brokers, Chemists and Engineers, Cottonseed Oil Mills and Machinery, Packers and Renderers.

The first hundred pages are devoted to matters of general interest to the fertilizer industry, giving the officers of the National Fertilizer Association, The Southern Fertilizer Association, Chemical Alliance Incorporated, location of the agricultural experiment stations and the officials of these various stations.

There is also an interesting table showing the fertilizers and tonnages by States.

This is followed by the Fertilizer Materials Statistics which is a very complete and interesting review of the fertilizer materials market, statistics of the production, imports, consumption, and prices of fertilizer materials for several years.

The Phosphate Rock, Sulfur, and Potash articles are very complete and show clearly the status of these materials up to 1918.

The Fertilizer Manufacturers Directory is a well arranged directory of the fertilizer manufacturers arranged by States.

The Directory of the Allied Fertilizer Trades is a buyers' guide to the fertilizer trade.

The Phosphate Rock section includes a treatise on the production of phosphate rock in 1916 by R. W. Stone, United States Geological Survey, Washington, and also gives a complete list of the phosphate mining companies, together with their addresses.

The Fertilizer Machinery section should be valuable to fertilizer manufacturers interested in new construction, equipment and supplies.

The Fertilizer Materials section is merely an advertisement of the companies handling fertilizer materials.

The Brokers Section is also a list of fertilizer brokers.

The Chemists and Engineers is a section covering advertisements by various chemists, assayers, engineers, constructors, lead burners, samplers, etc.

The Cottonseed Oil Machinery section covers in a commercial way the cottonseed oil and meal situation together with statistics. There is also in this section an interesting and very instructive article on the composition of cottonseed by Thomas C. Law, Atlanta, Ga.

The last section in the book, entitled Packers and Renderers, deals with the western animal ammonia market from May 1, 1917, to April 30, 1918. It also has charts showing the market fluctuations on high-grade tankage and blood. This section also has the directory of packing houses and rendering plants.

The book as a whole is a commercial book, a valuable addition as a reference book to anyone who desires information in regard to the fertilizer industry.

J. E. Breckenridge

Van Nostrand's Chemical Annual. Edited by John C. Olsen, A.M., Ph.D., Professor of Chemistry, Cooper Union, N. Y., and Maximilian P. Matthias, Ch.E., Lieutenant, Ordnance Dept., U. S. R., Assistant Editor. Fourth issue. 778 pp. D. Van Nostrand Co., New York, 1918. Price, $3.00.

When a chemical book has gone through four editions, the approval of the profession which has made this possible testifies more emphatically to its merit than it is possible for any reviewer to do. In this case, therefore, the work of the latter can be confined to the pleasant task of approving of the public's discernment and of calling attention to the advances made in the present over former editions.

The standard tables have, of course, been revised and extended in accordance with the latest information obtainable, making use therein of much of the data published by the Bureau of Standards. The new matter includes tables on the physical constants of the radioactive elements, critical data of gases, relative hardness of the elements, the calibration of glass vessels, indicators for volumetric analysis, weight of dry air at different temperatures and pressures, properties of the wrought copper alloys, specific gravity standards, refractometer readings and density of cane sugar solutions, composition of sea water, density and volume of pure water, reduction of weighings to vacuo, pressure of saturated aqueous vapor, weights and measures, capacities of tanks, values of electrical, mechanical, and heat units, conversion of Centigrade to Fahrenheit degrees, freezing mixtures and freezing point of brines, latent heat of vaporization, and the composition and heating value of natural gas.

Directions are given for using logarithms and the slide rule. The section on Stoichiometry has been revised and explanations of the use of the various tables have been inserted throughout the book. A feature of this issue as of others is a complete list of the more important American and foreign books which have appeared since the third issue of the Annual in 1913. The frontispiece of this issue consists of an excellent recent likeness in sepia of Professor Ira Remsen.

Richard K. Meade

Sir Wm. Ramsay as a Scientist and Man. By T. A. Chaudhuri, Professor of Chemistry, Edward College, Pabna, with introduction by Panchanan Neogi, Government College, Rajshahi. ix + 66 pp. Butterworth and Company, London and Calcutta, 1918. Price, 1/8 net.

This is an exquisite, short but accurate, oriental biography of a man, who not only interpreted, but added much to our technical knowledge of Nature. Students could profitably be directed to read this booked monograph not alone for information, but as an illustration of delightful literary style. It is "an estimate of the sublime lesson of the life and life-work of the British savant within a small compass."

Charles Baskerville

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Alloys: Introduction a l'Etude des alliages. W. BRONIEWSKY. Price, 18 fr. Delagrave, Paris.

Analysis: Course of Instruction in the Qualitative Chemical Analysis of Inorganic Substances. A. A. NOYES. 7th Ed. 8vo. 124 pp. Price, $1.50. The Macmillan Co., New York.

Chemistry: Senior Chemistry. G. H. BAILEY AND H. W. BAUSER. 2nd Ed. 8vo. 526 pp. Price, 5s. University Tutorial Press, London.

Color in Relation to Chemical Constitution. E. R. WATSON. 8vo. 197 pp. Price, $4.00. Longmans, Green & Co., New York.

Conservation of Food Energy. H. P. ARMSBY. 12mo. 65 pp. Price, $0.75. W. B. Saunders Co., Philadelphia.

Electric Motors and Control Systems: A Treatise on Electric Traction Motors and Their Control. A. T. DOVER. 8vo. 388 pp. Price, 16s. Sir Isaac Pitman & Sons, New York.

Engineering Drawing. T. E. FRENCH. 2nd Ed. 8vo. 329 pp. Price, $2.50. McGraw-Hill Co., New York.

Farm Engines and How to Run Them. J. H. STEPHENSON. 12mo. 252 pp. Price, $1.00. F. J. Drake & Co., Chicago.

Machine Design: Elements of Machine Design. H. L. NACHMAN. 8vo. Price, 9s. 6d. Chapman & Hall, London.

Mechanism: Principles of Mechanism. W. H. JAMES AND M. C. MACKENZIE. 8vo. Price, 7s. Chapman & Hall, London.

Metallurgists and Chemists' Handbook: A Reference Book of Tables and Data for the Student and Metallurgist. D. M. LIDDELL. 2nd Ed. 16mo. 656 pp. Price, $4.00. McGraw-Hill Co., New York.

Metals: Chemical Combination Among Metals. MICHELE GIUA AND CLARA GIUA-LOLLINI. Translated by G. W Robinson. 8vo. 341 pp. Price, $4.50. P. Blakiston's Son & Co., Philadelphia.

Metals: Les Metaux. Leurs conditions d'emploi dans l'industrie moderne. JEAN OERTLE. Price, 10 fr. Librarie Aeronautique, Paris.

Petroleum, Asphalt and Natural Gas. KANSAS CITY TESTING LABORATORY. 12mo. 248 pp. Price, $2.00. The Author, 1013 Grant Ave., Kansas City, Mo.

Pocket-Book for Mechanical Engineers. D. A. LOW. 16mo. 740 pp. Price, $3.00. Longmans, Green & Co., New York.

Rural Water Supplies and Their Purification. A. C HOUSTON. 8vo. 151 pp. Price, 7s. 6d. Bale, Sons and Danielssohn, London.

Steel: Fabrication de l'acier. H. NOBLE. 2nd Ed 632 pp. Price, 25 fr. H. Dunod et E. Pinat, Paris.

Steel: Trempe, Recuit, Cementation et Conditions d'emploi des aciers. L. GRENET. Price, 20 fr. Ch. Beranger, Paris.

Synthetic Dyestuffs and the Intermediate Products from Which They are Derived. J. C. CAIN AND J. F. THORPE. 4th Ed. 8vo. 440 pp Price, 10s. Charles Griffin & Co., London.

Testing, Fault Localization, and General Hints for Wiremen. J. WRIGHT. New Ed. 18mo. 88 pp. Price, 1s. 6d. Constable & Co., London.

Zinc Industry. E. A. SMITH. 8vo. 223 pp Price, $3.50. Longmans, Green & Co., New York.

RECENT JOURNAL ARTICLES

Alizarin. J. F. SPRINGER. *Color Trade Journal*, Vol. 3 (1918), No. 3, pp. 326–333.

Automatic Shell Heat-Treating Furnaces. W. J. HARRIS. *Iron Age*, Vol. 102 (1918), No. 10, pp. 565–568.

Bactericidal Efficiency of Soap Solutions in Power Laundry. H. G. ELLEDGE AND W. E. MCBRIDE. *American Journal of Public Health*, Vol. 8 (1918), No. 7, pp. 494–498.

Benzo Fast Scarlets. C. S. WEHRLY. *Color Trade Journal*, Vol. 3 (1918), No. 3, pp. 323–325.

Blast-Furnace Charge at the Bunker Hill Smeltery. C. T. RICE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 10, pp. 436–438.

Boiler Plates: A Cause of Failure in Boiler Plates; Effect of Grain Growth; Alteration of Crystalline Structure by Mechanical Deformation; Some Remedies. WALTER ROSENHAIN AND D. HANSON. *The Iron Age*, Vol. 102 (1918), No. 11, pp. 632–636.

Coal Storage in Large Quantities: Methods, Equipment and Typical Installations. H. J. EDSALL. *Industrial Management*, Vol. 56 (1918), No. 3, pp. 193–200.

Condensing Quicksilver from Furnace Gases. L. H. DUSCHAK AND C. N. SCHUETTE. *Mining and Scientific Press*, Vol. 117 (1918), No. 10, pp. 315–323.

Conveyors. R. S. LEWIS. *Mining and Scientific Press*, Vol. 117 (1918), No. 11, pp. 349–355.

Copper Refining: Recovery of Selenium and Tellurium in Copper Refining. M H MERRISS AND H. T BINDER. *Engineering and Mining Journal*, Vol. 106 (1918), No. 10, pp. 443–445.

Correcting Air Volume for Blowing: the Adjustment of Air Supply to a Blast Furnace is Governed Accurately by a New Constant-Volume Corrector, Independent of Temperature, Barometer, and Humidity. L. C. LOEWENSTEIN. *The Iron Trade Review*, Vol 63 (1918), No. 14, pp. 1004–1010.

Cottrell Processes of Electric Precipitation, with Especial Regard to the Application to the Recovery of Potash as a By-Product. J. S. GRASTY. *Manufacturers Record*, Vol. 74 (1918), No. 12, pp. 70–72.

Dyeing: Use of Organic Dyestuffs in the Preparation of Color Lakes. BARRINGTON DE PUYSTER. *Color Trade Journal*, Vol. 3 (1918), No. 3. pp. 320–322.

Dyeing of Feathers and Furs. R. W. SMITH. *Color Trade Journal*, Vol. 3 (1918), No. 3, pp. 304–310.

Electric Brass Melting: Present Status of Electric Brass Melting. H. M. ST. JOHN. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 6, pp. 321–328.

Electric Steel Production for Small Units. A. V. FARR. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 9, pp. 381–383.

Electric Welds. E. E. THUM. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 6, pp. 301–308.

Examination of Commercial Dextrin and Related Starch Products. F. W. BABINGTON, ALFRED TINGLE, AND C. E. WATSON. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 15, pp. 257–258.

Explosives: Handling and Storing of Explosives. ARTHUR LA MOTTE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 11, pp. 488–493.

Fuel Economy in Blast Furnace Practice. T. C. HUTCHINSON. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 9, pp. 378–380.

Gas-Firing: Methods of a New System of Gas-Firing: Method of Obtaining Uniform and Constant Gas Mixture for Proper Combustion Explained. A. C. IONIDES. *The American Drop Forger*, Vol. 4 (1918), No. 9, pp. 365–367.

Glass: Gas Firing and the Glass Industry. J. W. COBB. *Journal of the Society of Glass Technology*, Vol. 1 (1917), No. 4, pp. 223–238.

Glass: Some Notes on the Annealing of Glass. SOLOMON ENGLISH AND W. E. S. TURNER. *Journal of the Society of Glass Technology*, Vol. 2 (1918), No. 6, pp. 90–102.

Iron in Santo Domingo. R. B. BRINSMADE. *Mining and Scientific Press*, Vol. 117 (1918), No. 11, pp. 356–358.

Lead Plating: Some Information Regarding the Electrolytic Deposition of Lead. BUREAU OF STANDARDS, WASHINGTON, D. C. *The Metal Industry*, Vol. 16 (1918), No. 9, pp. 410–411.

Lighting Textile Mills in Wisconsin; General Lighting System of Indirect Type Commonly Used. J. A. HOEVELER. *Textile World Journal*, Vol. 54 (1918), No. 10, pp. 75–77.

Manganese: Conserving Manganese in Steel Production. A. N. DIEHL. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 9, pp. 366–367.

Molybdenum: Determination of Molybdenum in Ores. W. J. CROOK AND M. L. A. CROOK. *Mining and Scientific Press*, Vol. 117 (1918), No. 10, pp. 313–314.

Nickel and Cobalt Determination in Steel; Elimination of the Bulk of the Iron by Means of Sodium Carbonate. W. R. SCHOELLER AND A. R. POWELL. *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 9, pp. 359–360.

Niter Cake for Pickling Metal; How a Practical Man Eliminates Sulfuric Acid. G. P. BUTLER. *The Metal Industry*, Vol. 16 (1918), No. 9, p. 418.

Oil: Reclaiming Oil from Metal Turnings. C. L. SMITH. *The Iron Age*, Vol. 102 (1918), No. 10, pp. 558–559.

Oxide Film Lightning Arrester. CROSBY FIELD. *General Electric Review*, Vol 21 (1918), No. 9, pp. 597–601.

Oxide Film Lightning Arrester. C. P. STEINMETZ. *General Electric Review*, Vol. 21 (1918), No. 9, pp. 590–596.

Peat: Utilization of the Peat Resources of Canada. B. F. HAANEL. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 15, pp. 258t–261t.

Plating: Government Specifications for Copper and Nickel Plating. C. H. PROCTOR. *The Metal Industry*, Vol. 16 (1918), No. 9, pp. 407–409.

Potash: Availability of Potash in Some Common Soil-Forming Minerals. Effect of Lime Upon Potash Absorption by Different Crops. J. K PLUMMER. *Journal of Agricultural Research*, Vol 4 (1918), No. 8, pp 297–316.

Potash: Possibilities of Developing an American Potash Industry. A W. STOCKETT. *Manufacturers' Record*, Vol. 74 (1918), No. 12, pp. 68–69.

Potash: The Recovery of Potash as a By-product in the Manufacture of Portland Cement. J J PORTER. *The American Fertilizer*, Vol. 49 (1918), No. 5, pp. 58–72.

Potash: A Wet Process for Extracting Potash from Cement Dust. J G DEAN *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No 6, pp. 439–446.

Powdered Coal: A Diversified Application of Powdered Coal. CHARLES LONGENECKER. *The Iron Age*, Vol. 102 (1918), No. 11, pp. 619–623.

Producer Gas, Its Manufacture and Use: An Interesting Discussion on the Chemical Analysis of Producer Gas; Methods of Burning It and Results Obtained as Compared with Other Gases; Relative Specific Heats of Gas Mixtures Given. C. S PALMER. *The American Drop Forger*, Vol 4 (1918), No 9, pp. 345–346.

MARKET REPORT—OCTOBER, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON OCTOBER 19, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs	nominal		
Alum, ammonia, lump	100 Lbs.	7.00		
Aluminum Sulfate, (iron free)	Lb.	4	@	5
Ammonium Carbonate, domestic	Lb.	nominal		
Ammonium Chloride, white	Lb.	19	@	20
Aqua Ammonia, 26°, drums	Lb.	nominal		
Arsenic, white	Lb.	91/4	@	17
Barium Chloride	Ton	75.00	@	90.00
Barium Nitrate	Lb.	12	@	14
Barytes, prime white, foreign	Ton	30.00	@	35.00
Bleaching Powder, 35 per cent	Lb.	4½	@	5
Blue Vitriol	Lb.	9¾	@	9¾
Borax, crystals, in bags	Lb.	7¼	@	10¼
Boric Acid, powdered crystals	Lb.	7¾	@	8¾
Brimstone, crude, domestic	Long Ton	nominal		
Bromine, technical, bulk	Lb.	75	@	
Calcium Chloride, lump, 70 to 75% fused	Ton	20.00	@	22.00
Caustic Soda, 76 per cent	100 Lbs.	4.40	@	4.50
Chalk, light precipitated	Lb.	4¾	@	5
China Clay, imported	Ton	20.00	@	30.00
Feldspar	Ton	8.00	@	15.00
Fuller's Earth, foreign, powdered	Ton	nominal		
Fuller's Earth, domestic	Ton	20.00	@	30.00
Glauber's Salt, in bbls	100 Lbs.	2.10	@	3.00
Green Vitriol, bulk	100 Lbs.	2.00	@	2.25
Hydrochloric Acid, commercial	Lb.	C. P. nominal		
Iodine, resublimed	Lb.	4.25	@	4.30
Lead Acetate, white crystals	Lb.	17	@	18
Lead Nitrate	Lb.	C. P. 85		
Litharge, American	Lb.	14	@	15
Lithium Carbonate	Lb.	1.50		
Magnesium Carbonate, U. S. P.	Lb.	20	@	30
Magnesite, "Calcined"	Ton	60.00	@	65.00
Nitric Acid, 40°	Lb.	7¾		
Nitric Acid, 42°	Lb.	8½		
Phosphoric Acid, 48/50%	Lb.	7½	@	9
Phosphorus, yellow	Lb.	1.10	@	1.15
Plaster of Paris	Bbl.	2.00	@	2.50
Potassium Bichromate	Lb.	44	@	46
Potassium Bromide, granular	Lb.	1.25	@	1.30
Potassium Carbonate, calcined, 80 @ 85%	Lb.	35	@	
Potassium Chlorate, crystals, spot	Lb.	40	@	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal		
Potassium Hydroxide, 88 @ 92%	Lb.	60	@	70
Potassium Iodide, bulk	Lb.	3.75	@	4.00
Potassium Nitrate	Lb.	27	@	30
Potassium Permanganate, bulk, U. S. P.	Lb.	1.85	@	2.00
Quicksilver, flask	75 Lbs.	125.00	@	130.00
Red Lead, American, dry	100 Lbs.	11.25	@	11.50
Salt Cake, glass makers'	Ton	17.50	@	22.00
Silver Nitrate	Oz.	63¼	@	65
Soapstone, in bags	Ton	10.00	@	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.65	@	2.75
Sodium Acetate, broken lump	Lb.	20	@	21
Sodium Bicarbonate, domestic	100 Lbs.	3.60	@	3.70
Sodium Bichromate	Lb.	22	@	23
Sodium Chlorate	Lb.	25	@	25½
Sodium Cyanide	Lb.	32	@	35
Sodium Fluoride, commercial	Lb.	17	@	18
Sodium Hyposulfite	100 Lbs.	2.60	@	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.42½	@	5.00
Sodium Silicate, liquid, 40° Bé.		3¼	@	3½
Sodium Sulfide, 60%, fused in bbls	Lb.	nominal		
Sodium Bisulfite, powdered		12	@	14
Strontium Nitrate	Lb.	25	@	30
Sulfur	100 Lbs.	2.25	@	4.60
Sulfuric Acid, chamber 66° Bé.	Ton	18.00		
Sulfuric Acid, oleum (fuming)	Ton	32.00		
Talc, American white	Ton	15.00		
Terra Alba, American, No. 1	100 Lbs.	1.17½		
Tin Bichloride, 50°	Lb.	28	@	30
Tin Oxide	Lb.	90	@	1.00
White Lead, American, dry	Lb.	10	@	10½
Zinc Carbonate	Lb.	18	@	20
Zinc Chloride, commercial	Lb.	15	@	15½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	65	@	70
Acetic Acid, 56 per cent, in bbls	100 Lbs.	9.30	@	9.55
Acetic Acid, glacial, 99½%	100 Lbs.	19.50	@	19.70
Acetone, drums	Lb.	25½	@	
Alcohol, denatured, 180 proof	Gal.	68	@	69
Alcohol, sugar cane, 188 proof	Gal.	4.90	@	4.95
Alcohol, wood, 95 per cent, refined	Gal.	91½	@	92
Amyl Acetate	Gal.	4.20	@	4.50
Aniline Oil, drums extra	Lb.	30	@	32
Benzoic Acid, ex-toluol	Lb.	2.85	@	3.00
Benzol, pure	Gal.	23	@	28
Camphor, refined in bulk, bbls	Lb.	1.24½	@	1.25
Carbolic Acid, U. S. P., crystals, drums	Lb.	42	@	45
Carbon Bisulfide	Lb.	9	@	10
Carbon Tetrachloride, drums, 100 gals	Lb.	nominal		
Chloroform	Lb.	68	@	70
Citric Acid, domestic, crystals	Lb.	1.00	@	1.05
Creosote, beechwood	Lb.	2.00	@	2.10
Cresol, U. S. P.	Lb.	20	@	22
Dextrine, corn (carloads, bags)	Lb.	8	@	9
Dextrine, imported potato	Lb.	nominal		
Ether, U. S. P. 1900	Lb.	27	@	30
Formaldehyde, 40 per cent	Lb.	16¼	Gov't price	
Glycerine, dynamite, drums extra	Lb.	60	@	62
Oxalic Acid, in casks	Lb.	41	@	43
Pyrogallic Acid, resublimed, bulk	Lb.	3.25	@	3.50
Salicylic Acid, U. S. P.	Lb.	85	@	95
Starch, corn (carloads, bags) pearl	100 Lbs.	6.00	@	7.00
Starch, potato, Japanese	Lb.	13	@	14
Starch, rice	Lb.	12½	@	13
Starch, sago flour	Lb.	9¾	@	10¾
Starch, wheat	Lb.	nominal		
Tannic Acid, commercial	Lb.	65	@	80
Tartaric Acid, crystals	Lb.	82	@	85

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63	@	65
Black Mineral Oil, 29 gravity	Gal.	24	@	25
Castor Oil, No. 3	Lb.	33¾	@	34½
Ceresin, yellow	Lb.	17	@	18
Corn Oil, crude	100 Lbs.	17.75	@	18.00
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½	@	—
Cottonseed Oil, p. s. y.	100 Lbs.	21.00	@	22.00
Menhaden Oil, crude (southern)	Gal.	1.15	@	1.25
Neat's-foot Oil, 20°	Gal.	3.45	@	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	9¾	@	10
Paraffin Oil, high viscosity	Gal.	40	@	41
Rosin, "F" Grade, 280 lbs.	Bbl.	15.10	@	15.20
Rosin Oil, first run	Gal.	75	@	76
Shellac, T. N.	Lb.	68	@	70
Spermaceti, cake	Lb.	31	@	33
Sperm Oil, bleached winter, 38°	Gal.	2.23	@	2.25
Spindle Oil, No. 200	Gal.	38	@	40
Stearic Acid, double-pressed	Lb.	24	@	25
Tallow, acidless	Gal.	1.58	@	1.60
Tar Oil, distilled	Gal.	36	@	38
Turpentine, spirits of	Gal.	65	@	66½

METALS

Aluminum, No. 1, ingots	Lb.	33	@	34
Antimony, ordinary	Lb.	13¾	@	14
Bismuth, N. Y.	Lb.	3.50	@	3.65
Copper, electrolytic	Lb.	26	@	
Copper, lake	Lb.	26	@	
Lead, N. Y.	Lb.	8.05		
Nickel, electrolytic	Lb.	55	@	56
Platinum, refined, soft	Oz.	nominal		
Silver	Oz.	1.01⅛		
Tin, Straits	Lb.	nominal		
Tungsten (WO_3)	Per Unit	20.00	@	24.00
Zinc, N. Y.		9.40	@	9.60

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	4.75	@	—
Blood, dried, f. o. b. Chicago	Unit	6.95		
Bone, 3 and 50, ground, raw	Ton	37.00	@	37.50
Calcium Cyanamide	Unit of Ammonia	nominal		
Calcium Nitrate, Norwegian	100 Lbs.	—		
Castor Meal	Unit	—		
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.25	and	20c
Phosphate, acid, 16 per cent	Ton	16.50	@	17.50
Phosphate rock, f. o. b. mine:	Ton	nominal		
Florida land pebble, 68 per cent	Ton	5.00	@	6.00
Tennessee, 78–80 per cent	Ton	7.00	@	8.00
Potassium "muriate," basis 80 per cent	Ton	300.00	@	310.00
Pyrites, furnace size, imported	Unit	nominal		
Tankage, high-grade, f. o. b. Chicago	Unit	6.75	@	6.80

The Journal of Industrial and Engineering Chemistry

Published by THE AMERICAN CHEMICAL SOCIETY

AT EASTON, PA.

Volume X | DECEMBER 1, 1918 | No. 12

Editor: CHARLES H. HERTY

Assistant Editor: GRACE MACLEOD

Advertising Manager: G. W. NOTT

ADVISORY BOARD

H. E. BARNARD H. K. BENSON F. K. CAMERON B. C. HESSE A. D. LITTLE A. V. H. MORY

Published monthly. Subscription price to non-members of the American Chemical Society, $6.00 yearly; single copy, 60 cents
Price per single copy to American Chemical Society members, 50 cents. Foreign postage, seventy-five cents, Canada, Cuba and Mexico excepted
Entered as Second-class Matter December 19, 1908, at the Post-Office at Easton, Pa., under the Act of March 3, 1879
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized July 13, 1918.

All communications should be sent to The Journal of Industrial and Engineering Chemistry.
Telephone: Vanderbilt 1930 **35 East 41st Street, New York City**
Subscriptions and claims for lost copies should be referred to Charles L. Parsons, Box 505, Washington, D. C.

ESCHENBACH PRINTING COMPANY, EASTON, PA.

TABLE OF CONTENTS

EDITORIALS:
A Victory of Arms, Not Yet of Ideals 966
National Self-Containedness 966
A Special Meeting of the Council 967
A Golden Opportunity 967
An Experiment in Publicity 967
An Embargo on Research Work 968
The Return of the Chemists 968

AN INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY:
A National Institute for Drug Research. John J. Abel 969
An Institute of Chemotherapy. P. A. Levene 970
Drug Research and the Bureau of Chemistry. C. L. Alsberg 971
An Institute for Research in Synthetic Organic Chemistry. A. S. Loevenhart 971
An Institute of Therapo-Chemical Research. Frank R. Eldred 973
Institute for Research on Synthetic Drugs. D. W. Jayne 975
Remarks Concerning Suggestion for Central Medicinal Research Laboratory. E. R. Weidlein 976

CHEMICAL MARKETS OF SOUTH AMERICA:
The Chemical Markets of Colombia, Ecuador, the Guianas, Venezuela, and Paraguay. O. P. Hopkins 977

ORIGINAL PAPERS:
A Study of the Conditions Essential for the Commercial Manufacture of Carvacrol Arthur W. Hixson and Ralph H. McKee 982
The Seeding Method of Graining Sugar. H. E. Zitkowski 992
A Study of Sources of Error Incident to the Lindo-Gladding Method for Determining Potash. T. E. Keitt and H. E. Shiver 994
Determination of the Value of Agricultural Lime. S. D. Conner 996
The Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon. H. S. Bailey and J. M. Johnson 999
Composition of the Waters of the Inter Mountain Region. J. E. Greaves and C. T. Hirst 1001
On Constituents of Oil of Cassia—II. Francis D. Dodge 1005

LABORATORY AND PLANT:
Methods of Analysis Used in the Coal Tar Industry. IV—Benzols and Light Oil. J. M. Weiss 1006
A New Illuminator for Microscopes. Alexander Silverman 1013
A Special Stopcock for Dropping Liquids Arranged for Equalizing the Pressure above and below the Outlet in the Stopcock. Harry L. Fisher 1014
A New Timing Device for Simplifying the Thermometric Reading of Calorimetric Determinations. Chas. A. Myers, Jr. 1015

ADDRESSES:
Some Applications of Physical Chemistry in the Coal-Tar Industry. Wilbert J. Huff 1016
A Manufacturer's Experience with Graduate Chemical Engineers. S. R. Church 1019

CURRENT INDUSTRIAL NEWS:
Burmese Monazite Sands; Incandescent Lamps; Aluminum and Its Alloys; Peat Fuel; Oils from Coal Tar; Soda and Sulfite Pulp; Ferromanganese Manufacture in Spain; Electric Lamp Industry in France; German Enterprise in the Ukraine; Annealing Aluminum; Tanning Material in Germany; Japanese Camphor; Nickel Steel; Gas-Fired Brazing Table; A Chinese Perfume Plant; The Schoop Metal-Spraying Process. New Source of Alcohol. Bichromate Manufacture in Sweden; Beechnut Oil in the Netherlands 1020

SCIENTIFIC SOCIETIES:
French Section, American Chemical Society; Iota Sigma Pi; Society of Chemical Industry, New York Section 1023

NOTES AND CORRESPONDENCE:
An Opportunity to Help the French. New After War Preparations in the Chemical Industry of Germany. The American Dyestuff Industry and Its Prospects. The Journals of the American Chemical Society. Theft of Platinum; Chemicals for Research Work; Cooperation between Manufacturers and Universities; Invention Problems; Safety of TNT as an Explosive. Women in the Chemical Industries of England. Two Letters on Effect of Coal Ash on the Nature of Cement Mill Potash 1024

WASHINGTON LETTER 1033
PERSONAL NOTES 1035
INDUSTRIAL NOTES 1036
GOVERNMENT PUBLICATIONS 1037
BOOK REVIEWS
Organic Compounds of Arsenic and Antimony. The Chemical Engineering Catalog—1918 Edition 1038
NEW PUBLICATIONS 1039
MARKET REPORT 1040
AUTHOR INDEX 1041
SUBJECT INDEX 1046

EDITORIALS

A VICTORY OF ARMS, NOT YET OF IDEALS

Thanks be to God, a new day has dawned! The forces of domineering might which at one time threatened to engulf the world have suddenly crumbled. Fantastic dreams of universal domination and world-wide loot have been dispelled by cold steel, high explosives, and the blood of those who believe in the brotherhood of mankind.

To those of our own and of our Allies who have made the great sacrifice of their lives our hearts turn first in this moment of victory. In spirit they will live forever honored among us. For those who soon will be returning a welcome awaits such as this country has never before given to any of its sons.

It is not yet possible to grasp the full meaning of the mighty events of the past month: the change is too stupendous. How far the actual change has progressed it is difficult now to tell. Certainly the military power of the Teuton has been crushed for generations; but has his heart been changed? We believe not. Has the Kaiser abdicated? We know not. Certainly no authentic publication of his abdication paper has appeared. The question has no military significance, but it has important bearing on the good faith of a nation which is now about to begin its elementary acquisition of this useful commodity; progress in this line cannot be made in his presence. Has defeat really been accepted by Germany? In a way, yes, but only in a way. The "solfings" of Dr. Solf, daily flashed to us by the wireless, show plainly that we are still facing the same German heart, have still to guard against the same machinations, have still to witness the same stupid psychology by which at one time we as a nation were charitable enough almost to be deceived.

No, Germany has not yet gone down through the dark valley of suffering where alone she can cleanse herself for fellowship in the great family of nations. Until that day is reached let us be on our guard. The sacrifices already made for civilization must not be in vain.

NATIONAL SELF-CONTAINEDNESS

For the past four years we have advocated the doctrine of national self-containedness. The vast and varied natural resources of this country justify the conviction that economic independence can be attained if opportunity is afforded the chemist to exercise his skill upon this raw material. Lack of independence resulted not long ago in serious economic disturbances; preparedness for the future demands that recent progress toward independence, intensified by war conditions, continue unabated. Ultimate reaching of the goal depends upon two factors, our ability as chemists and the coöperation of the body politic.

The first of these two factors is our own responsibility; the second has for its foundations a sympathetic, well-informed public opinion, confidence in the ability of American chemists, patience to wait through the unproductive days of investigation, and willingness to meet perhaps higher costs of production during the period of development of research results into sound and efficient manufacturing practice. Without attempting a systematic survey let us make candid inquiry as to the present state of security of these foundation stones.

Certainly public opinion is to-day better informed and more sympathetic than ever before. So, too, is there abundant evidence not only of confidence but of pride in the ability of the chemist. The constant increase in the number of industrial research laboratories bears witness to increased willingness to wait upon investigation. So far so good. The last stone, however, the willingness to meet temporary higher costs of production, seems to be wabbly. Evidently an insufficient amount of cement has been used to give it firm setting. That some cement has been used is evidenced by the prompt action of consumers in joining in the request for a protective tariff in order to insure independence in dyestuff supplies. But what about potash and duty-free imports for educational institutions?

First, as to potash, real progress has been made in the procurement of a domestic supply, but support has not been received from the great organizations of the chief consumers, the farmers. Why is this? We will not attempt to answer, for it would bring us into the region of surmises. Perhaps a partial answer is found on page 2 of the *U. S. Official Bulletin*, October 25, 1918. Summarizing the conference on potash held in the offices of the Department of Agriculture, the *Bulletin* states:

> "* * * the view of the Department of Agriculture is that the Government should do all that is possible to encourage the production of potash from the cheapest sources in this country in order to enable farmers to obtain it at a low price, *because foreign supplies are now unavailable.*" (Italics are ours.)

The reading naturally suggests the thought, What will be the attitude when foreign supplies are again available? The cement is weak, very weak.

Second, at the Urbana meeting of the AMERICAN CHEMICAL SOCIETY the matter of "duty-free imports" for educational institutions was thoroughly discussed and a committee appointed to find some way of removing this obstacle to the development of American manufacture of laboratory supplies. Up to date, however, we have heard of no action by the Association of American Universities or by the heads of the chemistry departments of these institutions. Our constant plea is that Americans should stand by the American chemical industry. Should we not practice among ourselves what we preach to others? Moreover, can we put the right spirit into the students we are training for the American industry when the "import" atmosphere pervades the whole laboratory? This seeming saving through "duty-free imports" is one of the costliest endowments our educational institutions possess, in that it cuts at the very heart of independence through instilling the spirit of dependence in the chemists of the future.

A SPECIAL MEETING OF THE COUNCIL

At the outbreak of the war the AMERICAN CHEMICAL SOCIETY led the way in a prompt tender to the Government of a wealth of information, through the census of chemists and their qualifications, compiled in cooperation with the U. S. Bureau of Mines, which has proved of inestimable value. Now it is incumbent upon this great organization of American chemists to do its part in the reëstablishment of normal conditions. With this in view, there has been called a meeting of the Council of the Society at New York City on December 14, 1918, which will doubtless prove the most important in the history of that body. The Secretary's notice of the meeting contains the following salient paragraphs:

The Advisory Committee of the AMERICAN CHEMICAL SOCIETY has requested President Nichols to call a meeting of the Council at as early a date as practicable, in order that the Council may carefully consider the whole question of the Society's opportunity and duty in regard to the reconstruction of conditions chemical which are to follow after the war. The AMERICAN CHEMICAL SOCIETY has had an influence, fully admitted by all, during the war; and now that the war is over and peace is in sight other great problems are before us in the solution of which the Society can again serve our country.

Accordingly, you are all asked to discuss these problems with the other chemists of your local section, or with anyone whose ideas are worth while, and to come to the meeting of the Council in New York prepared to present and elucidate your views. You are requested particularly to have a meeting of your local section called in advance of the Council meeting and to take up there with the members the general problem in order that the full force of the AMERICAN CHEMICAL SOCIETY may be felt in this matter.

You will find an interesting article by Dr. B. C. Hesse in the November issue of the *Journal of Industrial and Engineering Chemistry* which you should read. If possible, send to me in writing any ideas which may be evolved, to reach this office on or before December 10, in order that they may be brought before the Directors of the Society to be duly formulated with others in advance of the Council meeting.

Large problems loom before us which must be considered from the new viewpoint which a world freed from the scourge of Teutonic ideas presents. No one man or small group of men is qualified to decide such matters. Decision must be based upon a thorough knowledge of the views of all chemists, presented and discussed where common counsel can be deliberately taken and policies carefully formulated.

Much material for discussion should be furnished in the suggestions received by the Philadelphia Section in response to their effective action following Dr. Hesse's address, "Preparation for After the War," published in our last issue. It should be borne in mind, however, that at that Council meeting any subject which bears upon the welfare of this country through chemistry is in order for discussion. Now is the time, therefore, for meetings of local sections, at which every phase of this subject should be canvassed, insuring thus that the gathering in New York City on December 14 will be thoroughly representative, not simply of the personnel, but of the views of the membership of the Society.

In this connection it should be noted that the Advisory Committee meets in the early part of each month, and that the committee would gladly welcome at any time suggestions from local sections, councilors, or individuals.

A GOLDEN OPPORTUNITY

As a Nation we have just expressed on Thanksgiving Day our gratitude that peace has been justly restored to a war-torn world. Again we approach that natal day whose century-old maxim is "Peace on earth, good will toward men." Shall these expressions of thankfulness and good will stop with mere lip service? We never wish it so, but often know not where to turn to find that human objective which will give to our sentiments the glorifying touch of personal application. On page 1024 of this issue Secretary Parsons outlines the work of the American Ouvroir Funds, which is seeking the "adoption" of those French orphans whose fathers were technical men, graduates of l'École Polytechnique who have fallen at the front. The plan is so direct, so practical, and so filled with the human touch that it will grip the heart-strings of all who give it even a cursory reading.

The AMERICAN CHEMICAL SOCIETY has been asked to lend its aid in securing as many as possible of these "adoptions," which may be undertaken either by individuals or by groups. We are now in the midst of meetings of our local sections held for discussing constructive plans for the new period in the world's history into which we are about to enter. Could any more fitting prelude to these discussions be found than a warm-hearted presentation of the righteous claims of these orphans; could any nobler record appear upon the minutes of any local section than the statement of the number of these orphans "adopted" by the section or by its individual members? We would waive all precedent, all by-law requirements, and suggest that the first item of business at the important meeting of the Council on December 14, 1918, be reports from the Councilors of the number of orphans "adopted."

Six "adoptions" by members of the Society have already been recorded. May the number increase tenfold within the month!

What do we not owe to France, who for four years stood at the gateway of civilization and with all her resources, human and material, kept back the marauder? Silent in her great losses and suffering, cheerful in even the gloomiest days, determined in every fiber of her national being, she stands triumphant at last. Problems of reconstruction now confront her, and in at least one of these, the care of her orphans, it is our great privilege to share. Perhaps the little Jeans and Maries of to-day may prove to be the ties of strength which will bind France and America in closer union than could be possible through diplomatic scroll or statesmen's strivings.

AN EXPERIMENT IN PUBLICITY

Another experiment in chemistry has been in progress, and the results are indeed interesting.

At the April 1918 meeting the Directors of the Society appropriated $2500 for a revival and continuance of publicity work during this year. Admittedly this appropriation was in the nature of an experiment, undertaken because of the belief that a more sympathetic bond should be established between

the public-at-large and the chemists. It was felt that this purpose could be served best by seeking to develop in each Local Section talent for popular presentation of chemical facts. Contributions of short articles were therefore asked of the members, and a payment of $5.00 was offered for each article accepted.

The results of the experiment have just been compiled for the Directors. These show, first, that the administration and mechanical carrying on of the work is a much less formidable undertaking than was originally supposed, hence funds for continuance of this part of the work can be largely curtailed next year. Fifty bulletins have been issued to date. Returns from the clipping bureau, necessarily incomplete, show that the bulletins were used in varying numbers by 120 newspapers and magazines distributed through 72 cities in 26 states. Nineteen of the fifty bulletins were contributed by members of Local Sections other than the members of the General Committee or its office staff. All of the nineteen were received after July 30, 1918, and most of them originated within the Minnesota Section, not, we believe, because that Section has any special monopoly on popular writing but because it took hold of the matter in a live way and put some real punch into the effort. This is best illustrated by the following extracts from an announcement sent out in mimeograph form to each member of the Section:

Does $5.00 look good to you?

Now that you are interested we will tell you how you can make that much money in less than 30 minutes. You are a chemist; you have a chemical hobby; you think it is really the only phase of chemistry worth working at; you feel sorry for others because they can't see all of the interesting phases of your work; you are even in a line of work which is of great scientific and practical value to the nation.

Sit down and write a 500-word article full of interest with lots of "news punch" about your favorite line of science and write it so that people may not only be interested but that they may also gain some information as to the importance of chemistry in its relation to the every-day things of life.

Send this article to Chairman Publicity Committee, AMERICAN CHEMICAL SOCIETY, 35 East 41st St., New York City. If the article is of general interest, and is accepted you will receive $5.00 in the return mail.

If you don't need the money, write an article anyhow and buy Thrift Stamps with the proceeds.

We are asked by the Society officers to do all that we can to bring chemistry home to the people. Pay your annual dues by writing two articles of general interest. The Chairman of the Committee on Publicity has requested that we bring this to your attention. Individuals and local sections will receive credit for accepted articles. These articles will be published all over the country. If you have chemical items of local interest, don't fail to write them up.

If each Local Section in preparation for the new year would follow the worthy example of the Minnesota Section in presenting this matter directly to each member, we are confident that headquarters would be overwhelmed with material for consideration, and that results of incalculable value would be secured, whether or not the contributions were accepted.

Try your hand who knows?

AN EMBARGO ON RESEARCH WORK

We print here a letter which has been received from a research chemist whose amiable disposition precludes his being classified as a chronic kicker:

I think the following letter from a manufacturer may interest you, as it indicates what amounts to a government embargo, in all probability unintentional, on research work in chemistry in the United States:

> "We cannot ship you any phosgene for the reason that the Government has put in new regulations regarding shipments of phosgene gas.
>
> "The new regulations provide that this must be shipped in special trains accompanied by messenger. Hence you can see the impossibility of our making shipment."

I deem it imperative that this restriction on the transport of all chemicals, at least as far as universities and the chemical industry are concerned, be removed at the earliest possible date, and I trust your Journal will consider this question of sufficient importance to give publicity to the law herewith concerned, and will also suggest whatever remedy the situation may warrant. Furthermore, I am certain chemists will be interested in knowing just what chemicals come under this embargo. I know that metallic sodium, as well as phosgene, is under the ban. Now how far can the organic chemist go without sodium? If we consider its use in the manufacture of veronal, luminal, adalim, and phenyl ethyl alcohol, substances for which there is a great demand and a limited supply, I think the predicament of the research chemists in this country, who may be engaged in developing methods for the manufacture of these important pharmaceuticals, is sufficiently emphasized. We are progressing with giant strides in building up chemical industries in the United States, but we should not lose sight of the fact that the only solid foundation on which successfully to rear a permanent business in this direction is *research*.

Before the war there was a way to get any chemical from Germany to our laboratories. It is true there were certain rules that had to be observed in reference to containers, but the important fact is there was a "way" to get phosgene, metallic sodium, picric acid, etc. The question arises, would it not be a happy solution of the problem in hand for the Government to call to its assistance a few representative chemists and have them indicate how the needs for chemicals of every description which our laboratories and industrial plants require may be met? All the chemicals at present under embargo, with the proper safeguards, have been in the past, and could be now, transported without extra hazard.

It may be interesting to call attention to the fact that, if I am correctly informed, the only practical way for the manufacturer to obtain metallic sodium is to incur the expense of an auto truck to and from Niagara Falls.

The point raised is one which will affect every research laboratory. With the early return to the universities from war service of professors and graduate students, general research should soon get under full swing, but this important work will be sorely handicapped if a change from conditions here depicted is not quickly obtained. It is therefore earnestly urged that the proper officials of the Railroad Administration modify existing regulations so as to give the necessary relief.

THE RETURN OF THE CHEMISTS

In the development of the Chemical Warfare Service into an effective war machine invaluable service was rendered by Major Allen Rogers, chief of the Industrial Relations Branch, in establishing a sensible balance between the supply of chemists for service in the military ranks and in essential industries. Now that the demobilization of this great force of soldier chemists is about to begin, it is fortunate that the work is to remain in charge of the same efficient officer, as noted from the following announcement:

When the United States entered the European War one of the first problems to be considered was the effect of the draft upon our essential industries. It was early appreciated that in order to maintain our full efficiency it would be necessary to conserve

as far as possible our skilled workers and men with technical training. In order that we might not suffer from the depletion of our ranks, steps were taken to secure deferred classification, and later on provision was made to furlough back to industry. This arrangement made it possible for chemical industries to maintain their efficiency and has contributed largely to the effectiveness of our forces in the field.

Up to the time of cessation of hostilities the Industrial Relations Branch of the Chemical Warfare Service had recommended for deferred classification 641 chemists and skilled workers. These recommendations were favorably considered, as a rule, by the Local Boards, and as a result about 90 per cent of the men so recommended were put in a deferred class.

Many cases, however, were not brought to the attention of this branch until the men had actually been called into service. Such chemists or skilled workers as were essential to industry were then furloughed in order that the production of war materials might not be retarded. Through this method 156 men had been returned to industry, and at the time of the signing of the armistice 120 more cases were pending in the Adjutant General's Office.

As hostilities cease we naturally must again turn to peace time conditions and look forward to the future development of chemical industry in America. The problem now before the Industrial Relations Branch of the Chemical Warfare Service is to assist chemists in service to secure positions where their training and experience can be used to the best interests of the Government. This enormous readjustment is rendered possible through the information gathered by Dr. Charles L. Parsons, secretary of the AMERICAN CHEMICAL SOCIETY, and through the questionnaires sent out by Major F. E. Breithut of the Personnel Division of the Chemical Warfare Service.

In order to accomplish results the chemists now in military service who desire to return to chemical industry are being requested to inform the chief of the Industrial Relations Branch concerning their future prospects, while the manufacturers are being asked to designate their requirements for chemists. The administration of this work will be carried out by the Industrial Relations Branch. Any information desired may be obtained by writing to Major Allen Rogers, Chief, Industrial Relations Branch, Chemical Warfare Service, 7th and B Streets, N. W., Washington, D. C.

Here is a definite problem of readjustment of the utmost importance, and we congratulate the Chemical Warfare Service on the promptness with which it has moved. We are led, however, to wonder what plans are being made for the demobilization of the large number of chemists secured recently for war purposes in other branches of the government service, for example, the Ordnance Department. Up to the present time we have not heard that specific steps have been taken, although the problem is fully as important in these other departments.

AN INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY

Addresses delivered before the New York Section of the AMERICAN CHEMICAL SOCIETY, November 8, 1918

At the meeting of the New York Section of the AMERICAN CHEMICAL SOCIETY on November 8, 1918, a symposium was held upon the subject of an institute for coöperative research by chemists, biologists, and manufacturers as an aid to the development of the American drug industry. The basis of the discussion was an editorial in the September 1918 issue of THIS JOURNAL entitled "War Chemistry in the Alleviation of Suffering." At the conclusion of the regular program Dr. E. R. Weidlein, Acting-Director of the Mellon Institute, upon invitation, spoke of the early steps in the foundation of that institution. He traced its continuing growth, outlined the conservative principles which had proved such wise safeguards for its well-being, and in a spirit of enthusiastic support of the movement offered to aid to the fullest extent desired in the formulation of the policies of the proposed institute. In the following report of the meeting there is included a communication subsequently received from Dr. Weidlein.

As the matter under discussion was of national rather than of local import, the resolutions adopted at the close of the meeting were referred to the Advisory Committee of the AMERICAN CHEMICAL SOCIETY.

The feeling of those present at the meeting seemed to be epitomized in the remark of a prominent manufacturer who said, "Something has been started to-night."—EDITOR.

A NATIONAL INSTITUTE FOR DRUG RESEARCH

By JOHN J. ABEL

I am greatly interested in the plan for a national institute in which chemists would coöperate with specialists in the medical sciences to produce new remedies for the alleviation of human suffering.

The need for such an institute is very great and its opportunities are boundless.

Among the many problems which it might undertake would be the isolation of powerful drug principles, like the so-called hormones, problems which cannot be solved without the help of the funds and the facilities offered by a great central institute. For example, the investigator who attempts to isolate the active principle of the pituitary gland, the most powerful uterine stimulant known to medicine, finds that the price of the raw glands is six dollars a pound in the Chicago slaughter houses and that he must be on hand with the proper equipment to work up the fresh glands as they are gathered. Considering the large amount of material necessary and the cost of all the operations involved, it is plain that the individual investigator would have no chance to solve a problem of this sort without generous financial assistance.

This is but an example of the innumerable problems, all of the greatest scientific and practical importance, that lie all about us. There are a great number of crude drugs known to barbarous, as well as civilized peoples, which should be exhaustively studied in the interest of both science and medical practice. Furthermore, with the knowledge that is already at hand, the joint labor of pharmacologists and organic chemists should lead to the synthetic production of a very great number of drugs of the most diverse qualities

and remedial powers and hence of the greatest service to mankind, or, stated more precisely, combining the chemo-therapeutic data already in hand with the innumerable hints that are given by nature's own remedies should yield an enormous return in new synthetic products.

The time at my disposal does not permit me to elaborate this theme as much as I could wish or to cite examples in illustration. The wonderful work of Ehrlich in giving us organic arsenical derivatives for the cure of syphilis is an illustration of what was accomplished by the combined labors of pharmacologists and chemists supported by adequate funds. What has been done in our own country in the way of the isolating of active principles from natural sources, as well as in the production of synthetics, should make us certain that from the large number of trained pharmacologists and organic chemists among us a group of men could be selected who would turn out brilliant work in a national institute such as has been proposed.

What are the requirements for a successful national institute of therapeutics and pharmacology, or whatever it might be called?

I—A large endowment, the income of which should be sufficient to finance the following groups of workers.

II—Workers: Group 1 would consist of pharmacologists who should have some knowledge of chemistry as well as of medicine. With this group must be associated a certain number of pathologists, bacteriologists, biological chemists, and such other specialists from the medical and biochemical field as the needs of the work require, a fluctuating number, at least in subordinate capacities. Biological chemistry, however, would play such a large rôle that this first group would always contain at least one eminent leader in this field.

This first group would in the course of time naturally divide itself into various sub-groups each devoting its energies to a special field, but all working in close coöperation. Thus, it is evident that there would be a sub-department for pharmacological and toxicological testing of new drugs and poisons. Such a sub-department could very easily train young men to take positions with manufacturing firms which more and more require the service of such men. This department of the institute could also undertake the pharmacological and toxicological testing for individuals and firms who have no laboratories of their own.

Group 2 must be made up of capable and highly trained organic chemists and their main work would be in perfecting various syntheses, the hints for which would probably be derived from the work of the first group. Individuals of the two groups would naturally pair off to work together on some given problem.

In this second group there would also develop various subdivisions; thus, one or more men would take charge of the microchemical and ultimate analysis. In time there might even be a division for the prosecution of pharmaceutical chemical research; a subdivision of this character could be depended on to stimulate scientific pharmacy in this country.

I will not now elaborate further on the various subdivisions of a national institute of the character under discussion. I would, however, emphasize that the two important things to be borne in mind are:

(1) A sufficient endowment to make the institute independent of any outside influences.

(2) The Board of Trustees of this institute must see to it that those selected for the leading positions are men of ability and promise, whose one interest is research of a high order, whether in the field of pure or of applied science.

It is evident that an institute of this kind must do work in both pure and applied science as indicated in the above outline.

While I have attempted to give a brief outline of what seems to me a feasible scheme for the development of our proposed institute, I would welcome any modification, however extensive, which would be found advisable by those selected to man such an institute, for we shall all agree that these men must be the very best that the country can furnish. Men of this caliber must be given great freedom of action.

Johns Hopkins University Medical School
Baltimore, Maryland

AN INSTITUTE OF CHEMOTHERAPY

By P. A. Levene

The thought that the American chemical industry, in order to be successful and impregnable against foreign competition, needs the most careful utilization of all intermediary products, is not novel and requires no new advocates. It is also well recognized that the most profitable utilization of the intermediary products of chemical industry lies in their conversion into drugs. The problem which confronts us to-day is how to establish the American drug industry on a solid basis.

It is needless to say that in order that the production of a drug shall be profitable to American industry the drug must be American in origin, and in order to be successful it must equal and, if possible, excel the corresponding drugs of foreign origin.

Naturally, as in every other enterprise, one must have a certain faith that the work has promise of success. Fortunately every one of the more successful remedies is far from the state of perfection, and new fields of application of chemical remedies in connection with preservation of health or with treatment of disease are being discovered every day.

Thus the chemical knowledge of the cardiac vasoactive remedies is in an elementary state; the field of anesthetics, though it has received some attention, remains rich in promise of fruitful results; there is much to be discovered in the field of antiseptics; the chemical treatment of infectious disease is a field all new and most attractive to the chemist; and those substances known as accessory food elements or vitamines, have as yet not emerged from the darkness of mystery.

However, several conditions have to be met in order that the enterprise may end in success:

First, the existence of a chemical industry furnishing the intermediary products.

Second, the existence of facilities and equipment for pure scientific research in the field of medical chemistry.

Third, the existence of trained specialists for the required work, and finally, the existence of ample and generous material support of the work and of the workers.

The chemical industry has come to stay in this country, hence one of the conditions is already met. The question of capital is not the domain in which the biochemist is at home. I shall dwell principally on the plan of organization which will aim to satisfy the two remaining conditions.

Every one intimately familiar with the development of medicinal remedies realizes the fact that there are very few, if any, individual workers who possess all the technical skill and the theoretical information required for the development of any one remedy. As a rule, drugs are poisons. Both their toxic and therapeutic properties may be altered by the mode of administration or by chemical modifications. The rules which govern the toxicity or therapeutic properties of drugs are not constant, hence before any remedy is offered to the profession, all its toxicological, physiological, therapeutic, as well as chemical properties, have to be established. For the efficiency and expediency of the work it is most desirable that all the work should be done in close coöperation with a group of specialists, preferably housed in the same institution.

I therefore suggest the organization of an institute of chemotherapy in the broader sense of the term. The aim of the institute should be on one hand to promote this branch of science, on the other to offer the facilities to industrial institutions to solve specific problems which they may encounter.

To meet this double function the institute is to consist first, of a permanent staff of investigators engaged in free, independent, and undisturbed research; and second, of groups of workers employed by their individual industries for special investigations. The aim of the first group will be principally to advance theoretical knowledge, which ultimately may establish the correlation between chemical structure and biological action, and furthermore, to train younger investigators.

The second group shall consist of temporary units employed by the industrial institutions, but working under supervision or control of members of the permanent staff. These temporary units may then serve as a nucleus for development of laboratories housed in the respective industrial institutions.

This plan is offered as one of three possible alternatives, the other two being the coöperation of the existing industrial laboratories with either the medical college or with the government laboratories.

In order to appreciate my objection to the medical school it is necessary to recall the history of modern medicine. Medicine of to-day became a science with the development of the microscope and galvanometer Cellular pathology, electrophysiology, and bacteriology are the foundations of recent medicine. These subjects dominate the horizon of the medical school.

It is perhaps right that it should be so. True, those of us who are chemists are inclined to think that the chemical mode of reasoning will some day acquire ascendency in the medical mind, but this is a dream of the future. For the present, in the majority of medical schools, with few exceptions, the teachers and students think in terms of cellular pathology or electropotentials. This mode of thinking is scarcely conducive to the development and stimulation of chemical visions. There are other arguments against coöperation with the colleges, but time does not permit to analyze them all.

Against the coöperation with the government bureaus I have no argument of principle. I feel, however, that the existing Bureau of Chemistry is already so overtaxed with a multiplicity of functions that it can scarcely be expected to do justice to all. Besides, it is a difficult and unpromising task to educate a government to a more generous and liberal treatment of the scientist.

Rockefeller Institute for Medical Research
New York City

DRUG RESEARCH AND THE BUREAU OF CHEMISTRY

Abstract of Address by C. L. Alsberg

Dr. C. L. Alsberg, chief of the Bureau of Chemistry, United States Department of Agriculture, spoke extemporaneously of his deep interest in the subject of the evening, as for many years he has been particularly interested in the development of the synthetic pharmaceutical industry in the United States. In his own Bureau work along related lines has been undertaken, for the benefit of agriculture, in the production of insecticides and fungicides. The work of the Bureau's color laboratory was described and the hope expressed that with this work well established its next development would be in the closely related field of synthetic medicinals.

Dr. Alsberg agreed with previous speakers that part of the work contemplated in the subject of the evening could not be carried on under government auspices, as he felt that the federal laboratories could not be utilized for the study of specific problems for the benefit of individual manufacturers. He was confident, however, that the work of his Bureau would dovetail into the work of the proposed institute, and expressed his best wishes for the success of the movement which had within it many possibilities of lasting blessings.

Bureau of Chemistry
Washington, D. C.

AN INSTITUTE FOR RESEARCH IN SYNTHETIC ORGANIC CHEMISTRY

By A. S. Lorvenhart

In my work at the American University Experiment Station I have seen how satisfactory and effective research work in close coöperation between chemists and pharmacologists may be. The object toward which we are working there is the development of materials destructive of life, but the thought naturally presents itself that if this coöperative work is so effective

in war time for the development of offense weapons, in peace time such coöperation would be of enormous value in promoting the security of life and its comforts.

I may briefly recount the way in which the work at American University has been conducted. Most of the materials are produced by chemists working in the Station. Formal conferences are held twice a week between pharmacologists and chemists, and there are informal conferences each day. At these conferences it is decided what substances should be prepared. When the materials are synthesized they are turned over to the Pharmacological Section for every sort of test. The results of these tests are then made known to the chemists and the possibilities of improving the materials are then discussed. I may say that the work has been eminently successful from every standpoint, and that the coöperation has been delightful. One can hardly realize until he has experienced it how the pharmacologist and chemist working together mutually stimulate one another.

I am therefore prepared to testify that coöperation of the kind proposed is not only practicable, but is the ideal condition for productive research. The question then presents itself: What should be the character of the proposed institution? What fundamental ideas should guide in its organization? The previous speakers have mentioned several possibilities. I propose to bring up for discussion a somewhat different type of institution. The proposition under consideration has interested me for many years, and I have only been awaiting the time when a realization of this dream might be possible. This is the propitious time for establishing such an institute, at the close of the great war, when we must face the great reconstruction period. Bold ideas, and large development along chemical lines are in order. The marvelous struggle that Germany has been able to put up against the rest of the world has to be attributed largely to her fostering of synthetic organic chemistry, during the last fifty years, so that they have been able to develop every manner of substitute for essential things. The great war has brought home to every one the thought that national security rests largely upon chemical development and especially upon the fostering of synthetic organic chemistry. Since the fostering of this subject is essential for national security, every patriot must do what he can to see that the subject is developed so that our country shall not only be independent of the rest of the world but that it shall lead if possible in this line of work. Such organizations as the National Security League should have brought to their attention in the most forcible manner possible the essential character of organic chemistry, in order that they may not devote their entire energies to the building up of an army and navy, but may apply some effort to the more subtle and less obvious forces required for the national security, and which also in time of peace shall be a source of great value and profit to the world at large.

The question then naturally presents itself: How may the production of organic chemicals be built up into a great industry in this country? In this connection we may for a moment consider what factors have played a rôle in Germany in building up their immense development in this field of endeavor. While the establishment of such an institute will be a wonderful stimulus and factor, it alone will not suffice. It is obvious that one of the most important factors will be the filling of our chairs of organic chemistry in the universities with the truly inspirational type of teacher, and provision must be made that he shall receive more for his service than the niggardly salaries which the universities at present pay. I understand that when the University of Heidelberg desired to obtain the services of Victor Meyer as professor of chemistry they asked him under what conditions he would come. He stated that he would require a salary of 25,000 marks; that a new chemical laboratory should be built in addition to the old one of Bunsen; and that his first assistant should be a full professor. In Germany the professor receives in addition to his salary the fees of his students, which in the case of Victor Meyer probably amounted to 75,000 marks a year. On the supposition that this story, which I have from one of Victor Meyer's old students, is correct, Victor Meyer was receiving upwards of 100,000 marks a year, in addition to whatever income he may have received from his patents. It must be borne in mind that this occurred about thirty years ago, when the purchasing power of the mark approximated that of the dollar. This story is told merely to indicate that when the German university desired to have a man to fill the chair of chemistry the authorities ascertained under what conditions he would come and met his conditions. Teachers of this type should not be allowed to go into the industries in order to receive the compensation which their talents justify.

The lack of coöperation which has existed between men in university chairs and manufacturing concerns has been due to many factors. The university man had to feel absolutely certain that his name and university connection would not be used in any way for advertising purposes. Again, many of our best drug firms have been in the habit of making unwarranted statements in their advertising which were not borne out by the facts. The drug firms, like other commercial enterprises in this country, spent far more money and laid more stress on their advertising and salesmanship departments than on research to insure that they had a product which would stand on its own merit and which would require less advertising and not such a high order of salesmanship in order to place it on the market successfully. The recent campaign for honest advertising in all lines has produced splendid effects, and the work of the American Medical Association through the Council on Pharmacy and Chemistry and the issuing of *New and Non Official Remedies* has done a wonderful service which cannot be praised too highly.

The need for an institution of the type proposed is obvious when one realizes that there is no institution in America to-day where the therapeutic value of a

drug can be determined in a manner acceptable alike to scientific men and physicians. To my mind such an institute should not only foster the production and testing of remedial agents, but every phase of synthetic organic chemistry should be considered within its domain. This is necessary because remedial agents may be found among any group of organic chemical products. Remedial substances do not fall entirely within the field of the coal-tar series, as many chemists seem to think.

I will briefly and roughly outline what I think should be the scope of the proposed institute. In the first place, it must be endowed. The initial endowment should be at least $1,000,000, but preferably not less than $5,000,000. The institute should be entirely independent of any existing institution, but it should establish very close working relations and coöperation, especially with the following institutions: the AMERICAN CHEMICAL SOCIETY, the American Medical Association, the American Pharmaceutical Association, the Hygienic Laboratory of the Marine Hospital Service, the Bureau of Chemistry of the Department of Agriculture, the Chemical Warfare Service of the War Department (in case this is continued in peace times), all university departments of chemistry, research chemical institutions and industrial concerns.

There should be many departments, all headed by men of the highest rank who have the full confidence of the scientific and medical men of the country. The institute should not only encourage organic chemistry within its own walls, but in all universities and industrial concerns. To this end it should maintain the largest possible collection of organic chemicals, which would be furnished to any university or industrial concern at cost in smaller quantities. It should also be willing to synthesize for chemists any substances which they require for their work, these substances to be furnished at cost. This idea is prompted by the tremendous advantage German chemists have had in securing from industrial concerns any substances which they require in their work in almost any quantities, whereas this has been denied the best American investigators.

Another important function of the institute should be the obtaining and administering of patents by organic chemists. Any scientific man should be able to turn over to the institute any patent relating to synthetic organic chemistry on the basis that he receive as a maximum fifty per cent of the profits, or any less amount that he may elect, the remainder of the profits being his contribution to the research fund or the general fund of the institute. This would ultimately result in an institute of great financial strength, which is a matter of great importance. The institute might handle its patents by licensing a limited number of concerns to use them, or in special cases it might itself manufacture, in case existing manufacturers hesitated to make use of a given patent.

One of the departments of this institute should be devoted to pharmacology and toxicology, and it would be necessary in order to make the final therapeutic tests acceptable to the medical profession to control a hospital devoted to experimental therapy, to which only selected types of cases would be admitted. This feature alone would indicate the necessity of the institutes becoming financially strong in order to bear the expense of such a hospital.

In conclusion, I may say that I am willing and glad to do anything in my power to further such a project as this, because I have the feeling that it is a matter of the utmost importance, not only for the security of our national life but for the benefit of the world at large.

AMERICAN UNIVERSITY EXPERIMENT STATION
WASHINGTON, D. C.

AN INSTITUTE OF THERAPO-CHEMICAL RESEARCH

By FRANK R. ELDRED

In an editorial in the September issue of the *Journal of Industrial and Engineering Chemistry*, under the title "War Chemistry in the Alleviation of Suffering," Dr. Chas. H. Herty points out the need for a research institute for the pharmacological and clinical testing of medicinal substances.

In discussing such an institute from the standpoint of the manufacturer of medicinal products, I shall not attempt to dwell at length upon its relations with the manufacturer, since successful cooperation would depend entirely upon the organization and policy of the institute and the character of the work done.

If an institute of this kind is to attain a high degree of usefulness, its organization and management, both administrative and scientific, must receive the most careful consideration. Its field of work should be distinct from that of other similar institutions already established. It is of prime importance that the proposed institute be essentially a chemical institute. It should be organized and conducted under the sponsorship of the AMERICAN CHEMICAL SOCIETY and should in some manner be closely affiliated with that organization. Upon the above propositions will rest the success of the undertaking.

During the past four years we have made wonderful strides in all branches of chemical industry and with the coming of peace, steps must be taken to make these achievements permanent assets to our country and to assure continued progress.

In the branch of chemical industry devoted to the alleviation of human suffering the proposed institute would thus have a twofold function: to aid in making us as far as possible independent of all other countries in the production of necessary and valuable medicinal products, and to encourage, as well as take an active part in, researches directed towards the discovery of more effective agents for the prevention and cure of disease. Of these two functions the latter is undoubtedly the more important. With proper governmental protection the manufacturer can be trusted to make this country independent in the production of medicinal chemicals which have an established use, but it is in the development of new medicinal agents that the great difficulties and great opportunities lie.

It should be made clear that the need is not for

more drugs but for better—and fewer—drugs. It would be of slight value to establish an institution merely for the purpose of testing, pharmacologically and clinically, new or old drugs which might be submitted to it, but it would be difficult to estimate the immense value of a great research center for the study and improvement of our present chemical agencies for combating disease. In the ultimate analysis all agencies for this purpose are chemical agencies, just as the life processes are chemical processes, and it is for this reason that the institute should be so organized and supervised that all of the problems which come to it will be attacked from the chemical standpoint.

It is a rather disquieting thought that we know almost nothing about the mechanism of the action of medicines and that our present medicines have been developed by empirical methods. The effects of many drugs now widely used were discovered accidentally, while certain synthetic drugs were apparently developed for the purpose of utilizing a cheap by-product or a readily available intermediate, and still others were discovered by trying, more or less indiscriminately, one substance after another until one was found which had the desired action. Only a few of the many German synthetic drugs have proved to be of real value, while the larger number have been foisted upon the public by clever propaganda. It is not desirable that an institution should be established to foster this kind of research. Probably no one but a drug manufacturer knows how many remedies are proposed by chemists and others not chiefly occupied in the development or production of medicinal substances and therefore without any broad knowledge of the needs of medicine. No excuse can be found for many such proposals; some are based upon unsound reasoning and others are entirely lacking in originality, frequently to the extent of having been previously tried and discredited. It would only increase the number of drugs and at the same time lower their average efficacy if drugs inferior to those already available were placed upon the market. A research institute such as we are considering must not therefore lend its influence to the multiplication of drugs of doubtful value nor waste time in the investigation of many of the remedies which might be proposed.

Although little is known in regard to the manner in which medicines produce their physiological effects, animal experimentation and clinical tests have yielded a great mass of facts in regard to the effects which are produced by various drugs and this forms the foundation of our present efforts in the development of remedial substances. Such facts are of course very important and must not be disregarded. As a result of such studies it has been possible to correlate molecular structure with physiological action in such a way that it has become a most valuable guide to the chemist working in this field, but when substances of such diverse constitution as cocaine, quinine, novocain, benzyl alcohol, and magnesium salts all act as local anesthetics, it becomes apparent that we must look more deeply for the cause of their physiological action. The problem is one for the physical chemist, and until the methods of physical chemistry are applied to the study of drugs and the actual mechanism of their action is investigated, we cannot hope for real progress in this most important field. Pharmacology, the study of the action of drugs, then becomes a study involving the application of recognized physical and chemical laws to the investigation of the reactions occurring between the living organism and the chemical agents employed. It is along such lines that an institute of pharmacology or therapo-chemistry should be developed rather than along the more superficial lines usually thought of in connection with pharmacological work.

It is evident that animal experimentation of the conventional type is necessary in order to establish the action and value of drugs and that connections with hospitals of the highest class must be maintained so that clinical trials can be carried out under the most favorable conditions, but this part of the work, while indispensable, should be subordinated to the fundamental researches already mentioned.

If an institute were organized in which fellowships could be established by manufacturers or others for the study of specific problems, the usefulness of the institute would largely depend upon the support which the institution received in this way as shown by the number of fellowships maintained. It is safe to say that an institute of the character which has been outlined, under the management of men having the proper conception of the work and the necessary training and experience for directing it in an efficient manner, would receive the support of the manufacturers. It would of course be necessary to guarantee to those establishing fellowships, advance reports of the work and proper patent protection. This would give the manufacturer without research facilities an opportunity to secure the advantages of research of the highest type and at the same time to contribute something to the sum of knowledge in the field from which all or part of his livelihood is derived. The manufacturer with research facilities would often welcome an opportunity to supplement the work carried on in his own laboratories by establishing fellowships in a well-equipped and competently supervised institute.

If this branch of the chemical industry is built up in this country along the lines indicated, it will add to our national prosperity and at the same time contribute to the welfare of mankind. To bring about this result the manufacturer must receive the support and protection which will enable him to make his business profitable. It must be remembered that with the exception of a very few drugs which have come into general use by the laity, the volume of sales of any one medicinal substance is very small when compared with the relatively enormous sales of many technical chemicals and other manufactured commodities. The responsibilities and almost endless detail entailed in this branch of manufacturing are also out of all proportion to the returns. The commercial possibilities are therefore not sufficient to justify expensive research and the installation of costly manu-

facturing equipment unless the manufacturer can secure, for a limited time, a monopoly in the sale of the products which he originates. Indeed it often happens that on account of the limited demand for many well-known medicinal chemicals their manufacture cannot be made profitable if engaged in by more than one manufacturer. The drug manufacturer must therefore receive the full measure of protection accorded to other manufacturers. He must not be discriminated against in the matter of patent protection as has been advocated in certain quarters. No other factor could be more potent in preventing progress in this branch of industry than the elimination of product claims from chemical patents. Since the progress of the industry depends upon the success of the manufacturers engaged in it, one of the most important duties of the institute would be to assist the manufacturer of medicinal products in every way consistent with the objects to be accomplished.

An institute organized for the purpose of promoting the welfare of the industry and at the same time the health and welfare of the people, and conducted along the most strictly scientific lines could not fail to have a far-reaching influence. It would be a unique institution of which the founder, the AMERICAN CHEMICAL SOCIETY, and the Nation could be justly proud.

Dr. Herty deserves great credit for discerning the need for such an institution and for laboring so unselfishly to make it a reality.

ELI LILLY AND COMPANY
INDIANAPOLIS, INDIANA

INSTITUTE FOR RESEARCH ON SYNTHETIC DRUGS

By D. W. JAYNE

My contribution to this subject is an endeavor to give the viewpoint of the manufacturer of synthetic drugs, or the manufacturer who could, under certain conditions, properly become a producer of these drugs.

There is no doubt that the field of synthetic drugs, especially of a coal-tar origin, has been largely overlooked by American chemical manufacturers. Many concerns have entered the manufacture of dyestuffs, and that industry has, no doubt, come to stay, but many of the dyes that are still lacking are those of comparatively small tonnage. It is the tonnage of an article that usually first attracts the American manufacturer, and synthetic drugs cannot be considered from a tonnage standpoint. With the coming of competition on the items of larger tonnage the products used in smaller quantities are turned to, and have frequently been found to be more remunerative than the larger volume items.

The coal-tar drugs which are made here to-day, are, like the dyes, merely copies of those formerly imported from Germany. With the coming of competition on the old lines in the dyestuffs, the manufacturers are putting more and more effort on research work to discover new dyes, and it is a safe prediction that the results of our American chemists' work in research on dyes, will lead to new things in that field.

It is also safe to believe that if American chemists begin in earnest on research in drugs, surprising results will be obtained. The field is certainly broad enough to give ample opportunities to satisfy both the pure scientist and the investor.

This turning to the coal-tar and other synthetic drugs by present chemical manufacturers, especially of dyestuffs, is certain to come. Peace time uses for the vast resources of this country developed for war purposes are sure to be sought. This field, however, can be pressed forward to the attention of manufacturers, and it should be.

I express, I believe, the thought of our Chairman, when I say it is right and proper that the forces which wrought for destruction in war time, should, in peace time, turn to the conservation of the health and happiness of the human race.

The great obstacle to the development of the synthetic drug industry from the manufacturer's point of view is, in my opinion, the inability to properly try out the results obtained in the laboratory. In research on dyestuffs, a new product or an old one can be definitely tested in the manner of its intended use, but lacking any constructive theory, the application of the results of the research chemist in drugs can be determined only in an unsatisfactory way at present.

I am, therefore, of the opinion that the establishment of such an institute as we are discussing, if properly carried out, would be the greatest stimulus to the rapid creation and development of a real American synthetic drug industry.

I believe that this institute should have two functions: First, research in the pure science, to determine the general effects on the human system of each class of chemical compounds, and the probable relative efficiency of these compounds by classes against certain ailments; second, the determination of the efficiency for the purpose proposed of any drug submitted to it by a manufacturer, with a simultaneous determination of any side- or after-effects of the use of such drugs.

Under the first head would come, for example, the determination as to whether the introduction of the acetic acid radical tends to increase the febricidal efficiency of given compounds, and how that increase in efficiency compares with the introduction of, say, a formic acid radical.

Under the second heading would come the submission of a drug, claimed, for example, to be more efficient than salvarsan. This would require considerable work, not only to determine its efficiency as a specific, but to establish the quantities to be used over a given period to secure results without consequent side effects. This would imply that the determination of the proper dose should be a part of such investigations.

Both of these functions would require the highest integrity and ability in the institute as an organization, and in its personnel individually. Its work in pure research should be recognized as the best authority. The results of such research would then make more evident to the chemists in the industry the direction in which to make their effort, either in finding a drug for a specific purpose, or finding a pur-

pose for a drug which would be especially fitted for their manufacturing conditions.

The second-mentioned function, that of reference for report, also makes it essential that such an institute be conducted on the highest plane, to insure the confidence of the manufacturers and also of the medical profession, which above all must be convinced of the merits of the drugs, in order to provide a market for them not based merely on clever advertising.

I am not attempting to detail the method by which the research in the pure science should be carried on, whether by fellowships or otherwise, except that the central organization should be big enough and strong enough to pass on any work done, and approve or disapprove of the results in the name of the institute.

This same central organization would also necessarily be charged with direct supervision of the work done on drugs submitted to it. The manufacturer who submitted a drug would pay for the report on it, but the institute should not submit to limitations on the work to be done. The results, of course, would belong to the manufacturer, and if the report showed lack of merit of the product, or harmful effects from its use, it would be for the information of the manufacturer, a favorable report also being his, for use with proper and necessary restrictions.

The institute could cover synthetic flavors and perfumes, as well as drugs, as, especially in the case of flavors, the absence of toxic or other harmful effect is a necessary requisite.

It is also entirely possible, even probable, that certain natural products now used in food, can be nearly duplicated synthetically, and such products would certainly be proper ones for submission to the institute.

It has also occurred to me that this same institute could fill another want, that of the investigation of industrial diseases, due to working in various chemicals. No doubt many concerns had unlooked-for trouble with occupational diseases when they began the manufacture of dyestuffs and explosives ingredients. The effects of working in nitro compounds are well recognized, but what effects should be expected in the manufacture of other and more complex compounds should be studied and made available to prospective manufacturers, as well as methods of avoiding and combating these troubles.

The effect of these various compounds on the man working in them is certainly a parallel problem to the use of certain finished products to purposely produce a result on the human system.

No doubt the results of the research of such an institute would shortly lead to an ability to definitely predict results in the manufacture or use of any given product.

SUMMARY

I—Chemical manufacturers should be encouraged to enter the wide field which exists in the production of synthetic drugs.

II—To secure rapid and proper development, a link should be formed between the manufacturers and the medical profession.

III—An independent organization of the highest type of men is needed to form this link.

IV—If formed, it would undoubtedly be used by the manufacturers, and should shortly become the leading factor in the situation.

THE BARRETT COMPANY
NEW YORK CITY

REMARKS CONCERNING SUGGESTION FOR CENTRAL MEDICINAL RESEARCH LABORATORY

By E. R. WEIDLEIN

The various papers presented on the necessity for a central medicinal research laboratory were exceedingly interesting and show conclusively the need for such an organization. The matter has come to my mind several times since the meeting, and, while my few remarks were along the lines of coöperation with medicinal manufacturers, I do not believe that the importance of this coöperation was sufficiently emphasized. The industrialist needs all possible assistance in undertaking and developing research work as a means of enlarging his output and improving its quality. However, in order to be effective, this assistance must increase his independence and power of initiative and be so given as to enlist his active support. It has been the coöperation of progressive industry with science which has led to the practical application of the results obtained in the laboratories of scientific men. Fortunately the policy of industrial secrecy is now being more generally regarded in the light of reason and more liberal views are taken, thus bringing about a closer union between science and industry. Nevertheless, large corporations will not be willing to enter into such a scheme of coöperation until they have a vivid and broad comprehension of the need of the efficiency which the scheme represents and a realization that the scheme itself is founded on sane and practical considerations.

It is also equally important that the central medicinal research laboratory should have complete control over its work, and especially, over how the results shall be used. The introduction of a commercial atmosphere or the use of its results for advertising purposes would soon prove fatal to such an institution.

It is important to realize that investigations on a large scale ultimately bring considerable benefit to the community generally, that every scientific discovery applied through industry results to the public gain, and that, consequently, industrial organizations will be justified in supporting a movement to carry on such investigations, since it is only where there are large aggregations of capital that the most extensive and productive research facilities can be obtained.

The Mellon Institute of Industrial Research is willing at all times to coöperate and render any informative service necessary for the establishment and organization of such a laboratory. A spirit of coöperation should be encouraged among all types of research laboratories, as no greater good to society can arise than from a wider distribution of the duties and responsibilities of research.

MELLON INSTITUTE FOR INDUSTRIAL RESEARCH
PITTSBURGH, PA.

CHEMICAL MARKETS OF SOUTH AMERICA

By O. P. Hopkins, Washington, D. C.

THE CHEMICAL MARKETS OF COLOMBIA, ECUADOR, THE GUIANAS, VENEZUELA, AND PARAGUAY

Received October 30, 1918

Excluding Paraguay, the countries considered in this article form the northernmost portion of the continent and all fall within the tropics. They are not so well developed as the countries treated in previous articles of this series, although like them, they have great resources awaiting outside capital and direction. The fact that they are within comparatively easy reach of American ports gives our traders an advantage that they do not possess in the countries farther south, and make the markets much more attractive than might at first thought be suspected. This is particularly true of the markets for medicines, toilet articles, paper, and so forth.

To most of these countries the war has meant increased prosperity, as their products have been in unusual demand. Capital has accumulated as the result of shipping restrictions which have cut down their imports, and it is reasonable to assume that the coming of peace will find the inhabitants with more money to spend than ever before and a pent-up desire to spend it. Trade with Colombia and Venezuela, which has always been attractive to Americans, should be even more so when normal conditions are restored. While trade with the other countries will increase, it will not be of great importance, comparatively, for many years to come.

Paraguay, which does not belong to this group of countries geographically, is nevertheless included to make the series complete. It should perhaps have been considered in the first article with Argentina, Brazil, and Uruguay.

As in the other articles, there is given for each country a table showing the imports of chemicals and allied products from all sources, compiled in each case from the official statistics of the country under consideration. These figures are in some cases meager, are never very nearly up to date, and are in some respects not particularly accurate. They should be used only as a general guide to the extent of the markets. The tables showing the trade with the United States are compiled from statistics published by the Bureau of Foreign and Domestic Commerce of the United States Department of Commerce.

COLOMBIA

Lack of transportation, an indifferent labor supply, and small white population have in the past retarded the development of Colombia's magnificent mineral resources, upon which depend the prosperity of the country. In recent years, however, there has been a decided change for the better, in which American capital and machinery have been prominent factors. The opening of the Panama Canal has been a great help, and since the reaction that followed the outbreak of the war the country has had its share of war prosperity.

Gold is the principal product and silver is mined to some extent. As the only important source of platinum outside of Russia, the country has aroused much interest in Allied circles. Emeralds are also an important product, and there are supplies of iron, coal, salt, and petroleum, although they have received but little attention. Manufacturing and agriculture are comparatively unimportant.

Considering the size of the white population, Colombia has been a rather important purchaser of the products considered in these articles, and American houses have done the bulk of the business, although previous to the war Germany's share was not inconsiderable, as is shown in the following table, which is a compilation from the Colombian official statistics for the latest available calendar year.

Colombian Imports of Chemicals and Allied Products

Articles	1914	1915
Chemicals, Drugs, Medicines, Druggists' Articles	$750,123	$797,076
France	137,890	
Germany	134,323	
United Kingdom	87,930	
United States	135,992	
Colors, Paints, Inks, Varnishes	118,909	150,784
Germany	33,489	
United States	62,594	
Soaps and Perfumery	112,249	87,722
France	16,673	
United Kingdom	21,291	
United States	65,012	
Explosives	79,281	86,824
United Kingdom	37,835	
United States	30,940	
Oils and Fats, Exclusive of Mineral Oils	194,749	180,713
United Kingdom	16,357	
United States	135,625	
Mineral Oils and Combustibles	540,081	590,848
Germany	43,811	
United Kingdom	57,175	
United States	344,776	
Glass and Glassware, Earthenware, Stoneware	481,890	242,398
Germany	124,510	
United Kingdom	95,164	
United States	180,512	
Paper, Cardboard, and Manufactures of	551,582	494,673
Germany	122,629	
United States	195,458	

That the war greatly increased the dependence upon supplies from the United States is shown in the next table, which is based upon American statistics for the fiscal years 1914 and 1917. The marked gains under the heading "Chemicals, drugs, dyes, etc.," are in a measure due to high prices, but may in part be attributed also to the fact that former European sources had been cut off and to the fact that the purchasing capacity of the country had increased. It is unfortunate that the most striking gain under this head is entered as "All other." The most impressive increase in the list is shown for paper, $85,165 to $688,310. Colombia is a market that deserves close attention from American exporters.

As a source of supplies for the materials under consideration in these studies, Colombia is noted chiefly for platinum, of which more than a million and a half dollars' worth was imported into the United States in 1917. Rubber and tanning extract are the only others of any importance purchased from that country.

AMERICAN PRODUCTS SOLD IN COLOMBIA

ARTICLES	1914	1917
Aluminum and manufactures	$ [illegible]	$ 21,793
Babbitt metal	640	1,680
Blacking, shoe paste, etc.	7,246	11,312
Celluloid and manufactures	1,221	50,603
Cement, hydraulic	126,333	122,277
Chemicals, drugs, dyes, etc.:		
Acids:		
Sulfuric	5,328	6,787
All other	3,212	32,222
Dyes and dyestuffs	55	24,372
Medicines, patent or proprietary	254,643	342,157
Petroleum jelly, etc.	765	5,858
Roots, herbs, barks	195	4,053
Sodas salts and preparations		65,594
All other	92,232	540,863
Explosives:		
Cartridges, loaded	8,681	9,400
Dynamite	7,483	33,401
Gunpowder	25,461	17,440
All other	9,218	145,255
Flavoring extracts	5,143	10,343
Glass and glassware	56,034	233,804
Glue	1,182	5,238
Grease:		
Lubricating	7,525	17,040
Soap stocks and other	5,639	2,923
India-rubber manufactures	38,212	107,603
Ink	6,412	23,255
Leather, patent	9,232	33,719
Naval stores	49,457	81,112
Oilcloth and linoleum	10,345	14,443
Oils:		
Animal	74	646
Mineral:		
Crude	97,527	150,014
Gas and fuel	161	6,467
Illuminating	148,045	45,609
Lubricating, etc.	67,946	38,050
Gasoline	33,709	81,047
Other light	1,184	911
Vegetable:		
Cottonseed	2,523	5,424
Linseed	6,629	33,077
All other fixed	4,362	20,077
Volatile	2,263	6,656
Paints, pigments, etc.:		
Dry colors	4,634	19,128
Ready-mixed paints	23,416	45,691
Varnish	4,562	7,319
White lead	789	1,636
Zinc oxide	....	6,719
All other (including crayons)	6,538	54,106
Paper and manufactures	85,165	688,310
Paraffin and paraffin wax	55,750	130,259
Perfumery, cosmetics, etc.	17,325	37,159
Photographic sensitized goods	7,290	14,796
Plumbago and manufactures	916	5,978
Soap:		
Toilet	28,675	44,875
All other	32,096	14,413
Stearin, vegetable	....	5,573
Sugar and molasses	5,374	17,616
Wax and manufactures	1,350	9,188

Ipecac, which grows wild, is exported to the extent of fourteen or fifteen tons annually, but no imports into the United States are shown separately in the statistics. The following table shows imports from Colombia into this country for the fiscal years 1914 and 1917:

COLOMBIAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Chemicals, drugs, dyes, etc.:		
Extracts for tanning	$ 25,494	$142,064
Chicle	....	515
Indigo	....	6,128
Copper	841	5,886
India rubber, etc.:		
Balata	....	243,322
India rubber	175,870	492,432
Oils:		
Animal	....	4,650
Vegetable	....	239
Platinum:		
Unmanufactured	398,657	1,524,039
Ingots, bars, etc.	....	12,383
Tanning materials, crude		
Mangrove bark	80	9,169
Quebracho wood	....	2,887
All other	300	
Zinc	114	5,168

ECUADOR

As Ecuador is the smallest country on the West Coast and has a white population of not much more than two hundred thousand, the market for imported goods is naturally limited, and it would be an exaggeration to say that much improvement in that respect can be expected in the near future. The mineral resources have barely been scratched, agriculture in the main has received little attention, and, aside from the Panama-hat industry, which does not require imported equipment or materials, there is very little manufacturing. Cacao beans make up more than half of the exports ordinarily, the other principal products entering the export trade being Panama hats, ivory nuts, coffee, rubber, gold, and hides, the total in normal times not amounting to much more than thirteen million dollars.

Very little in the way of chemicals is imported, but such business as there was in normal times was fairly evenly divided between the United States, France, England, and Germany, in the order named. In drugs and medicines the United States has had the advantage of all competitors. Belgium was formerly most successful in supplying the demand for soap, England has a virtual monopoly of the candle business, and Germany was favored in orders for paper, as the following official Ecuadorian figures show:

ECUADORIAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1913	1915
CHEMICALS, DRUGS, MEDICINES	$299,558	$284,184
Drugs and medicines	139,534	195,436
France	26,432	54,331
Germany	22,814	113
United Kingdom	15,265	11,515
United States	65,315	114,072
Chemicals n. e. s.[1]	54,776	12,132
France	17,296	1,659
Germany	8,698	....
United Kingdom	10,800	119
United States	17,560	9,786
SOAPS	136,888	158,521
Soap, ordinary	126,016	143,338
Belgium	51,189	10,348
Germany	24,103	97
United Kingdom	35,992	24,209
United States	4,416	53,885
Soap, perfumed	10,872	14,572
United States	9,699	13,593
PAINTS AND VARNISHES	34,659	33,900
House paints	24,866	20,966
France	8,468	4,727
United States	7,070	10,742
ARMS, AMMUNITION, EXPLOSIVES	86,960	42,193
Dynamite	12,787	14,616
United States	12,787	14,616
STEARIN CANDLES AND PARAFFIN	109,230	164,003
Stearin candles	106,322	151,700
United Kingdom	89,721	143,920
United States	1,625	5,741
OILS, ANIMAL AND VEGETABLE	77,901	74,400
Olive oil	20,830	25,520
Italy	14,214	17,747
Spain	4,020	6,179
Machine oil	24,919	13,397
United States	16,733	12,915
OILS, MINERAL, AND COMBUSTIBLES	330,067	327,176
Gasoline	57,768	56,015
United States	2,958	605
Kerosene, refined petroleum	72,821	76,525
United States	71,643	75,542
GLASS, GLASSWARE, EARTHENWARE	99,655	41,880
Sheet glass	10,783	7,563
Belgium	2,602	3,179
Germany	6,645	....
United States	291	3,723
PAPER AND CARDBOARD	152,400	119,968
Printing paper	47,718	26,488
Belgium	7,761	....
Germany	28,557	3,347
United States	9,284	20,369
Writing paper	21,813	11,662
Belgium	5,227	88
United States	5,831	6,695
PERFUMERY AND TOILET ARTICLES	73,400	199,075

While the sales of American chemicals and allied products are not imposing, there has been a substantial gain all around since the war started, and as our exporters are more advantageously situated geographically than their competitors there is no reason to suppose that the increased business cannot be maintained, at least in part, when normal conditions are restored. The effect the war has had on the trade is shown by the following fiscal year American figures:

[1] Not elsewhere specified.

AMERICAN PRODUCTS SOLD IN ECUADOR

ARTICLES	1914	1917
Aluminum and manufactures	$ 44	$ 2,138
Blacking, shoe paste, etc.	3,224	14,971
Candles	19	3,410
Celluloid and manufactures	632	16,849
Cement, hydraulic	9,198	59,790
Chemicals, drugs, dyes, etc.:		
Acids	510	6,666
Copper sulfate	270	1,309
Dyes and dyestuffs	124	7,578
Medicines, patent and proprietary	98,454	71,564
Soda salts and preparations	(a)	13,588
All other	31,082	141,877
Explosives:		
Cartridges, loaded	8,720	13,115
Dynamite	60,142	13,210
Gunpowder	4,058	30,597
All other	3,733	8,564
Glass and glassware	7,426	76,076
India-rubber manufactures	48,289	42,265
Ink	2,077	7,250
Naval stores	6,544	11,612
Oilcloth and linoleum	4,691	22,517
Oils:		
Refined mineral:		
Illuminating	67,855	66,660
Lubricating	19,825	21,669
Vegetable:		
Linseed	561	5,296
All other	6,164	10,862
Paints, pigments, etc.:		
Dry colors	265	7,709
Ready-mixed paints	5,878	7,314
All other (including crayons)	7,093	15,923
Paper and manufactures	78,089	293,344
Paraffin and paraffin wax	321	22,026
Perfumeries, cosmetics, etc.	11,802	52,917
Photographic sensitized goods	693	5,137
Soap:		
Toilet	13,103	23,516
All other	1,081	46,633

(a) Not stated separately in 1914.

The next table, also based upon American returns for the fiscal years 1914 and 1917, shows that of the materials under consideration rubber alone is exported to the United States in anything like an appreciable quantity.

ECUADORIAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Bones, hoofs, horns	....	$ 2,174
Chemicals, drugs, dyes, etc.:		
Extracts for tanning	....	2,538
All others	....	12,893
Copper	17,570	991
India rubber, etc.:		
Balata	....	3,908
India rubber	136,903	296,208
India-rubber scrap	....	80
Tungsten-bearing ore	....	5,300

BRITISH GUIANA

Of the three Guianas, the British colony is the most important, but it does not offer an extensive market for American goods. Sugar makes up the bulk of the exports from the country, although there are some shipments of gold, rum, balata, and rice. England ordinarily furnishes about half the imports and, with Canada, takes the major portion of the exports. The imports of chemicals and allied products from the United Kingdom and the United States in 1913, 1914, and 1916 are shown in the following table, other details of origin not being available.

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO BRITISH GUIANA

ARTICLES	1913	1914	1916
UNITED KINGDOM:			
Medicines and drugs (not containing alcohol):			
Patent and proprietary	$ 18,877	$ 16,959	$ 20,440
All other, and chemicals	42,402	66,317	93,641
Oils, all kinds	32,450	38,724	45,856
Soaps, all kinds	94,035	115,442	129,096
Paints, colors, pigments	23,805	23,174	....
Paper and stationery[1]	53,584	89,180	87,154
Glass and glassware	14,974	16,109	19,369
UNITED STATES:			
Medicines and drugs (not containing alcohol):			
Patent and proprietary	8,487	13,721	17,333
All other, and chemicals	18,963	29,336	112,038
Oils:			
Petroleum, refined	106,551	99,394	138,819
All other	110,787	148,647	201,001

[1] Does not include printing paper, which, however, is not shown elsewhere.

The next table shows that the United States has improved its share of the trade in chemicals and allied products since the war started. These are fiscal year American figures.

AMERICAN PRODUCTS SOLD IN BRITISH GUIANA

ARTICLES	1914	1917
Blacking, shoe paste, etc.	$ 6,281	$ 6,091
Candles	....	3,106
Cement, hydraulic	5,617	36,293
Chemicals, drugs, dyes, medicines:		
Acids:		
Sulfuric	6,491	26,095
All other	8,303	25,361
Medicines, patent or proprietary	18,166	14,893
Petroleum jelly	1,419	1,550
Soda salts and preparations of	(a)	3,627
All other	10,373	140,103
Explosives	3,733	2,487
Fertilizers	100	18,836
Glass and glassware	960	15,625
Grease:		
Lubricating	539	3,537
All other	245	355
India rubber, manufactures of	8,940	17,689
Matches	35	3,255
Naval Stores:		
Tar, turpentine, pitch	4,598	5,736
All other	1,194	2,356
Oils:		
Animal	1,845	3,726
Mineral:		
Fuel and gas	1,297	7,119
Gasoline	31,736	13,887
Illuminating	95,950	86,454
Lubricating, etc.	14,878	30,281
Vegetable:		
Corn	4,769	102,725
Cottonseed	98,357	20,930
All other	57	2,628
Paints, pigments, colors, varnishes:		
Ready-mixed paints	721	2,971
All other (including crayons)	1,270	5,615
Paper and manufactures	6,417	56,986
Perfumeries, cosmetics, etc.	6,701	15,703
Photographic goods	244	6,544
Salt	....	4,833
Soap:		
Toilet	2,110	5,227
All other	10	8,657
Sugar, refined	12,002	16,430

(a) Not stated separately in 1914.

Sugar and balata are the only materials of the sort under consideration imported into the United States from British Guiana, as the following table, for fiscal years, shows.

PRODUCTS OF BRITISH GUIANA SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Clays or earths	....	$ 3,577
India rubber, unmanufactured:		
Balata	$ 58,284	150,102
India rubber	....	23,543
Sugar, cane	125	737,456

DUTCH GUIANA

Conditions in Dutch Guiana do not differ greatly from those in the British colony and do not promise to improve sufficiently in the near future to make the market an attractive one for chemical products. Balata is the principal product of the country, followed by

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO DUTCH GUIANA

ARTICLES	TOTAL IMPORTS 1913	IMPORTS FROM Netherlands	IMPORTS FROM United States
CHEMICALS, DRUGS, ETC.			
Acid, acetic, and vinegar	$ 3,635	$ 3,474	....
Alcohol, ethyl	50,525	45,393	$ 564
Alcohol, methyl	490	....	....
Chemicals, n. e. s.	33,610	20,708	6,523
Ether and chloroform	64	63	....
Fertilizers	20,859	8,531	1,044
Opium	3,382	3,202	....
Perfumery	7,022	5,015	1,251
OILS, VEGETABLE			
Aromatic	1,240	1,000	110
Coconut, linseed, olive, rape, manila	67,601	45,990	15,651
OILS, MINERAL			
Benzine and gasoline	4,535	1,024	2,906
Crude petroleum	1,754	19	1,727
Kerosene	44,420	2	41,954
EXPLOSIVES			
Gunpowder	3,900	3,898	....
COLORS AND PAINTS	32,318	30,544	82
VARNISHES	873	795	50
GLASS AND GLASSWARE	7,626	7,080	248
PAPER	20,570	18,211	1,864

sugar, gold (which is mined in a primitive manner), and cacao. Manufacturing and agriculture are of little importance.

A glance at the preceding table will show that the market for chemical products is of little consequence and that such trade as there is, is dominated by the mother country. The statistics here given are for 1913, the latest available in the official records of the country.

The next table shows that the colony has been forced by the war to turn to the United States for supplies, but the total is, of course, not impressive even now. These figures are for fiscal years and are from American records.

AMERICAN PRODUCTS SOLD IN DUTCH GUIANA

ARTICLES	1914	1917
Blacking, shoe paste, etc.	$ 368	$ 2,914
Candles	1,291	7,019
Cement, hydraulic	....	8,235
Chemicals, drugs, dyes, medicines:		
Acid, sulfuric	512	360
Copper sulfate	1,448	
Medicines, patent or proprietary	5,533	6,252
All other	2,339	22,430
Glass and glassware	649	3,403
Grease	753	4,554
India rubber, manufactures of	658	5,491
Oils		
Mineral:		
Fuel and gas	4,652	8,522
Gasoline	1,797	12,068
Illuminating	46,966	88,283
Lubricating, etc.	3,221	12,152
Vegetable:		
Cottonseed	7,989	70,397
Linseed	....	5,010
All other	9	2,882
Paints, pigments, colors, varnishes:		
Ready-mixed paints	65	2,787
All other	281	4,366
Paper and manufactures	9,312	20,426
Perfumeries, cosmetics, etc.	967	2,197
Soap:		
Toilet	506	1,986
All other	3,122	9,301
Sugar, refined	8,661	8,900

Sugar, cacao, and balata are the only materials of any importance imported into this country from Dutch Guiana, as the following table shows.

PRODUCTS OF DUTCH GUIANA SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Cacao, crude	$473,883	$492,163
India rubber, unmanufactured:		
Balata	375,747	398,670
India rubber	12	23,639
Sugar, cane	7,617	692,382

FRENCH GUIANA

Most of the trading with French Guiana is, under normal conditions, controlled by France, but, as is the case with the other Guianas, it is unimportant. Gold is the most valuable product, the output approximating some two million dollars a year. Primitive methods prevail in the industry. There are important timber resources, as yet but little exploited. Rosewood is exported to France in considerable quantities normally and there used in the manufacture of rosewood extract. This extract is produced to some extent in the colony also. Balata and phosphate rock are exported.

IMPORTS OF CHEMICALS AND ALLIED PRODUCTS INTO FRENCH GUIANA

ARTICLES	1913	1914
CHEMICAL PRODUCTS	$11,164	$10,387
British Colonies	708	917
France	13,321	9,371
United States	15	78
PREPARED MEDICINES	19,891	11,468
SOAPS AND PERFUMERY	43,188	29,847
EXPLOSIVES		
Dynamite	2,039	704
Gunpowder	16	2,025
OILS, VEGETABLE		
Colza	80	116
Cottonseed	41,894	45,190
United States	37,995	25,678
Cocoa	616	317
Cocoanut	244	178
Linseed	3,895	3,333
Olive	17,684	13,306
Other fixed	138	96
Volatile	409	290
OILS, MINERAL	28,669	21,478
United States	19,034	852
COLORS AND DYES	7,813	6,196
GLASS AND GLASSWARE	11,719	11,550
France	11,704	10,964
PAPER AND PAPER WARES	50,648	51,761
France	50,341	51,440

The official statistics of the country prove that chemical products are not imported in large quantities, the preceding table showing such details as are available for 1913 and 1914.

The following table shows that the war has increased the demand for American cottonseed oil in the colony. Even if complete data were available there would probably be no other features sufficiently interesting to note. These are official American figures for the fiscal years 1914 and 1917:

AMERICAN PRODUCTS SOLD IN FRENCH GUIANA

ARTICLES	1914	1917
Cement, hydraulic	$ 34	$ 2,125
Chemicals, drugs, dyes, medicines	139	780
Oils		
Mineral illuminating	12,860	11,439
Vegetable—cottonseed	27,982	68,596
Quicksilver	....	5,052

Materials imported into this country from French Guiana are of very little value, and information as to their exact nature is not readily available.

VENEZUELA

In the extent of its foreign trade Venezuela is a close second to Colombia among the countries dealt with in this article. The country is sometimes considered as comprising three zones: The Coastal Zone, the principal products of which are coffee, cacao and sugar; the Orinoco River Zone, largely pastoral; and the Forest Zone, from whence come India rubber, balata, tonka beans, vanilla, and copaiba, and in which are found the mineral deposits, which only in recent years have begun to attract foreign capital. Manufacturing is not at all well developed.

Before the war the United States furnished about a third of all the goods imported into the country, but in 1917 the American share was seventeen out of twenty-five millions. In compiling the following table from the original Venezuelan statistics it was not found practicable to show the principal sources of origin for the individual items, but some idea of the extent to which the different competing countries divide the trade can be gained from the entries under "Total of all Imports," which includes all lines imported into Venezuela. As an importer of the finer chemical products Venezuela is rather important. Fiscal years are shown.

VENEZUELAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1914	1917
TOTAL OF ALL IMPORTS	$17,005,503	$25,053,092
France	5,150,981	1,042,170
Germany	5,401,692	
Netherlands	1,696,774	185,000
United Kingdom	3,923,856	4,604,149
United States	6,158,227	16,957,644
CHEMICALS, DRUGS, MEDICINES		
Acid, sulfuric	1,058	5,567
Acids, other	34,133	19,481
Calcium carbide	45,881	52,087

VENEZUELAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS (*Concluded*)

ARTICLES	1914	1917
CHEMICALS, DRUGS, ETC. (*Concluded*)		
Carbonic acid gas	12,103	13,961
Chemicals, drugs, medicines, n. e. s.	550,855	875,032
Disinfectants	30,320	45,929
Epsom and Glauber salts	2,295	7,373
Perfumery	131,445	202,153
Quinine	*a*	52,540
Soda, bicarbonates of	3,569	6,390
Soda, common, caustic, crystals	30,305	68,275
Soda, silicate of	6,246	8,617
COLORS AND VARNISHES:		
Paints and colors	84,534	119,129
Varnishes	5,855	10,661
EXPLOSIVES:		
Dynamite	14,523	2,145
Gunpowder	9,689	27,153
OILS, MINERAL:		
Benzene and gasoline	51,632	319,795
Kerosene	190,025	199,252
Lubricating oil	35,279	48,054
Paraffin	1,730	101,798
OILS, VEGETABLE:		
Linseed	17,804	29,387
Olive	119,381	168,581
Other	5,329	6,924
GLASS AND GLASSWARE:		
Bottles	70,306	72,630
Glassware	89,198	54,600
Sheet glass	12,316	18,438
PAPER AND CARDBOARD:		
Cardboard	32,014	36,405
Paper, printing	36,580	154,298
Paper, all other	177,705	358,697

(*a*) Not shown separately in 1914.

The following table for the fiscal years 1914 and 1917 shows that Venezuela is no exception to the rule that South American countries have turned to the United States for chemical and allied products since the war started. Imports of almost all lines have increased in value, some of them in a very marked manner, and the problem here is the same as in the other countries—to retain the advantage when European competition returns.

AMERICAN PRODUCTS SOLD IN VENEZUELA

ARTICLES	1914	1917
Aluminum and manufactures	$ 51	$ 5,206
Blacking, including shoe paste	2,808	5,167
Candles	8,674	8,393
Celluloid and manufactures	478	15,711
Cement, hydraulic	48,870	69,316
Chemicals, drugs, dyes, etc.:		
Acids:		
Sulfuric	473	5,364
All other	952	35,382
Calcium carbide	28,877	24,792
Copper sulfate	1,692	8,851
Dyes and dyestuffs	....	30,101
Medicines, patent and proprietary	173,613	299,408
Petroleum jelly, etc	191	3,982
Roots, herbs, barks	254	4,067
Soda salts and preparations	(*a*)	85,675
All other	70,145	434,467
Explosives:		
Cartridges, loaded	70,073	40,572
Dynamite	1,267	520
Gunpowder	11,862	25,740
All other	5,250	18,032
Flavoring extracts and fruit juices	5,101	8,458
Glass and glassware	16,079	141,738
Grease:		
Lubricating	4,766	13,814
Soap stock and other	1,934	7,700
India-rubber manufactures	42,377	224,487
Ink	6,058	14,156
Leather, patent	8,551	84,326
Metal polish	149	12,221
Naval stores	55,508	59,977
Oilcloth and linoleum	6,494	7,951
Oils:		
Mineral:		
Illuminating	198,295	195,932
Lubricating, etc	26,348	62,522
Gasoline	38,652	287,877
Other light	1,759	1,114
Vegetable:		
Cottonseed	1,133	4,342
Linseed	3,625	32,399
Other fixed	1,106	6,057
Volatile	2,596	8,739
Paints, pigments, etc.:		
Dry colors	2,851	18,535
Ready-mixed paints	15,348	33,575
Varnish	4,427	7,069
Zinc oxide	....	8,066
All other (including crayons)	23,166	47,521
Paper and manufactures	69,804	483,754
Paraffin and paraffin wax	29	113,881
Perfumeries, cosmetics, etc	11,998	33,466
Photographic sensitized goods	6,991	13,259
Plumbago and manufactures	411	3,067
Soap:		
Toilet	18,268	3,441
Other	172	884
Stearin, vegetable	....	51,420
Wax and manufactures	332	7,488

(*a*) Not stated separately in 1914.

Sugar, india rubber, balata, copper, and "All other chemicals" (including probably tonka beans, vanilla, and copaiba), are the principal items of Venezuelan export to the United States that can be considered of interest to the chemical industry. The extent to which they enter the American market is shown in the following table covering the fiscal years 1914 and 1917:

VENEZUELAN PRODUCTS SOLD IN THE UNITED STATES

ARTICLES	1914	1917
Asphaltum and bitumen	425,060	258,205
Bones, hoofs, horns	....	11,271
Chemicals, drugs, dyes, etc.:		
Chicle	28,975	23,324
Other gums	....	7,515
All other chemicals	71,056	304,369
Copper	208,364	507,369
Dyewoods, in crude state	1,260	4,086
Fertilizers	11,222	116,709
Fish sounds	7,822	37,404
Hide cuttings and other glue stock	....	3,518
India rubber, etc.:		
Balata	211,794	341,220
Guayule gum	....	3,985
India rubber	128,063	249,867
India-rubber scrap	80	703
Sugar, cane	10	1,126,788

PARAGUAY

Imports of all kinds into Paraguay in 1914 totaled only five million dollars, the United States ranking a rather poor fourth after Germany, England, and Argentina as a source of supply. Such export trade as there is consists of animal and forest products, fruits, petitgrain oil, tobacco (a German source of supply), and yerba maté (Paraguayan tea). As the following Paraguayan figures show, the United States has had the advantage in sales of chemicals, drugs, medicines, and explosives, while Germany has been favored in the glass business. The statistics are inadequate and do not represent actual market values.

PARAGUAYAN IMPORTS OF CHEMICALS AND ALLIED PRODUCTS

ARTICLES	1914	1915
CHEMICALS, DRUGS, MEDICINES	1226,528	$113,636
Germany	42,299	4,159
United Kingdom	33,017	24,339
United States	80,961	50,402
ARMS, AMMUNITION, EXPLOSIVES	58,674	3,532
Germany	12,993	7
United States	23,342	1,156
GLASS, GLASSWARE, EARTHENWARE	71,442	13,294
France	10,949	3,151
Germany	51,410	1,326
United States	393	515

Such details as are available in the American statistics of exports to Paraguay for the fiscal years 1914 and 1917 are shown in the following table:

AMERICAN PRODUCTS SOLD IN PARAGUAY

ARTICLES	1914	1917
Blacking, shoe paste, etc	....	$ 2,702
Chemicals, drugs, dyes, etc	$15,550	15,050
Explosives, loaded cartridges	17,193	7,181
Illuminating oil	8,394	....

As the exports from Paraguay pass through Argentina and Uruguay, and are credited to those countries in our own official statistics, it is difficult to determine the extent to which Paraguayan products are sold in this country, but it is known that quebracho extract and petitgrain oil are received in fair quantities. The tanning-extract industry has developed rapidly in recent years. An item of 1,108 tons of muriate of potash, valued at $45,161, was recorded as coming from Paraguay in 1914, but it has not appeared since.

ORIGINAL PAPERS

A STUDY OF THE CONDITIONS ESSENTIAL FOR THE COMMERCIAL MANUFACTURE OF CARVACROL

By Arthur W. Hixson and Ralph H. McKee

Received June 21, 1918

Carvacrol is closely related both chemically and physiologically to thymol. The latter substance is used as a specific for hookworm disease and as the principal ingredient in many antiseptic preparations. Hookworm is probably the greatest handicap to the full use and occupation of the tropics by the white races. On account of the general use of thymol in antiseptic manufacture and the widespread organized effort being made in many countries to combat the enormous inroads of the hookworm disease, the demand for it has become so great that the supply from present sources is entirely inadequate.

Attempts have been made to produce thymol synthetically, but up to the present time no process of any promise commercially has been developed.

Recent comparative tests[1] have shown carvacrol to be practically equal to and, in some cases, to possess greater antiseptic value than thymol. Its importance as a substitute for this substance is sufficient to warrant an investigation of its production.

Carvacrol is found as an ingredient in the essential oils of many labiate plants and particularly in those of the species *Origanum*. There are two kinds of *Origanum* oil[2] known commercially, namely, Trieste oil containing from 60 to 85 per cent of carvacrol, and Smyrna oil containing from 25 to 60 per cent. Both of these oils contain cymene. Carvacrol is also found in the oil of thyme from *Thymus vulgaris* in which it sometimes replaces all of the thymol.[3] The quantity of carvacrol available from these natural sources, however, is very small and of practically no commercial importance. These facts indicate that if carvacrol is to be used in the place of thymol a process for its synthetic preparation on a commercial scale must be developed. The prospects were such as to encourage a study of the synthetic preparation of carvacrol and the conditions essential for its commercial production, which is the object of this research.

Carvacrol was first prepared synthetically by Schweizer[4] who found that the same oil was obtained by treating caraway oil with potassium hydroxide, phosphoric acid, or iodine. Claus[5] heated camphor with iodine and obtained a product which he called camphor-creosote which was identical with the product made by Schweizer. Müller[6] while comparing cymene and thymol obtained from different sources, sulfonated pure cymene, made the sodium salt, fused it with sodium hydroxide and obtained an oil which he identified as carvacrol. Kekulé and Fleischer[1] treated carvone obtained from caraway oil with orthophosphoric acid and produced carvacrol. From cymene, obtained from camphor, Pott[2] made potassium cymene sulfonate, which he fused with potassium hydroxide. He poured the fusion mass into water, neutralized with sulfuric acid, and obtained a small amount of yellowish liquid which distilled at 230° C. He recognized it as an isomer of thymol. He also observed that if a few drops of an alcoholic solution of the oil were added to a solution of ferric chloride, a characteristic green coloration would be produced. Reychler[3] found that when carvo-chlorhydrate is distilled, hydrochloric acid split off and the distillate contained carvacrol. Etard[4] treated monochlorcamphor with a 10 per cent solution of zinc chloride and heated it. By distilling the mass and agitating the distillate with caustic soda he obtained carvacrol. Mead[5] and Kremmers converted pinene into nitroso-pinene and by hydrolyzing this substance produced carvacrol. The yield was about 60 per cent. Wallach[6] made amidothymol from oxydihydrocarvoxime, treated it with sulfuric acid, and found carvacrol to be one of the products. Harries[7] passed steam for a long time over hydrobromcarvone and produced a small amount of carvacrol. McKee[8] has patented a process for the manufacture of carvacrol based upon the use of spruce turpentine as the source of cymene.

A careful examination of these methods showed that in each case, with the exception of that of McKee, the raw materials used were of such a nature as to make them impracticable for the production of carvacrol on a commercial scale. However, the discovery that spruce turpentine consists mainly of cymene and the fact that it is produced in large quantities as a by-product in the manufacture of wood pulp by the sulfite process indicated that a method, along the line suggested by the experiments of Müller, Pott, and McKee might be capable of commercial development. For these reasons an investigation was made to determine whether a method based upon the following reactions could be carried out on a commercial scale:

I—Formation of cymene 1-sulfonic acid by treating spruce turpentine with sulfuric acid.

II—Removal of the excess sulfuric acid used in (I) and formation of calcium cymene sulfonate by treatment with finely divided limestone.

III—Formation of sodium cymene sulfonate in solution and removal of calcium as carbonate by treating with soda ash.

[1] The average results of four viability tests using the organisms *B typhosus*, *B communior*, and *Staphylococcus pyogenes aureus* furnished through courtesy of Dr A. K. Balls, Department of Bacteriology, College of Physicians and Surgeons, Columbia University, and Dr A. M. Buswell, Department of Chemical Engineering, Columbia University, New York City.

[2] U. S. Dispensary, 19th Edition, **1905**, 1432.

[3] *Ibid.*, 19th Edition, **1905**, 1571.

[4] *J. prakt. Chem.*, **24** (1841), 287.

[5] *Ibid.*, **25** (1842), 264.

[6] *Ber.*, **2** (1869), 130.

[1] *Ber.*, **6** (1873), 1087.

[2] *Ibid.*, **9** (1876), 468.

[3] *Chem. Centr.*, **63** (1892), 359.

[4] *Compt. rend.*, **116** (1893), 1136.

[5] *Am. Chem. J.*, **17** (1895), 607.

[6] *Ann.*, **291** (1896), 348.

[7] *Ber.*, **34** (1901), 1924.

[8] U. S. Patent No. 1,265,800, May 14, 1918.

IV—Formation of sodium carvacrolate by fusing the sodium cymene sulfonate with caustic soda.

V—Formation of carvacrol by treating the fusion products of (IV) with sulfuric acid.

A study of these basic reactions indicated that the following fundamental operations would be necessary:

1—Sulfonation of cymene.
2—Disposal of the sulfonation products.
3—Formation of calcium cymene sulfonate solution and precipitation of calcium sulfate.
4—Filtration and disposal of the filter cake.
5—Formation of sodium cymene sulfonate solution and precipitation of calcium carbonate.
6—Filtration and disposal of filter cake.
7—Evaporation of the sodium cymene sulfonate solution and disposal of the solid salt.
8—Fusion of the solid sodium salt with caustic alkali.
9—Disposal of the fusion products.
10—Neutralization of the fusion product solution and formation of carvacrol.
11—Separation of the carvacrol.
12—Purification of the carvacrol.

EXPERIMENTAL

The experimental work consisted of the determination of the relative importance of the preceding operations and the conditions under which they could be carried out with maximum efficiency.

MATERIALS—All of the materials used in the experimental work were of standard commercial purity, such as can always be obtained on the market, without difficulty in normal times, with the exception of spruce turpentine, which up to this time, although produced in large quantities as a by-product, has had no commercial value.

The spruce turpentine used was a steam-distilled product obtained from the New Process Gasolene Company, of Philadelphia, and was purchased in the crude form by that company from the J. and J. Rogers Company, of Au Sable Forks, N. Y. This product was clear and nearly white. After remaining in the laboratory for several months a distinct yellow tinge appeared. The product was used in the "as received" condition without treatment of any kind. A fractional distillation of 1.5 liters gave the following results:

Temperature Degrees C.	Fraction Cc.	Per cent
Below 171.5	50	3.33
171.5–178.5	1250	83.34
Above 178.5	200	13.37

Kertesz[1] found spruce turpentine to contain 80 per cent of cymene, from 10 to 12 per cent of sesquiterpene, and the remainder diterpene. The fractionation results show that nearly 80 per cent of the material came off at about 175° C., the boiling point of cymene.

SULFONATION—The prime variables in this operation are (*a*) strength of acid, (*b*) temperature, (*c*) time, (*d*) proportional amount of acid, (*e*) amount of stirring, (*f*) type of sulfonating vessel.

STRENGTH OF ACID—The adoption of 66° Bé. sulfuric acid as the most practical strength for the sulfonation of benzene in phenol manufacture led to the belief that this strength would also be the most practical in the sulfonation of cymene. 400 cc. of commercial 66° Bé. acid (checked by titration with standard alkali) were placed in a liter Erlenmeyer flask with 200 cc. of spruce turpentine. This was placed in a water bath and heated to 96° C. A two-blade glass propeller stirrer was placed in the vessel below the level of the acid and was run at a speed of 700 r. p. m. in the direction that would throw the acid toward the top of the flask. At the end of $3^1/_2$ hrs. sulfonation was complete. This proved that 66° Bé. acid could be used. A similar experiment with 60° Bé. acid showed that sulfonation was less than 50 per cent complete at the end of 12 hrs. Acids of greater strength were not tried although it was obvious that the reaction period would be shortened somewhat by their use. The fact that 66° Bé. acid can normally be obtained at less expense and trouble than the stronger acids and that it can be handled in a plant with less difficulty prompted its adoption for all of the sulfonation experiments.

TEMPERATURE—The apparatus described in the preceding section was used. The sulfonation vessel was filled with 200 cc. of spruce turpentine and 400 cc. of acid. The stirrer was run at 700 r. p. m. Four hours was the standard time. At the end of the reaction period the stirrer was removed and acid allowed to settle and separate from the cymene and the sulfonated portion. The upper layer was then siphoned off, shaken well, and 25 cc. removed by means of a pipette. This was placed in a graduate and 75 cc. of water added, shaken well, and allowed to stand for 12 hrs. The unsulfonated cymene formed a layer at the top and its volume was read directly. The following table and curve, Fig. 1, show the results:

TABLE I

Temp. ° C.	Unsulfonated portion Cc.	Per cent sulfonated
20	19.3	22.80
40	14.5	42.00
60	7.8	68.80
80	2.0	92.00
90	0.2	99.20
100	Trace	99.5+

The rate of sulfonation varied almost directly with the increase of temperature up to 90°. Between this temperature and 100° C. the rate was highest, indicating that the temperature should be kept within this range for efficient sulfonation. This temperature being near the boiling point of water makes it an easy one to maintain in both laboratory and plant. Sulfur dioxide is evolved at all temperatures. The amount was slight at low temperature and increased as the temperature was raised.

TIME—With the same apparatus and the same quantities of materials, time experiments were run. The data in the preceding table indicate that a temperature between 90° and 100° would give the shortest time required for complete sulfonation. 96° C. was chosen for the reason that it was convenient to maintain. The extent to which the reaction had proceeded was determined by the same means used in the preceding experiments, that is, 25 cc. portions were taken from the upper layer which had been separated

[1] *Chem. Ztg.*, **40** (1916), 945.

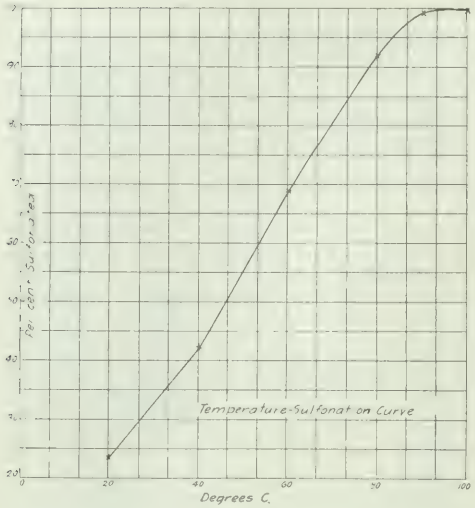


FIG. 1

from the acid and, after diluting and standing for 12 hrs., the volumes of the unsulfonated portions were read. The results are given in Table II.

TABLE II

Time Hrs.	Unsulfonated portion Cc.	Per cent sulfonated
1/2	18.4	26.40
1	12.4	50.40
2	4.3	82.80
3	1.2	95.20
4	0.1	99.60
5	Trace	99.6+

These data show that a 4-hr. period is sufficient for complete sulfonation at 96° C. with efficient stirring. The results are shown graphically in Fig. 2.

AMOUNT OF ACID REQUIRED—200 cc. charges of spruce turpentine were sulfonated at 96° C. with quantities of acid varying from 400 cc. to 150 cc. Sulfonation was complete with amounts down to 200 cc. With amounts below this complete sulfonation could be obtained, but the time required was greatly increased. Many batches were run using equal volumes of acid and cymene and complete sulfonation was obtained in 4 hrs., with the temperature at 96° C. These results show, contrary to previous records, that a volume of 68° Bé. acid equal to that of the cymene is sufficient. It is to be noted also that the decrease in the amount of acid used to the equal volume limit did not decrease the rate of reaction.

AMOUNT OF STIRRING—McKee[1] has shown that the rate of sulfonation of hydrocarbons is distinctly dependent upon efficient stirring, other things being equal. By increasing the efficiency of his stirring device he was even able to sulfonate kerosene with ease. No experiments were made to determine the effect of different degrees of stirring upon the rate of sulfonation of cymene, but the type of stirrer used, the speed at which it was run, and the shape of the reaction chamber insured an extremely intimate contact of reacting materials.

TYPE OF SULFONATING VESSEL—To determine whether a cast iron or steel sulfonating vessel could be used, one was made by screwing a cast iron cap on the lower end of a 6 in. length of 4 in. pipe. A similar cap provided with stuffing-box openings for a stirrer and the thermometer was used for a cover. A two-blade stirrer of the propeller type was used. The blades were set at such an angle that when run at speeds above 500 r. p. m. the liquid was thrown against the cover of the vessel. To the stem a series of pulleys of different diameters was fastened in order to use different speeds. The stirrer was driven with an electric motor. A thermometer was placed in the vessel at such a depth as to be well in the liquid, and it was held in place by a stuffing-box similar to that used for the stirrer. When the cover was screwed on well the vessel was gas-tight. The vessel was set into a water bath to such a depth that the surface of the water came to the lower edge of the cover. The water bath was heated by an ordinary Bunsen burner and the temperature was controlled within two degrees without difficulty.

With this apparatus many runs using 300 cc. of spruce turpentine and 300 cc. of acid were made. The temperature in all cases was from 96° to 98°. With the stirrer running 500 to 600 r. p. m. sulfonation was complete in from 3 1/2 to 4 hrs. A larger amount

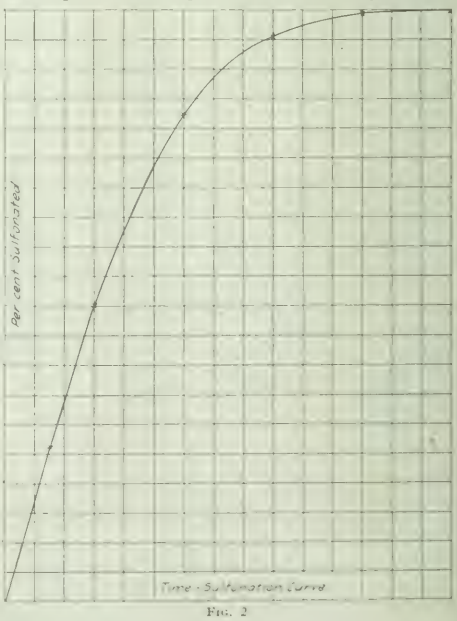


FIG. 2

of sulfur dioxide was given off than with the glass vessel. When all openings in the cover were tightly closed, a considerable pressure was developed. It was observed that although a considerable surface of the sulfonator was above the surface of the water, the temperature inside of the vessel during the opera-

[1] *Science*, **35** (1912), 388

tion was less than one degree below that of the bath. When the sulfonation products were poured into a glass vessel and allowed to cool, a white solid settled to the bottom of the acid layer. This was found to be ferric sulfate. The iron had reacted with an excess of concentrated sulfuric acid forming ferric sulfate and sulfur dioxide. This accounted for the increased amount of sulfur dioxide observed during the reaction period. The amount of ferric sulfate formed varied from 3.55 to 5.6 g., representing a loss of iron of from 0.73 to 1.57 g. The weight of the sulfonator was 3500 g. The loss was quite small and undoubtedly in a larger vessel of special cast iron would be still less on account of the relatively smaller contact area and refractory skin on the surface of the vessel. The presence of this iron was not objectionable. If for any reason its removal might be desired this could be done at practically no increase of cost by the addition of a small quantity of lime just after the precipitation of the calcium sulfate in the next operation.

SULFONATION PRODUCTS—When sulfonation was complete and the mixture allowed to stand for a short time, two distinct layers formed. The lower, lighter colored layer contained the greater portion of the excess sulfuric acid and about 20 per cent of the total amount of the cymene sulfonic acid. The upper, darker colored layer contained the greater part of the cymene sulfonic acid, some sulfuric acid, and materials resulting from the action of the acid on the impurities in the spruce turpentine. The formation of the layers took place rapidly when the materials were hot. When cold, the upper layer became very thick and viscous. When allowed to stand for a few days at 20° C. the cymene sulfonic acid began to crystallize and finally the whole layer became solid. With the temperature below 10° C. the upper layer solidified very rapidly. Colorless, transparent crystals of cymene sulfonic acid, isolated from the upper part of the lower layer, melted at 50° to 51° C. This was the melting point found by Spica[1] and later by Eaton and McKee[2] for a cymene sulfonic acid of the composition $C_{10}H_{13}SO_3H.2H_2O$, which the latter two made from spruce turpentine. All of the constituents of the upper layer were found to be soluble in water with the exception of a small amount of a very finely divided white substance which settled out after standing for a number of days. Examination of this white precipitate showed it to be sulfur. Evidently it came from the complete reduction of a small portion of the sulfuric acid.

DISPOSAL OF SULFONATION PRODUCTS—The formation of two distinct layers which could easily be separated suggested that a recovery of the unused sulfuric acid might be possible. The problem was to recover the sulfuric acid without losing the cymene sulfonic acid which was present in considerable quantity in the lower layer. Inasmuch as it was necessary to add water in the next operation, experiments were made to determine whether the distribution of the substances in the layers was affected by dilution.

[1] *Ber.*, **14** (1881), 653.

[2] Unpublished thesis, University of Maine, 1911.

For these experiments 150 cc. of spruce turpentine and 150 cc. of 66° Bé. acid were used in the sulfonation. When sulfonation was complete the hot products were poured into a 500 cc. graduate and allowed to stand until the volumes of the layers became constant. After reading the volumes a definite quantity of water was added and the mass shaken until the mixing was complete. The mixture was then allowed to stand until the volumes became constant again. 10 cc. samples were taken with a pipette and analyzed. The total acid content was determined by titrating with standard sodium hydroxide. The free sulfuric acid was determined by precipitation with $BaCl_2$.

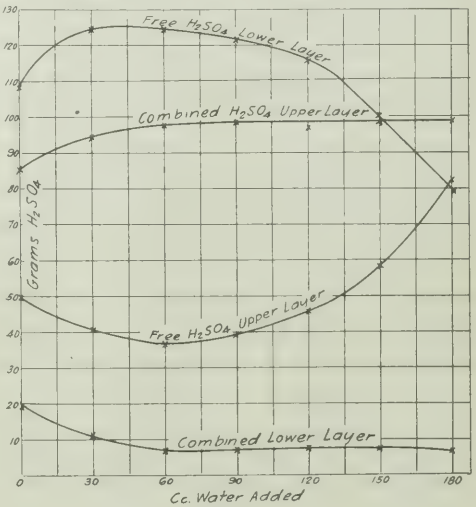


FIG. 3

The difference between these gave the sulfonic acid content which was calculated as sulfuric acid. The results are given in Table III and are shown graphically in Fig. 3.

TABLE III

Water added Cc.	Free H_2SO_4 lower layer G.	Free H_2SO_4 upper layer G.	Combined H_2SO_4 lower layer G.	Combined H_2SO_4 upper layer G.
None	108.16	49.22	19.94	85.19
30	124.88	40.73	11.89	94.24
60	123.60	36.57	6.54	97.30
90	121.03	39.87	7.59	98.15
120	116.43	45.38	7.62	96.96
150	99.39	58.68	7.63	97.93
180	79.06	82.70	6.50	98.64

These results show that by the addition of a quantity of water equivalent to one-fifth of the total volume (approximately 300 cc.) the combined sulfuric acid, which represents the cymene sulfonic acid, dropped from 19.94 g. to 6.54 g. in the lower layer and increased from 85.19 g. to 98.15 g. in the upper layer. After this the values remained practically constant with further dilution. The values given in the above table for the combined sulfuric acid represent approximately the percentages of cymene sulfonic acid in the two layers.

The dilution experiments were carried out to the point where the two layers merged; analyses at these

dilutions were not made for the reason that the acid was not worth recovering. Although it was possible to reduce the cymene sulfonic acid content in the lower layer 60 per cent, the amount which still remained was such that its loss probably more than balanced the value of the acid recovered and the amount of ground limestone saved. Market and plant conditions will be the deciding factors. If the acid is recovered the conditions that will give the lowest cymene sulfonic acid loss should be used. At that dilution the acid would have a concentration of about 60° Bé. and could be used to neutralize the fusion mixture in a later operation. The separation of the layers could be made in the sulfonation kettle after the products were cooled, if the kettle was made with a bottom discharge as is usually the case.

NEUTRALIZATION OF THE SULFONATION PRODUCTS—This is a standard operation in many processes and the conditions controlling it are well understood. The neutralizing agents may be a good grade of finely divided limestone or lime. Limestone is the cheaper and is efficient, although the operation does not go quite as smoothly as with lime on account of the evolution of a large amount of carbon dioxide. A lead-lined tank with a stirrer and foam breaker should be used unless care is taken to discharge the sulfonation products into a slurry of limestone in which case the lead lining is not necessary. The calcium sulfate formed may be removed without difficulty by using a filter press. The filter cake has no value.

FORMATION OF SODIUM CYMENE SULFONATE—Sodium carbonate or sodium hydroxide may be used. Under normal conditions soda ash would be the material to use on account of its cheapness and the greater ease of filtering the precipitated calcium carbonate as compared to calcium hydroxide. A standard, mechanically stirred wooden tank should be used.

SIMULTANEOUS NEUTRALIZATION OF SULFONATION PRODUCTS AND FORMATION OF SODIUM CYMENE SULFONATE SOLUTION—This may be done by neutralizing partially or completely the sulfonation products with limestone and then adding the requisite amount of soda ash. By this method the calcium sulfate and calcium carbonate can be removed by a single filtration. This procedure requires closer chemical control than when the two operations are separated for the reason that it is much more difficult to tell when the reaction with the soda ash is complete. Unless close watch is kept on this operation under plant conditions an excess of soda ash will often be used by the workmen. It is doubtful if this combined procedure will work out as well as the former in plant practice as the resulting saving in limestone and labor will be small.

EVAPORATION OF THE SODIUM CYMENE SULFONATE SOLUTION—It is obvious that the use of as little water as possible in the preceding steps will save time and expense in the production of dry sodium cymene sulfonate. This salt is very soluble in water and its water solutions are difficult to evaporate to dryness at atmospheric pressure. The presence of a small amount of water causes the salt to form a thick pasty mass which becomes liquid above 70° C. This last portion of solvent may be removed, in plant practice, by either drying in vacuum or by use of a film dryer such as the drum dryers (atmospheric pressure or vacuum) which have lately come into such wide use in drying concentrated or pasty substances in chemical plants.

FUSION OF THE SODIUM CYMENE SULFONATE—The problem was to determine (*a*) the best fusion reagent, (*b*) the proper fusion temperature, (*c*) the most suitable type of fusion kettle, (*d*) the time required for completion of the reactions, and (*e*) the minimum amount of fusion reagent for maximum yield.

The apparatus used for the preliminary fusion experiments consisted of a cylindrical steel vessel $4^1/_4$ in. in diameter and 5 in. deep. The steel was $^3/_{16}$ of an inch thick. The cover was a steel plate with openings for a stirrer shaft and thermometer and could be closed tightly by means of stove bolts and winged nuts. It was necessary to have the stirrer work through the whole mass of the liquid in order to break up surface crusts and prevent the material from sticking to the bottom and sides of the kettle. The vessel was heated with a Fletcher burner. After making a number of fusions with this apparatus it was obvious that it was not possible to control the temperatures closely enough. To overcome this difficulty the fusion vessel, equipped as described, was placed in an insulated bath containing about 20 lbs. of a eutectic mixture of sodium and potassium nitrates. This bath, provided with a propeller type stirrer, was heated with a Fletcher burner. With this arrangement there was no difficulty in keeping the temperature constant within one degree. The difference between the temperature of the bath and that inside of the fusion chamber was less than one-half degree when the stirrers were running.

FUSION REAGENT—Heretofore, those who have prepared carvacrol by a fusion method have used potassium hydroxide in large excess. Although scientific literature favors the use of this reagent for the fusion of sodium cymene sulfonate and similar salts, such as sodium benzene sulfonate, modern commercial practice on the latter has demonstrated that caustic soda can be used with equal efficiency and at much less expense. For this reason a good grade of commercial caustic soda was used in all of the fusion experiments.

FUSION TEMPERATURE—To determine what effect temperature has upon the efficiency of the fusion operation, fusions were made at different temperatures. The charges consisted of 150 g. of dry sodium cymene sulfonate and 450 g. of caustic soda. The fusion period was 6 hrs. The caustic soda which melted at 319° C. was fused first. To this the sodium cymene sulfonate (in granular form) was slowly added. At the end of the fusion period the products were poured gradually into 2 liters of cold water, forming a strongly alkaline solution which was neutralized by adding dilute sulfuric acid (40° Bé.). The carvacrol set free in this operation was extracted with benzene. After separation of the benzene solution from the neutral

liquors, the benzene was distilled off and recovered. The residue was distilled yielding carvacrol and a tarry residue. The carvacrol was weighed, and the yield thus obtained was used as the criterion by which the efficiency of the fusion operation was determined.

As the sodium cymene sulfonate dissolved in the molten caustic the temperature at which the mass remained molten rapidly fell. The average time required to get a smooth fusion was one-half hour. It was possible to lower the fusion temperature to 255° C. and still have the mass molten enough to stir well. If a quantity of water equal to 10 per cent of the weight of the caustic was added, the fusion took place much more smoothly and the mixture was kept molten at a still lower temperature. However, the addition of water was of no advantage for the reason that its rapid evolution as steam at higher temperatures made it difficult to keep the molten material in the fusion chamber until it was all given off. When 280° C.

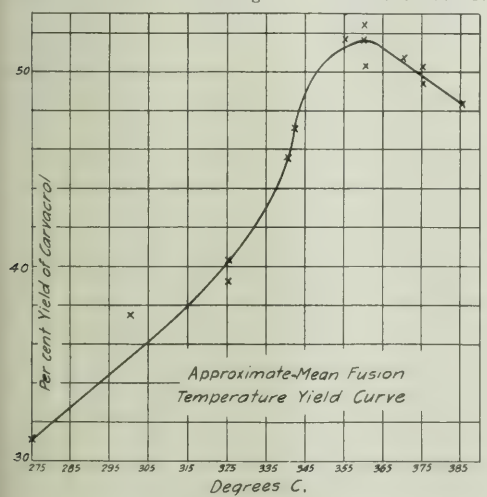


FIG. 4.

was reached (fusion vessel uncovered) a bluish white fume was observed. This increased in amount rapidly with the rise of temperature until at 325° C. it was quite dense. The mass thickened under these conditions and at the end of the fifth hour it was granular and would not pour. If the temperature was kept below 300° C., although some fume was evolved, the material remained liquid until the end of the fusion period and poured well. At 280° C. when a flame was held in the upper part of the fusion chamber a flash was observed. As the temperature was raised the flash became more pronounced and at 300° C. the gas burned for a number of seconds. At 325° C. it burned longer. With the fusion chamber open at temperatures from 275° to 300° C. the yield of carvacrol varied from 8.25 to 43.19 g. Above 300° C. the yields varied from 35.30 to 45.27 g. and, though higher than for temperatures below 300° C., were very erratic and difficult to duplicate. These facts are revealed by the data in Table IV.

TABLE IV

(Fusion Chamber Uncovered)

No.	Sodium cymene sulfonate G.	Caustic Soda G.	Time Hrs.	Temp. ° C.	Carvacrol G.	Yield Per cent	Remarks
1	150	450	6	267	15.75	16.53	No fume.
2	150	450	6	275	15.10	15.80	No fume. Inflammable gas.
3	150	450	6	275	8.25	8.66	No fume. Inflammable gas.
4	150	450	6	285	23.45	24.62	Slight fume. Small amount of inflammable gas.
5	150	450	6	295	35.00	36.74	More fume. More gas.
6	150	450	6	300	43.19	45.34	More fume. More gas.
7	150	450	6	300	45.27	48.57	More fume. More gas.
8	150	450	5	325	35.30	37.06	Rapid evolution of fume. Solidified before end of period.
9	150	450	3.75	345	36.15	37.85	Rapid evolution of fume. Solidified before end of period.

From 150 g. of sodium cymene sulfonate a yield of 95.25 g. of carvacrol should have been produced. The percentage yields in this table and those following were calculated on this basis.

Above 300° C. there was less variation in the yields. This and the fact that the yields were higher led to the belief that still higher temperatures might give better results. It was also noted that when the fusion chamber was covered no fume was evolved, but as soon as the cover was removed it appeared, showing that there was a reaction with the oxygen of the air. To determine whether this reaction was in any way responsible for the great variation in yields, a series of fusions was made at different temperatures with the fusion chamber closed. The cover with an opening and connections for a condenser was screwed down tightly after each charge was inserted. A Liebig condenser provided with an air-tight receiver was attached. From one opening in the receiver a tube ran to a gas holder. With the exception of the cover and the accessories mentioned, the conditions for this series were the same as for the previous one. The data and results are given in Table V and shown graphically in Fig. 4.

TABLE V

(Fusion Chamber Covered)

Charges consisted of 150 g. sodium cymene sulfonate and 450 g. caustic soda. Fusion period, 6 hrs.

No.	Temp. ° C.	Carvacrol G.	Yield Per cent	Remarks
1	275	29.65	31.13	6.5 cc. H_2O and trace of yellow oil distilled off. Small amount of inflammable gas.
2	300	35.71	37.41	6 cc. H_2O, 15 cc. amber colored oil. Oil fluorescent.
3	325	37.16	39.01	6.5 cc. H_2O, 21 cc. amber colored oil. Oil fluorescent. About 3 liters gas.
4	325	38.20	40.10	8 cc. water, 22 cc. amber colored oil. Fluorescent. Passed gas through bromine. No reaction.
5	340	43.57	45.74	9 cc. water, 25 cc. amber colored oil. About 4 liters gas. Oil less fluorescent.
6	342	44.81	47.04	7.5 cc. water, 23.5 cc. oil. Oil amber colored and fluorescent.
7	355	49.36	51.71	Lost distillate.
8	360	48.33	50.14	9 cc. water, 22 cc. amber colored oil. Fluorescent.
9	360	49.91	52.31	9.5 cc. water, 23 cc. oil darker colored and more fluorescent.
10	360	49.14	51.60	11 cc. water, 22 cc. amber colored oil. Fluorescent. When cover was removed, mass flashed.
11	370	48.26	50.65	11 cc. water, 22 cc. lighter colored oil. Not quite as fluorescent.
12	375	47.92	50.31	14 cc. water, 22 cc. amber oil. Oil fluorescent. When cover was removed, mass ignited.
13	375	46.97	49.31	11 cc. water, 22.5 cc. amber colored oil. Fluorescent. When cover was removed, mass ignited.
14	385	46.10	48.39	10.5 cc. water, 22 cc. amber colored oil. Oil fluorescent. Mass did not ignite when cover was removed.

The data of Table V show that the yields of carvacrol increase and become more uniform with the rise of temperature. Also that the range for maximum uniform yield is from 350° to 370° C. Schorger[1] states that the fusion temperatures should not be above 300° C. That this is not correct is demonstrated by the results of these experiments. Neither could he get uniform yields at temperatures below 300° C. Above 370° C. decomposition becomes noticeable and the yields decreased. Between 360° C. and 370° C. the fusion mass had a tendency to ignite when exposed to the air. This was much more marked at higher temperatures. A comparison of the data obtained from this series of fusions and that of the previous one shows plainly that it is necessary to use a covered fusion vessel. Without a cover the fusion mass thickens, due to reaction with oxygen of the air, and the volatile oil which distils off is lost.

It was noted that in all of the fusions an amber colored, fluorescent oil came off. The quantity distilled from the different fusions was quite constant. It varied somewhat in color and in the degree of fluorescence with different fusions. As a rule it became darker on standing. In some instances it became more fluorescent, and in others less, when exposed to the air for some time. A quantity of this oil was carefully fractionated; 75 per cent of it boiled between 172° C. and 178° C. This fraction was water-white and had the odor and characteristics of cymene. The higher boiling fraction varied in color from light straw to very dark brown and was relatively small in amount. All of the fluorescent material boiled above 210° C.

To verify the belief that the oil was principally cymene, the fraction boiling between 172° C. and 178° C. was sulfonated in the usual manner. The sodium salt was made and fused with caustic soda. Fifty grams of the sodium yielded 10 g. of carvacrol and 3.5 cc. of an amber colored, fluorescent oil similar to that described. This proved that the oil which distilled from the cymene sulfonate was essentially cymene. Inspection of the results of this series of fusions shows that the cymene recovered in the distillate from the fusions represents a decomposition of from 18 to 20 per cent of the sodium cymene sulfonate fused. Experiments showed that this cymene could be easily recovered and re-used. On a factory scale its recovery would be profitable. The presence of sodium sulfate in considerable quantity as one of the fusion products along with cymene seemed to indicate that two reactions took place between the sodium benzene sulfonate and the caustic soda, one of which formed sodium carvacrolate and sodium sulfite, the other cymene and sodium sulfate. However, the evolution of hydrogen and methane and the formation of a considerable quantity of tarry matter indicated that other reactions took place.

The gas evolved during the fusions varied in quantity from 2 to 4.5 liters. Samples from two fusions were analyzed and were found to contain hydrogen and methane. There were no traces of carbon monoxide, oxygen, or unsaturated hydrocarbons.

[1] THIS JOURNAL, 10 (1918), 289

TABLE VI

Gas from Fusion 280. (Table V)	Hydrogen Per cent	Methane Per cent
3	78.16	21.84
6	80.00	20.00

by volume

To get some idea of the stability of sodium cymene sulfonate 150 g. (containing 0.57 per cent moisture) were placed in the fusion kettle alone and heated. Between 345° and 350° C. it melted and showed no signs of decomposition. The temperature was gradually raised to 375° C. and at this temperature a distillate consisting of 13½ cc. water and 7 cc. of a dark oil came over during the first hour. The heating was continued for 3 hrs. During the entire period hydrogen sulfide came off in large quantities. The mass gradually thickened and was sticky and black when poured. The oil from this salt was somewhat similar to that obtained from the fusions with caustic soda except that it was smaller in amount, very much darker in color, and was saturated with hydrogen sulfide. The hydrogen sulfide formed showed that the reaction without caustic soda was not the same as that with it. If it were, sodium sulfide would have formed during the fusion. This, in turn, would have reacted with the sulfuric acid in the neutralization operation and hydrogen sulfide would have been evolved. Such was not the case.

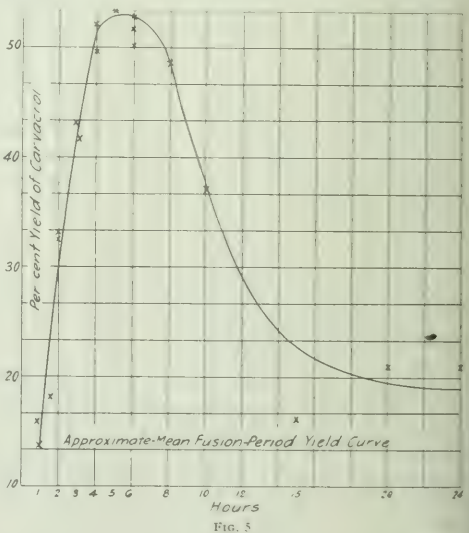


FIG. 5

TIME REQUIRED FOR FUSION was determined by making a number of fusions with the temperature and the composition of the charges constant using the quantities of carvacrol as the criteria. The results appear in Table VII and Fig. 5.

Fusion periods of from 4 to 6 hrs. gave the best results. With longer periods the yields gradually fell off and were more or less erratic. The same was true for the shorter periods. The curve in Fig. 5 shows the relation between the length of fusion period and the yield of carvacrol. The products of the 15, 20, and 24 hr. periods were dry, granular masses

when removed from the fusion chamber. On exposure to air they gradually became hard and stony. In the cases of the 20 and 24 hr. fusions the products were liquid up to within 2 hrs. of the end of the periods. The amount of distillate was practically the same for all of the fusions of more than 2 hrs. duration, showing that the consistency of the products at the end of the period was in no way related to it.

TABLE VII

Temperature, 360° C. 150 g. sodium cymene sulfonate, 450 g. caustic soda.

No.	Time Hrs.	Carvacrol G.	Percentage Yield of Carvacrol	Remarks
1	1	15.15	15.90	Liquid when poured.
2	1	13.71	13.39	Liquid when poured.
3	1.5	17.21	18.07	Liquid when poured.
4	2	31.15	32.59	Liquid when poured.
5	2	31.43	32.99	Liquid when poured.
6	3	39.78	41.76	Liquid when poured.
7	3	41.14	43.19	Liquid when poured.
8	4	47.12	49.47	Liquid when poured.
9	4	49.36	51.82	Liquid when poured.
10	5	49.81	52.29	Liquid when poured.
11	6	49.91	52.31	Liquid when poured.
12	6	49.33	50.14	Liquid when poured.
13	6	49.14	51.60	Liquid when poured.
14	8	46.31	48.69	Liquid when poured.
15	10	35.41	37.17	Remelted after 5 hours.
16	15	15.41	16.18	Remelted after 5 hours.[1]
17	20	20.01	21.01	Remelted after 5 hours.[1]
18	24	20.10	21.10	Remelted after 5 hours.[1]

[1] Solid at end of period.

QUANTITY OF FUSION REAGENT REQUIRED—In all of the fusions made in the previous experiments a large excess of caustic soda was used. To ascertain the minimum amount required for the highest carvacrol yields and the best working conditions, fusions were made with different quantities. The results are given in Table VIII and Fig. 6.

TABLE VIII

Temperature, 360° C. 150 g. sodium cymene sulfonate. Fusion period, 6 hrs.

No.	Caustic Soda G.	Carvacrol G.	Percentage Yield Carvacrol G.	Remarks
1	450	49.91	52.31	Distillate 9.5 cc. water, 23 cc. oil.
2	150	48.12	50.52	Distillate 9 cc. water, 22 cc. oil.
3	100	48.95	51.39	Distillate 9 cc. water, 23 cc. oil.
4	75	48.50	50.92	Distillate 11.5 cc. water, 22 cc. oil.
5	50	49.50	51.96	Distillate 11 cc. water, 22 cc. oil.
6	25	18.97	19.91	Distillate 7 cc. watet, 17.5 cc. oil.
8	0	00.00	00.00	Distillate 13.5 cc. water, 7.5 cc. black oil.

It is interesting to note that the quantity of the fusion reagents could be reduced almost to the theoretical amount required without much effect upon the carvacrol yields. With less than 100 g. the mass could not be poured from the kettle. With smaller amounts the products were of a pasty consistency and had to be scraped out. It is quite necessary that the contents of the kettle be discharged rapidly in order to prevent excessive loss due to reactions which take place on exposure to the air. These reactions were so rapid that ignition took place on two occasions. This was especially true when the fusion products were semi-solid. The results of the fusion in which no caustic soda was used have been discussed previously.

FUSION OF CALCIUM CYMENE SULFONATE—It is possible to fuse calcium cymene sulfonate with caustic alkali and obtain carvacrol. Schorger[1] obtained his highest yield by using this salt. Although one filtration and the soda ash required for the making of the sodium salt, would be saved, more caustic would be necessary for the fusion; and mechanical difficulties, resulting from the insoluble calcium sulfite formed during fusion, would be experienced, thus over-balancing the advantage of the process.

[1] *Loc. cit.*

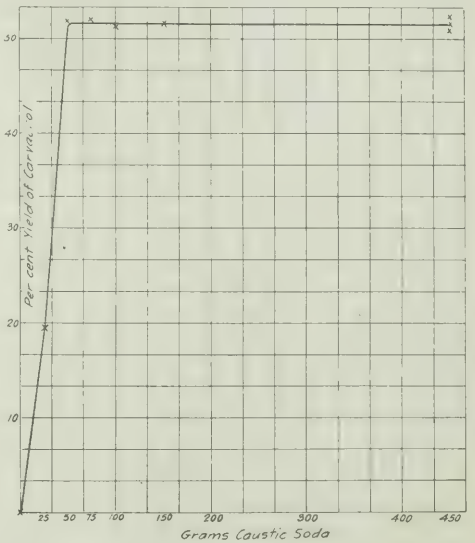


FIG. 6

Two fusions using calcium cymene sulfonate were made with the following results. The charge consisted of 80 g. of caustic soda and 80 g. of calcium cymene sulfonate. The temperature was 360° C.

No.	Carvacrol G.	Per cent of Theoretical Yield	Remarks
1	14.82	28.80	16.5 cc. of fluorescent oil and 11 cc. of water distilled during fusion. Fusion was thick when poured.
2	17.70	34.41	14 cc. of fluorescent oil and 13 cc. of water came off during fusion. Fusion quite thick when poured.

The oil which distilled from the fusion was identical with that obtained from the fusions of the sodium salt. Although the two fusions were made under the same conditions, there was quite a perceptible difference in the yield of carvacrol.

NEUTRALIZATION OF THE FUSION PRODUCTS—The fusions were poured into 2 liters of water and allowed to dissolve. To this solution dilute sulfuric acid (40° Bé.) was added in sufficient quantity to neutralize the excess caustic soda and free the carvacrol from the sodium carvacrolate. When the acid was added in excess it reacted with the sodium sulfite formed during the fusion, and sulfur dioxide was evolved. This served as a means of determining when the neutralization was complete. It was necessary to add the acid to the solution by leading it through a tube to the bottom of the vessel. If this was not done an excess of acid on the surface reacted with the sodium sulfite in that part of the solution before neutralization throughout was complete. The appearance of sulfur dioxide under such a condition was not evidence that neutralization was complete. If the excess sulfuric acid were recovered at the end of the sulfonation

operation it could be diluted and used for this purpose. If concentrated acid is used, the time required for neutralization will be greatly lengthened, due to the great amount of heat produced. If concentrated acid is added rapidly, the heat evolved will cause foaming and loss of much carvacrol.

SEPARATION OF THE CARVACROL—The specific gravity of carvacrol lies so near to that of water that it does not separate readily from water and dilute water solutions of salts. While some of it collects on the surface and forms an oily layer a great deal of it stays in the body of the solution in the form of an emulsion. For this reason it was necessary to remove the carvacrol either by means of a solvent or by steam distillation. When extracted by means of a solvent, one-half liter of benzene was used. It was well shaken with the neutral fusion liquors until it had dissolved all of the carvacrol. The benzene layer was then removed by means of a separatory funnel.

The removal of the carvacrol from the fusion liquors by steam distillation had the advantage that a considerable portion of the solid and suspended tarry matter was left behind. A great deal of this went into the benzene layer and caused trouble when the solvent was applied directly. The yields of carvacrol were the same by both methods. It was necessary to use a solvent to completely remove the carvacrol from the steam distillate. The benzene was recovered in all cases and it was found that an average of 4 per cent was lost in the extraction and distillation. When an excess of acid was used in neutralization a large amount of sulfur dioxide formed was taken up by the benzene.

After the removal of the benzene the residue containing the carvacrol was distilled. The carvacrol came over in the form of a clear, light yellow oil between 227° C. and 245° C., leaving a tarry residue which averaged 0.25 g. for each gram of carvacrol. It was noted that when the yields of carvacrol were low the quantity of tar extracted was also low. The amount of the residue depended upon the method used for removing the carvacrol from the fusion liquors. When the steam distillation method was used the quantity of tar was much smaller. If the carvacrol is extracted directly by means of a solvent, a still with a bottom discharge should be used for the distillation of the extract. This would provide for the removal of the tarry residue when it was hot. If allowed to cool it formed a hard, brittle mass.

PURIFICATION OF THE CARVACROL—This was done by redistilling the product obtained from the fusion liquor by either of the two methods mentioned. No difficulty was experienced in getting a product with a fairly constant boiling point.

LARGE SCALE EXPERIMENTS

Having determined the optimum conditions for the several operations involved in the production of carvacrol from spruce turpentine on a laboratory scale, it was desirable to test them by using larger quantities of materials. Accordingly this was done with apparatus of semi-commercial size.

SULFONATION—Fifty-three pounds of spruce turpentine were treated with 114 lbs. of 66° Bé. sulfuric acid for 6 hrs. at 98° C. in a cast iron sulfonation kettle. The time was longer than would have been necessary had the kettle been equipped with a thoroughly efficient stirring apparatus.

REMOVAL OF THE EXCESS SULFURIC ACID—No attempt was made to recover the excess acid. The sulfonation products were slowly poured into a 150 gal. wooden tank containing a slurry of limestone (95 per cent passed 100 mesh). On the basis of the spruce turpentine containing 80 per cent cymene the calculated amount of limestone required was 95.2 lbs. The quantity needed for complete neutralization was 102 lbs. The neutral solution was filtered with a 12 in., 12-plate Sperry press.

PRODUCTION OF SODIUM CYMENE SULFONATE—To the filtrate from the liming operation 16.5 lbs. of 58 per cent soda ash (58 per cent Na_2O) were added. The calculated amount was 17.1 lbs. The calcium carbonate formed was removed by filtration and the clear solution was evaporated in a 50 gal., steam jacketed, open iron kettle to a thick, sticky consistency. The salt was dried in a steam-jacketed shelf vacuum dryer to a moisture content of 0.7 per cent.

The yield was 70.5 lbs. of dry sodium cymene sulfonate. The calculated yield was 74.8 lbs. In factory practice the sodium cymene sulfonate solution should be evaporated to saturation with a vacuum and then finished with a film drum dryer.

FUSION OF THE SODIUM SALT—Forty pounds of 76 per cent caustic soda (76 per cent Na_2O) were fused in a 30 in. cast iron fusion kettle heated with gas. To the fused caustic 70.5 lbs. (calculated to dry basis) of sodium cymene sulfonate were slowly added. The kettle was tightly covered, the condenser connected, and the temperature gradually raised to 350° C. The temperature was kept between 350° and 360° C. during the 6 hr. fusion period. At 270° C. the fluorescent oil began to distill. The rate at which it came over increased as the temperature was raised. The fusion went smoothly and poured readily. Less caustic could have been used without the substance solidifying during fusion. The salt was poured into an iron tank containing 30 gal. of water.

NEUTRALIZATION OF THE FUSION LIQUOR—Dilute sulfuric acid (40° Bé.) was slowly added until the fusion liquor was neutral. 67.5 lbs. of acid were required. The calculated amount was 70.32 lbs. The operation was carried out in a steel tank.

SEPARATION OF THE CARVACROL—Forty-five pounds of benzene were thoroughly agitated with the neutral fusion liquors. The benzene solution was separated by drawing off the water solution from below. The benzene (43.75 lbs.) was recovered by distillation with a steam-jacketed still. The benzene loss was 2.7 per cent.

There being no direct heated still of sufficient size available, 1 liter of the extract was distilled in a distilling flask. The product obtained was slightly fluorescent and contained a little finely divided carbon which came from the cracking of the tarry substance.

When redistilled a clear, yellowish oil that boiled at 232° C. was obtained. From the quantity of carvacrol obtained the total yield was calculated. The data and results of the large scale experiments are given in Table IX.

TABLE IX—DATA AND RESULTS OF LARGE SCALE EXPERIMENTS

MATERIALS AND PRODUCTS	Quantity Used Lbs.	Theoretical Quantity Required Lbs.	Yield	Yield Per cent	Quantity Recovered Lbs.	Per cent Recovered
Spruce Turpentine	53	...	..	...	...	..
Sulfuric Acid (66° Bé.)	114	32.2	..	...	...	..
Limestone	102	95.2	..	...	...	..
Soda Ash	16.5	17.1	..	...	...	..
Sodium Cymene Sulfonate	...	...	70.5	94.25	...	..
Caustic Soda	40.0	23.9	..	...	...	..
Sulfuric Acid (40° Bé.)	67.5	70.32	..	...	...	..
Benzene	45	...	..	...	43.75	97.3
Fluorescent Oil (recovered for re-use)	...	...	7.3	...	...	..
Sp. Gr. = 0.8890 Carvacrol	...	...	25.3	57.2	...	..
Tar	...	...	3.8	...	...	..

DISCUSSION OF RESULTS AND OBSERVATIONS

The most favorable conditions for the various operations as determined in the laboratory when applied on a larger scale gave similar results. With the greater quantities of materials the conditions were more easily controlled. This was especially true of the fusion operation which was the most difficult one in the process to handle. The quantity of the cymene-bearing oil obtained from the fusion, per unit of sodium cymene sulfonate fused, was smaller than that obtained from laboratory experiments. From the latter it amounted to about 20 per cent of the original cymene used and from the former to 13.7 per cent. The apparatus required to collect this oil is simple and inexpensive and the quantity of the oil given off is such as to make its recovery imperative.

When the caustic soda was fused first and the sodium salt added afterwards, trouble was experienced with foaming unless the salt was added very slowly. However, this procedure may be used if the cover of the kettle is such that it can be opened and closed quickly so as to prevent oxidation and loss of the distillate. When the sodium salt and the caustic were well mixed together previous to charging, no trouble with boiling over during the fusion was experienced. The stability of the sodium cymene sulfonate permitted this to be done. The fusion kettle, however, should be of ample size to take care of the temporary swelling of the fusion mass.

When dry sodium cymene sulfonate was exposed to the air it took up moisture rapidly and became sticky. This property would prevent it from being stored in an open bin.

The time required for each operation was such that it could be completed within 8 hrs., the ordinary working day. This would be an important factor in plant operation.

The yield of carvacrol from the operations with the larger quantities of materials was about 5 per cent greater than with the quantities used in the small scale experiments. If the cymene recovered from the fusion operation is taken into consideration, as should be done, the carvacrol yield will be increased. The difference this makes is shown in the following table. The cymene content of the original spruce turpentine and of the oil recovered was taken as 80 per cent in each case. The cymene content of the recovered oil was subtracted from that originally taken. From this the theoretical yield and the percentage yields were calculated.

No. (Table V)	Per cent Yield Not Taking Recovered Oil into Consideration	Per cent Yield Taking Recovered Oil into Consideration	Increase Per cent
7	51.71	63.94	12.23
8	50.14	62.60	12.46
9	52.31	64.65	12.34
10	51.60	63.65	12.05
11	50.65	62.51	11.86
Large scale experiment	57.2	66.4	9.2

Carvacrol can be produced by the process outlined with the same equipment as that used in a plant for the manufacture of phenol or beta-naphthol, with but few changes. A fusion kettle equipped with a close fitting, easily opened cover and a water-cooled coil condenser would be necessary. In addition to this a direct heated still for the distillation of the carvacrol would be essential. Otherwise the phenol or beta-naphthol plant could be used as it is.

Inasmuch as practically the same plant can be used, the cost of production of carvacrol can be compared with that of phenol. The United States Government has fixed the price of phenol at 38 cents per lb. This is commonly known to give the manufacturer an average net profit of 7 cents per lb., thus making the total average cost 31 cents per lb. The total material cost per pound of carvacrol produced on the basis of 60 per cent yield would be about 35 cents per lb. The labor and overhead costs would be higher than those of phenol due to the lower yield obtained. The overhead cost would also be somewhat higher on account of the extra equipment required. The total cost per pound of carvacrol produced would be close to 60 cents, a cost well within the limits of commercial possibility.

SUMMARY

A process for the manufacture of carvacrol from cymene has been outlined and studied in detail.

The process depends upon the use of spruce turpentine as the source of cymene.

The optimum conditions for the necessary operations have been determined.

Briefly stated, the process consists of:

1—Making cymene sulfonic acid by thoroughly agitating spruce turpentine with an equal volume of 66° Bé. sulfuric acid at a temperature of 90° to 100° C. for 4 hrs. in a cast iron sulfonating kettle.

2—Neutralization of the excess sulfuric acid, formation of calcium cymene sulfonate in solution by adding ground limestone to the sulfonation products and removal of the calcium sulfate formed by filtration.

3—Formation of sodium cymene sulfonate by adding soda ash to the hot calcium cymene sulfonate solution and removal of the precipitated calcium carbonate by filtration.

4—Concentration of the sodium cymene sulfonate solution in a vacuum evaporator to the point of saturation.

5—Precipitation and drying of the calcium cymene sulfonate by means of a rotary steam heated film dryer, or other suitable means.

6—Fusion of the dry sodium cymene sulfonate with approximately one-half of its weight of 76 per cent caustic soda in a cast iron or steel fusion kettle provided with a cover and water-cooled condenser at a temperature of 350° to 370° C. for 6 hrs.

7—Pouring the fusion products into a minimum amount of cold water and neutralization of the solution so formed by adding just enough 40° Bé. sulfuric acid to neutralize the excess caustic soda and set free the carvacrol from the sodium carvacrolate.

8—Separation of the carvacrol from the neutral fusion liquid by steam distillation or by agitating with a solvent such as benzene.

9—Recovering the solvent by distillation.

10—Distillation of the carvacrol from the benzene extract with a direct heated still.

11—Purification of the carvacrol by redistillation with the same still.

This process was tested on a large scale which gave even better results than those obtained with the smaller quantities.

Chemical Engineering Laboratory
Columbia University
New York City

THE SEEDING METHOD OF GRAINING SUGAR

By H. E. Zitkowski[1]

Received June 17, 1918

There is a disposition in some quarters to deny to the sugar industry its claim as a member of the chemical industrial family. That the beet sugar industry, the direct descendant of scientific research and probably the oldest member of magnitude of the chemical industry family, should find it necessary to establish any claim in this direction is anomalous. Someone, sometime, as a labor of love, will bring this out as a matter of record.

Here I desire merely to state that nowhere else in industry has technical accounting been carried to the point that it has in the beet sugar industry. The beet sugar industry has taken laboratory manipulations or processes such as dialysis or diffusion, precipitation, filtration, evaporation, and crystallization and adopted them to factory scale, handling millions of pounds of material daily, and with a refinement which taxes the ingenuity of the most expert manipulator to now duplicate on a laboratory scale.

It is even held that the beet sugar industry, which established itself in Europe during the Napoleonic wars, deserves to a very large degree the credit for the rapid development of the chemical industry of Germany. It was the beet sugar industry which furnished the technically trained and experienced men, capable of transferring laboratory reactions and processes to a factory scale and keep the commercial requirements in mind, when the modern chemical industry sprang into being.

Men go so far as to state that it was the beet sugar industry of Germany which made possible the terrible war that Germany is waging, not only because it was the foundation stone for the chemical industry but also because the cultivation of the beet brought with it scientific agriculture which doubled the agricultural yields, thereby making Germany largely self-sustaining and eliminating the threat of being starved to submission by blockade. There is much that can be said in defense of such a view-point.

However, at this time here it is desired to discuss briefly the large scale practical application of the well known "seeding" method of inducing crystallization.

The oldest, and for many years the only method of producing sugar crystals was to concentrate the properly purified sugar-bearing syrups to the required density or supersaturation and set them away. In the course of days, or weeks, or even months, as the solution cooled, sugar would crystallize out. Even after the introduction of the vacuum pan method of "boiling" sugar, for many years this was the only method and was known as "boiling blanks." Sometime during the fifties of the last century the art or rather the "trick of the trade" of "graining" sugar while yet in the vacuum pan was acquired, though this was not generally adopted till 20 years later, and even up to this day frequently, for reasons which need not be discussed here, blanks are boiled. The general procedure at present is as follows:

A quantity of the properly prepared sugar-bearing syrup with a water content of from 30 to 40 per cent is introduced into a vacuum evaporator or "pan" and is concentrated till saturated. At this point the boiling mass will be at a temperature from 70° to 80° C., and under a vacuum of from 20 to 25 in.

Under certain conditions aqueous sugar solutions have the property of forming supersaturated solutions and in the presence of the non-sugars or impurities, such as occur even in purified juices, this tendency is greatly increased, so that in factory practice it is always necessary to carry the concentration to some degree of supersaturation before crystallization occurs. Now it is not to be inferred that in all cases simple supersaturation will bring about crystallization, for, if the content of non-sugars or impurities in the solution is great enough, crystallization will not occur even though evaporation be carried to the point of dryness.

Under the normal conditions of sugar manufacture, however, that degree of supersaturation is finally reached at which crystal formation begins. Sometimes a sudden shock applied to the boiling, supersaturated mass is resorted to in order to induce crystallization, such as a sudden raising of the vacuum bringing with it violent ebullition, or the introduction of a hot syrup of a lower density which has the same effect, or the injection of steam or air into the mass. No matter how produced, at the moment of their formation the crystals are infinitely small and some time is required to attain a visible size, though this may be only a few moments. Eventually the crystals formed do become visible and then the critical moment of the "boiling" of the "pan" arrives.

It becomes the attendant's business to allow the formation of crystals to proceed till, in his judgment, the proper number of nuclei for the apparatus in ques-

[1] Paper read before the American Institute of Chemical Engineers, Berlin, N. H., June 19, 1918.

tion have formed, then to arrest the formation of further crystals by lowering the supersaturation coefficient, which is done by lowering the vacuum, raising the temperature and diluting with syrup of a lower density. From then on it becomes his business so to regulate the temperature, the rate of evaporation, and the introduction of syrup that the minute crystals will grow, and, when the pan is full, be of the size to supply the market's demand.

Not much time for deliberation is available when it is realized that often a pan holding 200,000 lbs. of mass and yielding 80,000 lbs. of granulated sugar is boiled complete in less than 2 hours. If the operator's judgment at the time of "graining" is at fault, and he allows the formation of too many crystals, the final product will be too small, may cause great difficulties in separation from the mother liquor and decrease the yield; if the number of crystals formed is too small the resulting end-product will be too large, the time for crystallization will be longer, and again the yield will be reduced. In both instances the cost of production is increased.

But even at best the crystal formation at the time of graining is not instantaneous, and by the time that some have reached a visible size others are at the point of formation, therefore infinitely small, with the result that the final end-product is not uniform in size. This is objectionable, not only on economical ground, as the difficulty of separating the sugar crystals from the adhering mother liquor is greatly increased by uneven grains, but also a fastidious consuming public demands not only a pure, white, sparkling crystal of a certain size (varying somewhat in different parts of the country) but the crystals must also be fairly uniform in size.

The above points out briefly some of the problems in connection with producing the "granulated" crystals usually found on our markets. Not all of the sugar produced is, however, so directly obtained as granulated. Much of the final output is first obtained as a "raw" or impure sugar, which is melted, reprocessed and recrystallized. The liquors from which these raws are obtained are of a lower purity and therefore present greater difficulty to crystal formation or "graining." The impurities present, however, must not be above a certain ratio to the sugar present or crystallization in the pan will be entirely prevented and the mass will be blank, or if crystals form they will remain so small as to be separated from the surrounding mother liquor only with great difficulty, if at all.

Eventually a final liquor, molasses, remains, which in beet sugar manufacture may contain 50 per cent of sucrose but also sufficient of impurities to prevent further crystallization. Any procedure, therefore, which increases the quantity of sugar recoverable by direct crystallization, or which increases the yield with each crystallization, or reduces the time element, or even merely simplifies the procedure, may be very valuable. The saving may amount to only one hundredth of a cent per pound of sugar, and yet, on the quantity of sugar produced, run into astonishing totals.

A very valuable recent development in the art of boiling sugar is the "seeding" of the saturated mass in the vacuum pan with sugar dust to serve as nuclei for the sugar crystals, instead of the method above described of bringing about spontaneous crystal formation or "graining" by high supersaturation. Considering the simplicity of the use of sugar dust for this purpose and that it can be used without an expense or alteration of any kind in the equipment, this method is likely to prove to be one of the most valuable developments introduced into the industry in recent years.

While the method of "seeding" herein considered is a recent development, yet the principle underlying it is not at all new.

In U. S. Patent No. 489,879 dated January 10, 1893, covering a Process of Obtaining Sugar, is found the following:

"It has, however, long been known that if such impure solutions are brought in contact with a sufficiently large number of crystals, a very effective crystallization can be brought about in the vacuum pan; and this knowledge has been made practical use of in sugar factories by the addition of raw sugar crystals to juices which could otherwise only be boiled with great difficulty. Similarly it is sometimes customary in sugar refineries, when very small crystals are desired, to bring the liquor to the crystallization point, and then by the introduction of a quantity of finely pulverized sugar to start energetic crystallization, thus insuring the formation of small crystals by shortening the time of boiling and consequently that given to the crystals in which to grow."

Similar references to "seeding" sugar can be found at even earlier dates, and yet it appears very doubtful that this method was ever successfully used in producing marketable sugar until less than two years ago.

To Mr. John C. Bourne, now somewhere with the Canadian forces, belongs the credit of having called attention to this subject, which led to the present development. Mr. Bourne was not familiar with the literature on the subject and was not aware that the idea had ever been suggested—to him it was entirely new.

The method as at present used very successfully, is as follows:

The sugar-bearing syrup properly prepared is introduced into the vacuum pans and under the usual conditions of vacuum and temperature is concentrated till the point of saturation has been passed, that is, till the solution is slightly supersaturated or, in the language of the industry, till it reaches a light "string proof." At this point a quantity of sugar dust or powdered sugar, varying from $^1/_2$ qt. to 2 qts. for each 1000 cu. ft. of vacuum pan capacity, is introduced by aspiration, through suitable connection, beneath the surface of the boiling mass, care being taken to prevent the inrush of any considerable quantity of air, as otherwise a portion of the sugar dust introduced is likely to rush up with the air and on into the condenser. This operation requires not more

than half a minute. One or two minutes are required for the sugar particles introduced to mix through the boiling mass. For several minutes after the introduction or "seeding" the usual "proof" appears blank or at best simply shows a cloud, the sugar particles introduced being too small to be visible to the naked eye.

The solution, however, is supersaturated and is boiling vigorously and the crystals or fragments of crystals introduced immediately begin to grow and soon show up on the "proof." Evaporation is continued till about that density is reached usually obtained by the older methods of "graining." From here on the procedure is as usual except that experience has shown that less difficulty will be experienced to keep out false grain or "smear" in a "seeded" pan than one "grained" by the older method.

The essential difference between the two methods is that in the one case the crystallizing nuclei are introduced ready made, in the other are formed spontaneously by highly supersaturating the liquor which carries with it certain objectionable features as previously pointed out.

The quantity of sugar dust to be used per unit volume of pan capacity is dependent on the size of the dust particles and on the size of crystals required in the finished product.

In the writer's experience the "seed" used was such sugar dust as accumulates in the usual dust collectors of the sugar drying equipment. In size the dust particles ranged from an impalpably fine powder to particles just passing through a standard Tyler sieve of 100 mesh. Particles larger than this were screened out. In some instances powdered sugar as found on the market was used with success.

As a great difference in size or volume exists between particles or crystals just passing through a 100-mesh sieve and particles impalpably fine, it was considered that perhaps superior results would be obtained if the dust or "seed" used was more uniform in size. With this thought in mind trials were made with dust from which both the coarser and finer materials had been removed; improved results were obtained only if the seed did not contain too many particles larger than 80 mesh.

While at the time of seeding a vast difference in size and weight exists between a powder particle and a particle of 100 mesh, when these nuclei have reached the market size little difference exists. In all probability the rate at which the crystallizing sugar deposits on the nuclei is in direct proportion to their surface areas. The surface area of an impalpably fine particle in proportion to its volume is so immensely greater than that of a particle of 100 mesh that as the two particles grow, the smaller growing at a relatively faster rate than the larger, the difference in size will become negligible.

Then, also, possibly the tendency of crystal splinters to regenerate the original shape of the crystals from which they have been produced may play a rôle, as the finer particles especially are largely crystal splinters.

This describes briefly the new method of "graining" sugars in the vacuum pans as practiced for the first time during the past campaign in a dozen or more beet sugar factories of the Western States. It deserves further study before all the factors are determined. However, the results obtained during the past campaign in the factories coming under the writer's observation, especially on the lower products, were uniformly superior to the normal results.

ROCKY FORD, COLORADO

A STUDY OF SOURCES OF ERROR INCIDENT TO THE LINDO-GLADDING METHOD FOR DETERMINING POTASH

By T. E. KEITT AND H. E. SHIVER

Received June 19, 1918

Prior to our study[1] of the DeRoode method for the determination of potash in fertilizer materials, much data had been accumulated in this laboratory relative to sources of error incident to the Lindo-Gladding method for determining potash. In the interest of furthering the adoption of the modified DeRoode method we deem it advisable to present the results of these studies. In fact, the work on the DeRoode method was undertaken, primarily, because of the inaccuracies of the Lindo-Gladding method.

The determination of water-soluble potash in all samples reported in Table I was done by the official Lindo-Gladding method.[2] Another set of determinations was made exactly as outlined under the modified official method.[3] Still another set of determinations was made on these samples by the modified official method,[4] except that hydrochloric acid was not added to the filtrate nor was the ammonia and ammonium oxalate added after the solution had been made to volume and an aliquot of 100 cc. (equivalent to one gram) had been taken.

This was done in order that the ammonia precipitate and the lime might be separately estimated. The aliquots were brought to boiling and ammonia was added until alkaline, the boiling continued a few minutes to expel any considerable excess of ammonia, then the precipitate was separated by filtering hot and washing with hot water. The combined filtrate and washings from each determination was then evaporated to a volume of about 200 cc., made alkaline with ammonia, and precipitated with ammonium oxalate; the calcium oxalate precipitate was filtered after standing over night, and thoroughly washed with hot water. The combined filtrate and washings from each of these precipitations was then used for the determination of potash. In evaporating these filtrates, as well as all other large filtrates that have much salts of ammonia present, there is a decided tendency to crawl. This can be controlled by acidifying with 1 : 1 sulfuric acid, and filling the dishes only to within a quarter of an inch of the top. The volatilization of the ammonium salts was also accom-

[1] THIS JOURNAL, **10** (1918), 219.

[2] A. O. A. C., U. S. Dept. of Agr., Bureau of Chem., *Bull.* **107** (revised)

[3] U. S. Dept. of Agr., Bureau of Chemistry, *Bull* **152**.

[4] *Ibid*

panied with difficulties on account of the large amount of residue and the danger of spurting. After we began adding the sulfuric acid before evaporation was complete, this trouble was greatly lessened.

TABLE I— INFLUENCE OF IRON AND ALUMINUM IN SOLUTION ON THE ESTIMATION OF POTASH

SAMPLE NO.	Per cent Potash (K_2O), Lindo-Gladding Method	Per cent Potash (K_2O), Modified Lindo-Gladding Method	Potash (K_2O), Revised Modified Lindo-Gladding Method	Per cent of Ammonia Precipitate	Per cent Calcium Oxide (CaO)	Difference between Lindo-Gladding and Modified Method	Difference between Lindo-Gladding and Revised Modified Method	Difference between Modified Lindo-Gladding and Revised Modified Method
1214	3.89	4.04	4.00	0.77	0.13	—0.15	—0.11	0.04
1216	2.63	2.60	2.60	1.05	0.34	0.03	0.03	0.00
1218	1.69	1.62	1.71	1.55	0.95	0.07	0.07	—0.09
1220	4.16	4.30	4.55	2.43	0.15	—0.14	—0.39	—0.25

Table I shows that in comparing three methods for determining water-soluble potash, the essential feature of difference in the methods being the bulk and method of handling of the ammonia precipitate and the lime, the only large difference in results is correlated with the amount of ammonia precipitate, which consists mainly of hydrates of iron and of aluminum. These hydrates constitute a bulky, sticky, gelatinous precipitate, the influence of which will be proved later.

From the data already outlined, we were led to believe that some of the potash is occluded by the bulky precipitate formed on the addition of ammonia and ammonium oxalate. To test this point we procured ten samples that had been found deficient in potash by the Fertilizer Control.

The method of procedure was as follows: 10 grams of each sample were boiled with 300 cc. of distilled water for 30 min., then filtered into a 500 cc. volumetric flask to separate from the insoluble material. The residue was washed with hot water, and the combined filtrate and washings, about 350 cc., were brought to boiling, and ammonia and ammonium oxalate added as directed for the Lindo-Gladding method.[1] The solutions were cooled, made to a volume of 500 cc., and filtered rapidly by means of a suction pump to separate the ammonia and ammonium oxalate precipitate, the filtrate being used for the determination of potash.

TABLE II—VOLUME OF FILTRATE, AMOUNT OF POTASH RECOVERED IN FILTRATE, AMOUNT OF POTASH WASHED OUT OF RESIDUE, TOTAL POTASH DETERMINED, AND THE EFFECT OF DILUTION BEFORE PRECIPITATION ON POTASH CONTENT

	OFFICIAL METHOD					MODIFIED OFFICIAL METHODS	
SAMPLE NO.	Volume of Filtrate from 500 cc.	Per cent Potash (K_2O) Calculated on 500 cc. Volume	Per cent Potash in the Washings	Per cent Potash (K_2O) Washed Out Calculated on Difference Between Volume and 500 cc.	Per cent Total Water-Soluble Potash Determined	Per cent Soluble Potash (K_2O) Determined before Precipitation	Per cent Soluble Potash (K_2O) Determined not Diluted before Precipitation
38	478	3.15	0.13	2.95	3.28	3.13	3.05
160	463	2.71	0.18	2.69	2.89	2.72	2.64
547	483	5.98	0.24	5.06	6.22	5.92	5.91
850	478	2.68	0.17	3.86	2.85	2.71	2.72
1229	475	2.93	0.29	5.80	3.22	2.84	2.76
1387	470	1.87	....	....	....	1.85	1.82
1389	483	3.13	....	....	....	3.15	3.06
1991	470	3.04	....	....	....	2.84	2.68
2170	465	3.05	....	....	....	3.12	2.98
2473	482	4.09	....	....	....	4.28	4.16

Other determinations of water-soluble potash were made by the revised modified Lindo-Gladding method.

[1] Loc. cit.

which has already been discussed in detail. In making these determinations, two aliquots were taken from each flask, one of which was precipitated with ammonia and ammonium oxalate in the volume of the aliquot, 100 cc., while the other was diluted before precipitation. All were filtered and thoroughly washed, potash being determined in the combined filtrate and washings in each case.

Table III clearly brings out the compensation effects of decreased volume and of occluded potash. It also shows the relation of the volume in which the precipitation with ammonia and ammonium oxalate takes place, to the occlusion of potash.

The ammonia and ammonium oxalate precipitates on the filters which had been thoroughly washed to remove potash, were each placed in a soil digestion flask with 100 cc. hydrochloric acid (sp. gr. 1.115) and digested at the temperature of boiling water until solution was complete. The solutions were transferred to 500 cc. flasks, cooled, and made to volume. An aliquot was taken, diluted to 400 cc., reprecipitated, brought to boiling, and filtered. This operation was repeated twice, making three precipitations in all. The potash from each precipitation was determined separately, in order that we might determine when the separation was nearing completion. The results were so surprising that we had all of the work duplicated. Due to the large amount of work entailed, we used only five samples.

TABLE III—OCCLUSION OF POTASH IN THE PRECIPITATE FORMED ON ADDITION OF AMMONIA AND AMMONIUM OXALATE

	Per cent Potash (K_2O) in Three Reprecipitations of the Ammonia and Ammonium Oxalate Precipitate, in 400 cc. Volume.						
SAMPLE NO.	Analyst Kelly	Analyst Risher	Average	Per cent Water Soluble Potash (K_2O), Column 5, Table II	Per cent Total Water-Soluble Potash (K_2O) Recovered	Per cent Water Soluble Potash, Lindo-Gladding Method	Per cent of Water-Soluble Potash Corrected for Diminished Volume, Column 7, Table II	Per cent of Water-Soluble Potash not Determined by Lindo-Gladding Method
58	0.91	0.89	0.90	3.28	4.18	3.15	3.99	0.84
160	0.59	0.61	0.60	2.89	3.49	2.51	3.23	0.52
547	0.67	0.62	0.65	6.22	6.87	5.98	6.64	0.66
850	0.58	0.64	0.61	2.85	3.46	2.68	3.31	0.63
1229	0.64	0.74	0.69	3.22	3.91	3.10	3.71	0.61

Table III shows that in each case more than 0.5 per cent of potash was occluded by the ammonia and ammonium oxalate precipitate, showing that there are grounds for the manipulators' contention that the Lindo-Gladding method of analysis does not account for all of the potash added in the water-soluble form. It further shows that all the Lindo-Gladding method does not account for all of the potash soluble in water at the time of the analysis.

To secure additional information regarding the errors due to the occlusion of potash and diminution in volume incident to the Lindo-Gladding method, pure salt solutions were prepared as follows:

Solution 1 contained potassium chloride and ferric sulfate equivalent to 5.99 per cent K_2O and 10.31 per cent Fe_2O_3.

Solution 2 contained potassium chloride and tricalcium phosphate equivalent to 5.99 per cent K_2O and 10 per cent $Ca_3(PO_4)_2$.

Solution 3 contained potassium chloride, iron, and tricalcium phosphate equivalent to 5.99 per cent K_2O, 10.31 per cent Fe_2O_3, and 10 per cent $Ca_3(PO_4)_2$.

TABLE IV—ERRORS DUE TO DIMINISHED VOLUME AND TO OCCLUDED POTASH WHEN PURE SALTS ARE USED

Vol. of each stock solution used	Volume Made	Volume of Filtrate	Volume of Aliquot	Wt. of Potash (K2O) Calc. on Lindo-Gladding	Wt. Potash (K2O) on Actual Volume	Wt. Potash (K2O) in Wash Water Same Aliquot	Wt. Potash (K2O) Recovered from 1st Reprecipitation	Wt. Potash (K2O) Recovered from 2nd Reprecipitation	Wt. Potash (K2O) Recovered from 3rd Reprecipitation	Total Wt. Potash (K2O) Soluble in Water	Total Wt. Potash (K2O) Recovered by All Reprecipitations	Total Wt. Potash (K2O) Recovered by All Determinations	Total Wt. Potash (K2O) in Solution	Wt. Potash (K2O) not Recovered	Wt. Potash (K2O) not Recovered by Lindo-Gladding
	Cc.	Cc.	Cc.	Gram	Gram	Gram	Gram	Gram	Gram	Gram	Gram	Gram	Gram	Gram	Gram
25 cc. KCl	500	500	50	0.0304	0.0304	....	....	....	....	0.0304	....	0.0304	0.0312	0.07	0.07
50 cc. KCl	500	500	50	0.0611	0.0611	....	....	....	....	0.0611	....	0.0611	0.0621	0.10	0.10
25 cc. KCl, 25 cc. $FeCl_3$	500	485	50	0.0279	0.0288	0.0006	0.0002	0.0001	0.0004	0.0285	0.0007	0.0292	0.0318	0.19	0.26
25 cc. KCl, 50 cc. $FeCl_3$	500	475	50	0.0537	0.0565	0.0020	0.0009	0.0001	0.0007	0.0557	0.0017	0.0574	0.0621	0.47	0.64
25 cc. KCl, 50 cc. $Ca_3(PO_4)_2$	500	478	50	0.0279	0.0292	0.0009	0.0006	0.0002	0.0004	0.0288	0.0012	0.0300	0.0311	0.11	0.28
50 cc. KCl, 100 cc. $Ca_3(PO_4)_2$	500	475	50	0.0549	0.0578	0.0022	0.0008	0.0003	0.0005	0.0571	0.0016	0.0587	0.0621	0.34	0.50
25 cc. KCl, 50 cc. $Ca_3(PO_4)_2$, 25 cc. $FeCl_3$	500	475	50	0.0263	0.0277	0.0006	0.0019	0.0003	0.0005	0.0269	0.0027	0.0296	0.0311	0.15	0.42
50 cc. KCl, 100 cc. $Ca_3(PO_4)_2$, 50 cc. $FeCl_3$	500	468	50	0.0521	0.0557	0.0006	0.0008	0.0002	0.0005	0.1529	0.0015	0.0544	0.0621	0.77	0.92

Solution 4 contained potassium chloride, iron, tricalcium phosphate, and aluminum sulfate equivalent to 5.99 per cent K_2O, 10.31 per cent Fe_2O_3, 10 per cent $Ca_3(PO_4)_2$, and 10 per cent Al_2O_3.

These solutions were intentionally exaggerated as to content of impurities and were analyzed in the same manner as already described for the mixed fertilizers. The determinations shown are the first and only results obtained, emphasizing the ease and accuracy of the method of determination.

Table IV shows that the precipitate formed by the addition of ammonia and ammonium oxalate in the flask considerably diminishes the volume when tricalcium phosphate, ferric hydroxide, or a combination of the two are present. It further shows that some of the retained potash may be washed out with hot water, but that a considerable amount cannot be removed in this manner. Three successive reprecipitations in large volumes, dissolving the precipitate each time in hydrochloric acid and reprecipitating with ammonia, show a small amount of potash recovered. In the case of the potash, a larger amount was recovered in the third reprecipitation than in the second, indicating that a continuation of these reprecipitations might have shown a greater recovery. A comparison of the theoretical potash content with the amount determined shows slightly more occlusion by the amount of iron used than by the tricalcium phosphate, although the latter showed marked properties in this respect; a combination of the two increases the occlusion.

CONCLUSIONS

This work proves that there are two sources of error in the Lindo-Gladding method for determining potash: (1) the volume of the solution is decreased by the bulk of the precipitate formed on addition of ammonia and ammonium oxalate, which makes a plus error, and (2) the potash in solution is decreased by occlusion of potash by the heavy gelatinous precipitate formed. These two sources of error are partially compensating.

It is impossible to wash out with hot water the potash occluded within the precipitate.

The occluded potash may be separated to a certain extent by repeatedly dissolving the precipitate in hydrochloric acid, diluting to a large volume, precipitating with ammonia and ammonium oxalate, filtering, and determining potash in the filtrates and washings.

The use of pure salts for making known strength solutions shows that both iron and calcium phosphate, when precipitated with ammonia, occlude potash, and that a combination of the two is even more effective in producing occlusion.

LABORATORY OF THE SOUTH CAROLINA EXPERIMENT STATION
CLEMSON COLLEGE, S. C.

DETERMINATION OF THE VALUE OF AGRICULTURAL LIME

By S. D. CONNER

Received May 23, 1918

Three analytical methods are commonly used for determining the value of agricultural limes and limestones.

1—The making of an analysis and calculating the value of the material from the percentages of calcium and magnesium found.

2—The determination of carbon dioxide and calculating the value of the limestone from this alone. Quite a number of devices have been introduced in late years to make it possible to carry out this estimation quickly and easily.

3—The determination of the acid-neutralizing power of the material by digesting in a slight excess of standard acid, then titrating the excess acid with standard alkali. The titration method has been used during the past five years on many samples of limestone, burned lime, hydrated lime, gas lime, marl, shells, various by-products from beet sugar factories, acetylene generators, refuse from water-softening plants, etc. It has in all cases been found very accurate and rapid.

TITRATION METHOD

The procedure used by the author follows:

Pulverize a sample of the stone in an iron mortar until it feels free from grit. Weigh out exactly one gram and place it in a 250 cc. beaker, cover with a watch glass and introduce, at the lip, without removing the cover, 6 cc. of 4 N hydrochloric acid. When the effervescence nearly ceases add 75 cc. distilled water and boil gently in the covered beaker for 10 or 15 min., in which time the reaction is completed and the carbon dioxide driven off. Cool and titrate to faint pink with $N/2$ sodium hydroxide, using phenolphthalein as indicator.

The results are calculated to the equivalent of calcium carbonate and the acid-neutralizing power

of the limestone is reported in terms of per cent of calcium carbonate. With pure calcium carbonate at one hundred, some magnesites and dolomites will show a calcium carbonate equivalent of over one hundred.

PRECAUTIONS TO BE OBSERVED—It is best to cool the solution before titrating, as phenolphthalein is more sensitive in the cold and also because some limestones contain enough soluble iron to destroy the indicator. This destructive action is very much greater in a hot solution than it is in a cold one. Solutions which give much ferrous hydroxide on neutralization should be titrated slowly and with the addition of new portions of indicator when nearing the end-point.

With materials high in magnesium, such as magnesite, it is advisable to titrate slowly, as the color change of the indicator is slow. If the end-point is passed the solution can be titrated back with a standard acid.

By running a blank determination on the acid it will be found that boiling does not cause appreciable loss of acid and does not materially affect the determination.

POT TESTS

Pot tests on two types of acid soil with several calcium and magnesium stones have been conducted. The crops grown were wheat and red clover. Each treatment was conducted in duplicate in paraffined galvanized iron pots $9^1/_4$ in. in diameter and 11 in. deep. The pots were subwatered by means of a tube connected to an arch at the bottom of the pot.

Both the wheat and clover were sown February 27, 1917. After germination the seedlings were thinned so that only three plants of wheat and three of clover were left per pot. The pots were weighed at regular intervals and kept at one-half the water holding capacity of the soils throughout the experiment. The wheat was harvested September 1, 1917, and the clover January 15, 1918.

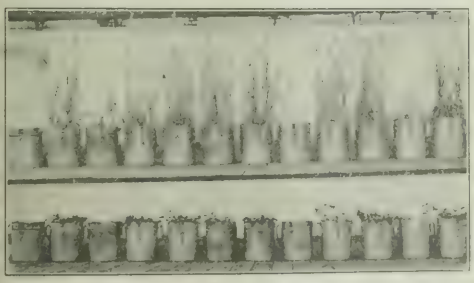


FIG. 1—POT TESTS WITH WHEAT AND CLOVER ON ACID BLACK SANDY SOIL TREATED WITH VARIOUS MINERALS. SEE TABLE II

Two radically different types of acid soils were used in the tests. Soil W is a peaty sand high in organic matter, containing 5.72 per cent ammonia-soluble humus before extracting with dilute HCl and 4.96 per cent humus after extracting with acid. Soil D is a yellow silty clay very low in organic matter, containing 0.73 per cent humus before and 0.70 per cent humus after extraction with acid. These soils were selected because Soil W represents a type predominating in organic acidity and Soil D represents a typical inorganic acid soil with very little organic acidity. In view of the fact that the results obtained on the two types of soil agree very closely it seems logical to conclude that like results would be obtained on other soils of an equal degree of acidity. Both soils used are very acid and it is quite probable that somewhat different relative results would be obtained if similar tests were conducted with soils of slight or medium acidity.

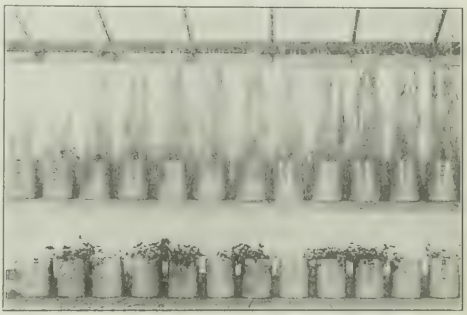


FIG. 2—POT TESTS WITH WHEAT AND CLOVER ON ACID YELLOW SILTY CLAY SOIL TREATED WITH VARIOUS MINERALS. SEE TABLE II

In addition to pure cleavable calcite (calcium carbonate) the following high-grade minerals, pulverized to pass a one-half millimeter sieve, were used to test their values in neutralizing soil acidity and increasing crop growth: Wollastonite (calcium silicate), raw rock phosphate (commercial), gypsum (calcium sulfate), dolomite (calcium magnesium carbonate), magnesite (magnesium carbonate), enstatite (magnesium silicate), serpentine (magnesium silicate).

The comparative test of the different minerals was made in addition to a basic application of nitrogen, phosphate, and potash fertilizer. This basic fertilizer was applied at the following rates per million pounds soil: 91 lbs. ammonium nitrate, one-third applied at the start and the remainder at intervals of two months; 73 lbs. di-ammonium phosphate all at the start; 100 lbs. di-potassium phosphate all at the start. The basic fertilizer was prepared from neutral chemicals of the highest purity free from calcium or magnesium. It is approximately equivalent to a field application of 1000 lbs. per acre of a formula containing 6 per cent N, 8 per cent P_2O_5, and 8 per cent K_2O. All treatments were thoroughly mixed with the proper weight of soil before the pots were filled. At the end of the experiment soil samples from each pot were taken the full depth of the pots by means of a soil tube and tested for acidity.

Table I shows the CaO, MgO, and CO_2 in the minerals used, also the calculated calcium carbonate equivalent as determined by three methods.

TABLE I—ANALYSIS OF MINERALS USED

Mineral	Theoretical Formula	Per cent Soluble in Dilute HCl—CaO Per cent	MgO Per cent	CO_2 Per cent	$CaCO_3$ Equivalent—By CaO and MgO Per cent	By CO_2 Per cent	By Titration Per cent
Calcite	$CaCO_3$	56.00	0.10	43.65	100.1	99.2	99.5
Wollastonite	$CaSiO_3$	38.65	0.12	0.13	68.8	0.3	68.6
Rock Phosphate	$Ca_3(PO_4)_2$	25.65	0.20	1.20	46.3	2.7	12.3
Gypsum	$CaSO_4.2H_2O$	33.25	0.22	0.12	59.3	0.5	0.0
Dolomite	$CaMg(CO_3)_2$	30.40	20.50	47.04	105.6	106.9	106.0
Magnesite	$MgCO_3$	0.12	46.20	51.00	115.6	115.9	116.2
Enstatite	$MgSiO_3$	0.08	0.28	0.16	0.8	0.4	0.3
Serpentine	$Mg_3Si_2O_5(OH)_4$	0.05	19.11	0.25	47.9	0.6	45.4

TABLE II—SOIL ACIDITY AND CROP RETURNS WITH DIFFERENT TREATMENTS IN POT TEST

Pot No.	Treatment	Acidity of Soil after Cropping[2]—Wanatah soil H[3] Lbs.	Wanatah soil J[3] Lbs.	Dupont soil H Lbs.	Dupont soil J Lbs.	Average Yields Per Pot—Wanatah soil Wheat Grams	Wanatah soil Clover Grams	Dupont soil Wheat Grams	Dupont soil Clover Grams
1	None	1800	6750	2460	4000	0.5	0.0	0.7	0.0
2	Calcite	80	3500	20	750	17.0	9.5	10.5	11.0
3	No Mineral (N P K)	1760	6750	2800	4125	1.5	3.5	44.0	2.0
4	½ Calcite (N P K)	520	4500	400	1750	27.5	8.0	54.5	12.5
5	Calcite (N P K)	40	3000	20	750	35.0	12.5	65.5	18.5
6	Wollastonite (N P K)	180	3250	260	1625	33.5	8.5	65.5	3.0
7	Rock Phosphate (N P K)	1160	5250	1780	3500	18.5	8.5	54.5	8.0
8	Gypsum (N P K)	1420	5500	1980	3500	1.5	0.5	50.5	0.5
9	Dolomite (N P K)	80	2750	40	750	35.0	11.5	62.5	20.0
10	Magnesite (N P K)	60	2500	20	625	34.0	8.5	64.0	16.0
11	Enstatite (N P K)	1780	6000	2260	3500	3.5	3.0	49.5	2.0
12	Serpentine (N P K)	1160	5250	1700	2750	21.5	8.5	54.5	3.0

[1] (N P K) = 91 lbs. ammonium nitrate, 73 lbs. di ammonium phosphate, and 100 lbs. di potassium phosphate per million pounds soil. All minerals were used at rate of 2 tons per million pounds soil, except Pot 4 which had one-half quantity of calcite.
[2] All acidity figures are in terms of $CaCO_3$ requirement per million pounds soil.
[3] H = By Hopkins potassium nitrate method, U. S. Dept. Agr., Bur. of Chem., *Bull.* **107** (revised). J = C. H. Jones calcium acetate method, *Proc. Off. Agr. Chem.*, **1914**.

TABLE III—SOIL ACIDITY DECREASES AND CROP INCREASES BY TREATMENTS AND SOILS

Pot No.	Treatment in addition to N P K	Decrease in Acidity per 1,000,000 Lbs. Soil—Wanatah soil H[1] Lbs.	Wanatah soil J[1] Lbs.	Dupont soil H Lbs.	Dupont soil J Lbs.	Average soils H Lbs.	Average soils J Lbs.	Average Crop Increases per Pot—Wanatah soil Wheat Grams	Wanatah soil Clover Grams	Dupont soil Wheat Grams	Dupont soil Clover Grams	Average soils Wheat Grams	Average soils Clover Grams	Wheat and Clover Grams
4	½ Calcite	1240	2250	2400	2375	1320	2312	26.0	4.5	10.5	10.5	18.2	7.5	25.7
5	Calcite	1720	4750	2780	3375	2250	3562	33.5	9.0	21.5	16.5	27.5	12.7	40.2
6	Wollastonite	1880	3500	2540	2500	2060	3000	32.0	5.0	21.0	1.0	26.5	3.0	29.5
7	Rock Phosphate	600	1800	1020	625	810	1062	17.0	5.0	10.5	6.0	13.7	5.5	19.2
8	Gypsum	340	1250	820	625	580	937	0.0	—3.0	6.5	—1.5	3.2	—2.2	1.0
9	Dolomite	1680	4000	2760	3375	2220	3687	33.5	8.0	18.5	18.0	26.0	13.0	39.0
10	Magnesite	1700	4250	2780	3500	2240	3875	32.5	5.0	20.0	14.0	26.2	9.5	35.7
11	Enstatite	—20	750	540	625	260	687	2.0	0.5	5.5	0.0	3.7	—0.2	3.5
12	Serpentine	600	1500	1100	1375	850	1437	20.0	5.0	10.5	1.0	15.2	3.0	18.2

[1] H = Hopkins potassium nitrate method. J = C. H. Jones calcium acetate method.

Table II gives the arrangement and treatment of the pots, together with the soil acidities found at the end of the test, also the yields in grams of air-dry wheat (grain and straw) and of clover hay. The widely divergent figures obtained in determining the acidity of the two soils with the various treatments illustrates the fact that the acidity of Soil W is largely organic in nature while the acidity of Soil D is almost all inorganic. The results obtained with the potassium nitrate method are not affected to any great degree by organic acidity, while the results obtained with the calcium acetate method are very largely affected by organic acidity.[1]

Figs. 1 and 2 show the appearance of the wheat and clover crops on each soil series just before harvesting.

Table III gives the relative decreases in soil acidity for each treatment as shown by the Hopkins potassium nitrate method and by the C. H. Jones calcium acetate method. The relative crop increases over the basic fertilizer treatment, as well as the average wheat increases, the average clover increases, and the total increases of wheat and clover, are shown for each treatment.

Fig. 3 gives the calcium carbonate equivalents of the different minerals used by the titration method in comparison with the relative crop increases and the soil acidity decreases as shown by the Hopkins and Jones methods. The full application of calcite was taken as one hundred in each case. The acid-neutralizing power of the minerals used, as determined by titration, correlates with the crop increases and acidity decreases except in two cases. The high crop yield in the case of the rock phosphate may be partly due to a phosphate action in addition to that of the neutralizing value of the calcium. The relatively lower crop increase with magnesite is probably due to the fact that magnesia has an injurious action under certain conditions.

When calcium and magnesium were determined by means of dilute hydrochloric acid the calculated $CaCO_3$ equivalent is a good indicator of the value of carbonates and silicates of either calcium or magnesium and of raw rock phosphate. This method fails entirely in the case of calcium sulfate. It should be noted here that if an analysis of the total calcium and magnesium is made, by fusion or otherwise, the results obtained for enstatite or other more or less insoluble silicates will be too high.

The results obtained by means of the CO_2 method are in accordance with the crop results only in the case of the carbonates and gypsum. This method fails entirely with silicates and raw rock phosphate. It is only with boiling acid that the CO_2 method will indicate the value of magnesite and some dolomitic limestones, as such minerals are not completely dissolved by cold hydrochloric acid. The CO_2 method, of course, would not indicate the value of burned or hydrated lime or of many waste products which might be used for correcting soil acidity.

[1] S. D. Conner, *J. Ind. & Eng. Chem.*, **3** 1917 139.

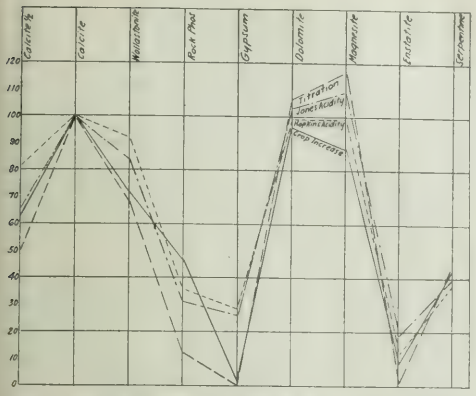


FIG. 3—RELATIVE EFFECT OF DIFFERENT MINERALS AS SHOWN BY AVERAGE INCREASE OF WHEAT AND CLOVER AND DECREASE IN SOIL ACIDITY BY THE HOPKINS AND JONES METHODS COMPARED WITH ACID-NEUTRALIZING POWER OF THE MINERALS DETERMINED BY TITRATION. FULL CALCITE APPLICATION TAKEN AS 100

It is a well-established fact that certain silicates of calcium and magnesium compare favorably with calcium and magnesium carbonates in neutralizing acidity and in their beneficial action upon soils.[1] Dana[2] states that gypsum occurs intermingled with limestone. Clarke[3] says, "Wollastonite is commonly found as a product of contact metamorphism, especially in limestones;" also, "In many localities serpentine is associated with dolomite or dolomitic limestones."

Taking all these factors into consideration it would appear that the acid-neutralizing power of the limestone as determined by titration is the best method to use for determining the value of agricultural limes and limestones.

SUMMARY

I—The value of agricultural limes was determined by means of the acid-soluble calcium and magnesium, by means of CO_2 determination with boiling hydrochloric acid, and by digesting in standard acid and titrating the excess acid.

II—Pot cultures on two very acid soils were conducted using calcite, wollastonite, raw rock phosphate, gypsum, dolomite, magnesite, enstatite, and serpentine as correctors of soil acidity.

III—Wheat and clover were grown in each soil and the crop increases reported.

IV—Soil acidity was determined after cropping by means of the Hopkins potassium nitrate method and the C. H. Jones calcium acetate method.

V—Crop increases due to various treatments were obtained in the following order, the highest being placed first: Calcite, dolomite, magnesite, wollastonite, rock phosphate, serpentine, enstatite, and gypsum.

VI—The treatments decreased the soil acidity in the following order: Magnesite, dolomite, calcite, wollastonite, serpentine, rock phosphate, gypsum, and enstatite.

VII—The results obtained in these experiments indicate that the value of agricultural lime is in accordance with its acid-neutralizing power, rather than with the CaO, MgO, or CO_2 contained, and that the titration method is the most accurate and reliable method for determining the value of agricultural limes.

SOILS AND CROPS DEPARTMENT
PURDUE UNIVERSITY AGRICULTURE EXPERIMENT STATION
LAFAYETTE, INDIANA

[1] McIntire and Willis, THIS JOURNAL, **6** (1914), 1005. Ames and Schollenberger, Ohio Expt. Sta., *Bull.* **306** (1916), 385; Cowles, *Met & Chem. Eng.*, **17** (1917), 664.

[2] Dana, "Manual of Geology," 234

[3] Clarke, U. S. Geol. Surv., *Bull.* **616**, 378 and 603.

THE DETERMINATION OF THE HEXABROMIDE AND IODINE NUMBERS OF SALMON OIL AS A MEANS OF IDENTIFYING THE SPECIES OF CANNED SALMON

By H. S. BAILEY AND J. M. JOHNSON

Received June 21, 1918

At the suggestion of Mr. H. M. Loomis, formerly of the Bureau of Chemistry, an examination of salmon oils for their chemical and physical characteristics was made in 1915 by L. B. Burnett in this laboratory. His preliminary experiments seemed to indicate that the iodine numbers and hexabromide values would furnish a method of distinguishing between the various salmon species.

We have this year made a further study of oils expressed from canned salmon and believe that the results we have obtained justify the assumption that the oil from different species of salmon have characteristic iodine numbers and hexabromide values. In order to get a good working method for determining the so-called hexabromide value of an oil, we carried out a series of experiments using the different procedures suggested by previous investigators.

METHODS OF ANALYSIS

The precipitation of insoluble hexabromides from the ether solution of oils and fatty acids was first accomplished in a qualitative way by K. Hazura.[1] A quantitative method for the determination of the hexabromide value was afterwards worked out by Hehner and Mitchell.[2] This method depends upon the low solubility of the hexabromides in a solution of ether and glacial acetic acid. In their method, the precipitate of hexabromides was brought upon a filter paper, washed with ether, dried and weighed. Procter and Bennett[3] found difficulty with Hehner and Mitchell's method especially with the filtration of the precipitate. They changed the solvent and used carbon tetrachloride instead of ether, finally precipitating with alcohol. However, they did not succeed in getting good results when brominating the glycerides and recommended working with the fatty acids. L. M. Tolman[4] modified Hehner and Mitchell's method, using a centrifuge for separating and washing

[1] *Monatsh.*, **7** (1886), 637; **9** (1887), 148.

[2] *The Analyst*, **23** (1898), 310

[3] *J. Soc. Chem. Ind.*, **25** (1906), 798.

[4] THIS JOURNAL, **1** (1909), 340

the hexabromides, instead of carrying out these operations on a filter. He also weighed in the same flask in which precipitation took place. Tolman allowed the mixture to stand only 30 min. after precipitation, but Sutcliffe,[1] as a result of his investigations, recommended that after bromination, the mixture stand over night at 11° before filtering and washing the precipitate. He found that it was also necessary to add enough bromine to give a good red color instead of merely a yellowish brown as recommended by previous investigators. Sutcliffe's method was later called in question by Gemmell,[2] but he in reply[3] demonstrated that if his directions were carefully followed his method could be used with satisfaction.

The procedure finally adopted by us is a combination of the methods of Tolman and Sutcliffe, as follows:

About 1 g. of oil is weighed into a tared weighing tube 1 in. in diameter and 6 in. long, 25 cc. of absolute ether are added, and the mixture cooled in ice water. Next there is added very slowly drop by drop from a small burette a mixture composed of 5 cc. of bromine and 25 cc. of glacial acetic acid. This reagent makes an excellent brominating agent and allows the bromine to be added more uniformly and gradually than when pure bromine is used. Besides, it gives the acetic acid necessary for a proper precipitation of the hexabromides. For most oils about 2 or 3 cc. of the solution are required to produce a deep red color, which is considered indicative of a proper excess of bromine.

After the addition of bromine, the weighing tube is allowed to stand in a refrigerator, temperature under 20° C., over night. Next morning it is cooled in ice water and centrifuged from 2 to 4 min., the solvent is then decanted from the precipitate, 10 cc. of ice-cold absolute ether added, the precipitate stirred up with the ether, cooled in ice water, again centrifuged 2 to 4 min. and the ether decanted off. This washing is repeated twice more and after decanting the final wash ether, the weighing tube is dried in an oven at 100° C. to constant weight, 1/2 hr. usually being sufficient. In the case of salmon oils which gave a very large percentage of hexabromides, a weighed quantity of the oil was mixed with a weighed quantity of a cottonseed oil, which by test had shown no hexabromide precipitate, and the hexabromide value was then determined upon the mixed oil and calculated back to the original salmon oil. This was found necessary as a very bulky hexabromide precipitate could not be readily centrifuged and washed rapidly enough to prevent the solution warming up and dissolving some of the hexabromides. In order to get concordant results with an empirical method of this kind of course every precaution must be taken to work always under exactly the same conditions. After a little experience in the manipulation of this method, it is possible to obtain duplicate determinations which agree within 0.2 per cent with oils having a hexabromide value of 25 to 50.

The iodine number was determined upon a separate portion of each sample by the regular official Hanus method.[4]

ANALYSIS OF SALMON OILS

The salmon oils which we examined were obtained from canned salmon furnished us by Dr. E. D. Clark of the Food Research Laboratory and were collected by him from various typical districts on the Pacific Coast in 1916. Enough cans to furnish the necessary amount of oil were opened, the contents ground in a meat chopper and squeezed in a cloth bag in a small screw press. The oil and water mixture thus obtained was centrifuged, the water layer removed with a siphon, the oil dried with anhydrous sodium sulfate and filtered through paper. The determination of iodine number and hexabromide value was made as quickly as possible after the sample had been prepared as a precaution against any oxidation which might take place upon standing. Table I gives the results obtained upon these samples.

TABLE I

O. F. W. No.	Variety Salmon	Source	Iodine Number	Hexabromide Value Per cent
611	Sockeye	Puget Sound	141.55	33.36
584	Alaska Red	So. Eastern Alaska	140.72	32.61
586	Alaska Red	Central Alaska	148.10	37.35
587	Chinook	Bristol Bay, Alaska	126.62	24.90
573	Chinook	Columbia River	128.03	24.58
577	Chinook	Rogue River (fall)	134.48	31.06
579	Chinook	Columbia River	129.13	26.45
583	Chinook	Rogue River (spring)	130.40	29.52
588	Chinook	Washington Coast	129.06	23.86
575	Silverside	Rogue River	166.30	59.31
576	Silverside	Columbia River	161.05	47.82
585	Medium Red	So. Eastern Alaska	166.40	50.91
590	Coho	Washington Coast	155.61	45.98
574	Chum	Columbia River	133.10	27.62
589	Chum	Central Alaska	136.19	30.12
595	Chum	Bristol Bay, Alaska	133.25	27.59
581	Steelhead	Columbia River	141.90	36.22

In the following table are given the figures found for oils extracted with ether from single cans of Puget Sound salmon packed under direction of Mr. R. W. Hilts in 1912–13.

TABLE II

O. F. W. No.	Variety Salmon	Iodine Number	Hexabromide Value Per cent
613	Coho	152.51	43.07
615	Pink	153.58	40.17
616	Chum	147.75	35.33

The ether in these oils was removed by evaporation on steam bath in a current of carbon dioxide. That ether extracted oils do not differ appreciably in their constants from cold pressed oils is shown by the analyses of two samples given in Table III.

TABLE III

O. F. W. No.	Variety	Iodine Number	Hexabromide Value Per cent
574	Chum (cold pressed)	133.10	27.62
574	Chum (ether extracted)	135.43	27.91
589	Chum (cold pressed)	136.19	30.12
589	Chum (ether extracted)	141.28	30.23

The original scheme for this study of the salmon oils contemplated the analysis of fresh salmon as well as the canned product. Dr. Clark had individual fish of several different species extracted with ether during the 1916 season and these ether extracts were later sent to Washington. Although the ether was only partially removed from the oils, and they were kept in well-stoppered bottles in the dark until they could be analyzed, there appears to have been a marked change in their composition. It is plainly evident that the figures obtained upon these samples, as shown in Table IV, do not agree with those from the canned fish of the same species.

TABLE IV

O. F. W. No.	Variety	Iodine Number	Hexabromide Value Per cent
598	King	139.49	26.83
602	King	67.08	...
605	Silver	75.99	0.44
603	Chum	112.22	2.36
604	Chum	71.68	...

[1] *The Analyst*, **39** (1914), 28.
[2] *Ibid.*, **39** (1914), 297.
[3] *Ibid.*, **39** (1914), 388.
[4] *J. A. O. A. C.*, [3] **2**, Part II, 305.

It might be assumed that there was a change in the constants of the oil during the cooking incident to the canning operations and that the values for the oil from the fresh fish were the more nearly normal, if the latter were not much lower than the corresponding values for the canned samples. An increase in the hexabromide and iodine values could hardly have been caused by canning as so far as we know any alteration in fish oils due to heat or oxidation always results in a decrease in these constants.

DISCUSSION OF RESULTS

Five species of salmon (*Oncorhynchus*)[1] are found in the waters of the north Pacific: (1) *Oncorhyncus tschawytscha* quinnat, tyee, chinook, spring or king salmon; (2) *Oncorhyncus nerka*, blueback, red, sukkegh, or sockeye salmon; (3) *Oncorhyncus kisutch*, silver, coho, white or medium red salmon; (4) *Oncorhyncus keta*, dog, keta or chum salmon; (5) *Oncorhyncus gorbuscha*, humpback or pink salmon. With them the fishermen also incorrectly class the steelhead trout, which really belongs to the closely related genus *Salmo*.

In Table I we have arranged the salmon oils according to these classifications. It is readily seen by reference to that table that the iodine numbers and hexabromide values run fairly close together for the same variety of salmon. O. F. W. 587 was labeled Alaska Red. Our analysis, however, indicated that this was Chinook. After this sample was analyzed, we submitted additional cans of the same lot to Drs. W. C. Kendall and W. T. Bower, of the Bureau of Fisheries, for identification. They, independently of each other and without knowledge of our results, pronounced the sample as Chinook. Therefore, we have classified it accordingly.

A digest of Tables I and II show the following variations:

TABLE V

	Iodine Numbers		Hexabromides	
	Lowest	Highest	Lowest	Highest
Red, Sockeye, or Blueback	140.72	148.10	32.61	37.35
Chinook, King, or Spring	126.62	134.48	23.86	31.06
Medium Red, Coho, or Silverside	152.51	166.40	43.07	59.31
Humpback or Pink	153.58	...	40.17	...
Chum or Dog	133.10	147.75	27.59	35.33

The oils, therefore, show a little more characteristic difference in their hexabromide values than in the iodine numbers. In their iodine numbers, chums and reds overlap, and pinks and medium reds overlap, the highest value in the chums being nearly the same as that in the reds. As only one sample of pink salmon was available for analysis, no sharp conclusion can be drawn as to the limits of the values for the oil of this species. Its iodine value would place it with the medium reds, but its hexabromide value is lower than the lowest found for any medium red sample.

If the coho oils are classified separately, and O. F. W. 616, chum salmon, omitted, we have the following limits in these particular samples.

[1] John N. Cobb, "Pacific Salmon Fisheries," Bureau of Fisheries, U. S. Department of Commerce, 1917, Document No. 839.

TABLE VI

	Iodine Number	Hexabromide Value
Chinook	127–134	23–31
Chum	133–136	28–30
Red	141–148	33–37
Coho	153–156	43–46
Pink	154	49
Medium Red	161–166	48–59

This arrangement gives a much cleaner-cut distinction between the various species, both with reference to the iodine numbers and hexabromide values. The only case of over-lapping of the constants is between the chums and chinooks.

CONCLUSIONS

1—A new method or perhaps more properly a modification and combination of several methods for the determination of the so-called hexabromide value of fish oils has been worked out, using an acetic acid solution of bromine as the precipitating reagent.

2—Oils expressed from canned salmon, and dried by the addition to them of anhydrous sodium sulfate, after the major portion of the water has been mechanically removed, have practically the same iodine and hexabromide value as the oils extracted with ether, provided proper precautions are taken to prevent oxidation in the extraction.

3—In so far as a definite conclusion can be drawn from the analysis of comparatively few samples, the results obtained seem to indicate that it may be possible to distinguish the variety of canned salmon by a determination of the hexabromide and iodine values of the oil.

OIL, FAT AND WAX LABORATORY
BUREAU OF CHEMISTRY
U. S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

COMPOSITION OF THE WATERS OF THE INTER-MOUNTAIN REGION

By J. E. GREAVES AND C. T. HIRST

Received April 1, 1918

During the years 1916 and 1917 the chemical department of the Utah Agricultural Experiment Station made several hundred analyses of waters representing 58 streams, the majority of which were extensively used for irrigation purposes. The results obtained are of exceptional interest, for they indicate the great quantitative and qualitative difference in the composition of the irrigation waters. Moreover, they clearly portray the enormous quantities of soluble salts which at times may be carried to soil by water and the great part which waters play in the formation of alkali soil.

From the majority of streams monthly samples were taken during the irrigation seasons. These were collected according to standard methods in carefully cleaned containers and shipped to the laboratory where the analyses were made as soon as possible and according to the following methods.

METHODS OF ANALYSIS

TOTAL SOLIDS—Fifty cc. of water were evaporated to dryness on an electric hot plate in 100 cc. beakers, cooled in desiccators, and weighed accurately to the fourth decimal place.

CARBON DIOXIDE—Fifty cc. of water were titrated

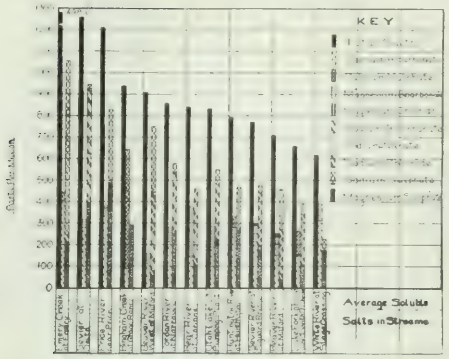


FIG. I

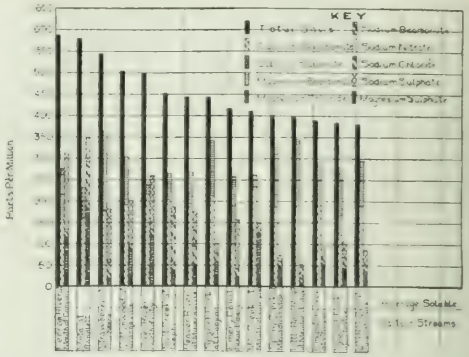


FIG. II

against $N/30$ H_2SO_4, using methyl orange as an indicator.

CHLORINE—Determined by Volhard's method, using $N/50$ $AgNO_3$.

CALCIUM—Twice precipitated as calcium oxalate, each time washed, and finally titrated against $N/10$ $KMnO_4$.

MAGNESIUM—The filtrate from the calcium was concentrated, the magnesium precipitated by microcosmic salt and weighed as magnesium pyrophosphate.

NITRIC NITROGEN—Fifty cc. of water were evaporated to dryness, the residue treated with 2 cc. phenoldisulfonic acid, allowed to stand ten minutes, and then diluted with water. The solution thus obtained was made alkaline with ammonia, and the color compared with a standard solution of potassium nitrate in a Kennicot colorimeter.

The analysis of the water would give the basic and acidic ions in the water, but in reporting the results conventional combinations have been made according to the calculations recommended[1] by the Association of Official Agricultural Chemists. These results are reported as parts per million of water. That is, according to the recommendation the hypothetical combinations are made by calculating the calcium and magnesium to the acid ions in the following order: bicarbonate, sulfate, and chloride. Any remaining acid ions are calculated to sodium.

The results, which are the average of from three to seven analyses made on samples of water taken at different times, are given in Figs. I to IV. The results so presented give us at a glance the total and relative quantities of total soluble salts, non-toxic bicarbonates and calcium sulfate, and toxic chlorides and sulfates.

In so grouping the various streams into the four divisions we do not wish to convey the idea that all in the first group may prove injurious or that all in the second or third group may be used with impunity, but it has been used merely as a convenient method of dividing, although a glance at the tables shows quite a marked qualitative and quantitative difference in the various groups.

[1] *J. A. O. A. C.*, [4] 1, Part II, 51.

All of the waters, the analyses of which are listed in Fig. I, are high in soluble salts.

It is, however, questionable whether any of them are high enough in saline constituents to destroy plants at the present concentration. But the magnitude of the problems which confront the users of such waters is made clear by the following consideration: one acre-foot of the Sevier River water would carry to the soil 3581 lbs. of soluble salts which in 20 such irrigations would reach the enormous sum of 71,628 lbs., 75 per cent of which consists of toxic salts. This in itself, if it be allowed to concentrate in the surface foot, would be sufficient to render the soil sterile. White River, which is lower in soluble salts than any of the others in this group, would carry to the soil in every acre-foot 1502 lbs. of salts, or in 20 such applications there would be added to the soil over 15 tons of soluble salts.

Moreover, the water of the Sevier contains comparatively small quantities of calcium and magnesium bicarbonates and enormous quantities of the chlorides and sulfates. The unbalanced condition of the salts in Beaver River water makes it even more dangerous than are the Sevier or Price River waters. It is important to note that in all of these streams, with the exception of the White River, the toxic chlorides and sulfates greatly predominate over the bicarbonates.

While the composition of these waters do not vary greatly from year to year, there is a great variation within one season. As a general rule, the concentration of the salts in the water increases with the season. The Sevier water is only two-thirds as concentrated during June as it is during September.

The fourteen streams listed in Fig. II are quite different in composition from those previously considered.

With the exception of Ferron, Uinta, and Green Rivers, the non-toxic bicarbonates predominate, and even in these three streams there are large quantities of calcium and magnesium bicarbonates which would tend to neutralize the toxicity of the other salts, although the problem confronting the users of these waters is not nearly so complex as is the problem

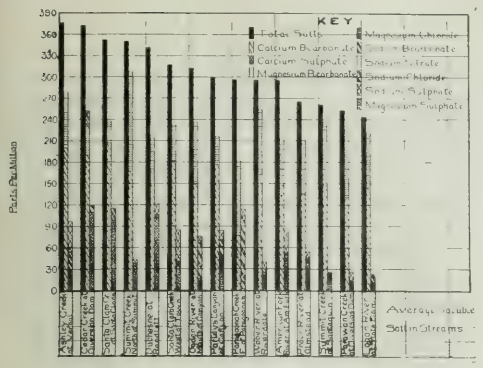


FIG. III

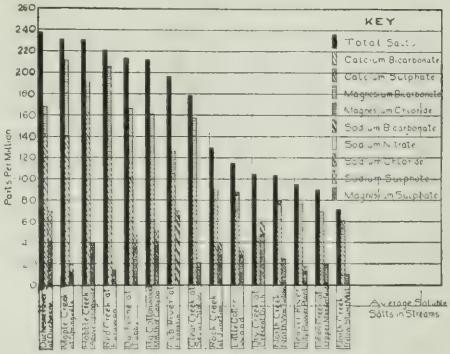


FIG. IV

which confronts the users of the waters listed in Fig. I. None of these waters contain sufficient salts to be of injury to plant life, but the tendency to accumulate in the soil is impressed upon the individual in passing over districts in which the waters have been injudiciously used.

The streams which are listed in Fig. III contain between 340 and 380 p. p. m. of soluble salts and in every case the non-toxic bicarbonate greatly predominates. In not one case do the toxic salts reach 150 p. p. m. and in most cases the quantity present is far below this amount.

These waters, if intelligently used on land, with even fair drainage and not already filled with alkali, should give no trouble. On the contrary, the quantity and quality of the soluble constituents act as plant stimulants. In short, this condition is found to occur with many of even the high alkaline waters and the injury comes only after there is a concentration of the soluble salts within the soil.

All of the waters which are listed in Fig. IV contain less than 180 p. p. m. of soluble salts and in every case the toxic salts make up only a small fraction of the total salts.

Sevier River and its tributary, Clear Creek, present an interesting study. Clear Creek is a stream containing only a small amount of soluble salts and over 76 per cent of this in the form of the non-toxic bicarbonates. But after flowing about 50 miles through a district rich in soluble salts, receiving seepage and being concentrated by evaporation, its nature has been so changed that by the time it reaches Sigurd Bridge, at Sigurd, it is a strongly saline water. In flowing from Sigurd to the out-take of the Delta Land and Water Company's canal there is a decrease in common salt, but an increase of over 100 per cent in the equally noxious sulfates. In flowing from Clear Creek to Sigurd Bridge this stream has gained over 400 per cent in soluble salts and the per cent of non-toxic bicarbonates in the water has decreased from 76 per cent to less than 35 per cent of the total. Moreover, by the time the water reaches the Delta Land and Water Company's canal the salts have increased over 600 per cent, with only 25 per cent of them in the form of the calcium and magnesium bicarbonate. We therefore have the transformation from a good carbonated water to a strongly saline sulfate water which presents a tremendous problem to the water user.

It is hard to place a limit upon the quantity of alkali which may be in a water and the water still be used for irrigation purposes, for it varies greatly with a number of factors, chief among which are the kind and quantity of alkali and the soil; the method of irrigation and the quantity of water applied; the physical nature of the soil as to whether sandy or clayey and whether drained or water-logged.

It is generally conceded that sodium carbonate is more injurious than the chlorides or sulfates. Practically all of the waters examined are very low in sodium carbonate, but we must not lose sight of the fact that sodium sulfate or sodium chloride, in the presence of large quantities of decaying organic matter which liberates carbon dioxide, may be readily transformed in the soil into the more harmful carbonate. Moreover, water which contains sodium carbonate, if used on soils containing large quantities of gypsum, will be no more detrimental than if it contained an equal amount of sulfate; for the gypsum would readily convert the carbonate into the less toxic sulfate.

Moreover, as we have seen from the given results, a stream may be comparatively free from alkali at one season while at another it may be heavily charged with alkali. The melting of snow in the mountainous regions usually has the effect of freshening the water, while local rains often have the opposite effect. Drainage water, especially from alkali soils, greatly increases the alkali content of the water. Many of the cases in which large increases of alkali are noted in the water during the later irrigation season must be attributed to this factor.

With good natural drainage a more highly concentrated water may be used than where drainage is poor. For instance, in the Algerian Oases, where alkaline waters are used, the conditions are as follows: "The

Arabs' gardens are divided into small plots about 20 ft. square, between which run drainage ditches dug to a depth of about 3 ft. The soil being very light and sandy, this ditching at short intervals insures the most rapid and thorough drainage. Irrigation is carried on by the check method and application is made at least once a week, although two wettings are often deemed necessary. A large quantity of water is used at each irrigation. Thus a continuous movement of water downward is maintained. There is little opportunity for the soil water to become more concentrated than the water as applied, and the interval between irrigations being so short but little accumulation of salt from evaporation at the surface takes place."

The difficulty here is added to by the fact that the soil is heavily charged with alkali. Under these conditions such plants as melons, tomatoes, cabbage, pepper, figs, and pomegranates do well. In this work by Means[1] the water used was all artesian water.

Where the soil is a clay loam, heavy adobe or soils with hard pan or poor sub-drainage, entirely different methods must be employed, for the salt would tend to accumulate near the surface and soon become injurious to plants. In soils such as named, every effort must be made to conserve the soil moisture and in this way cut down on the quantity of water added to the soil and with it the alkali salt. It is a fact that often better crops can be produced with 15 in. of irrigation water than with more.

Furthermore, there may be cases in which, because of the physical and chemical composition of the soil, together with the alkali content of the water, the crop must be selected with this fact in view. For instance, sweet or Egyptian clover may be irrigated with water of such a high saline content that it would be fatal to other crops. Old alfalfa is much more resistant to alkali than is young alfalfa.

A soil which is heavily charged with soluble salts may often be tilled if care be exercised in the use of the irrigation water, but when we have such a soil and have to use on it a highly saline water, the problem becomes complex.

Although the use of a saline water on any soil is a problem which must be solved independently in each locality, taking into consideration the saline content of the water, the quantity and nature of alkali in the soil, and the physical conditions of the soil, yet there are certain standards which have been laid down which are valuable guides. Hilgard[2] considers that the extreme limits of mineral content usually assigned for potable waters, viz., 40 grains per gal. (571.2 p. p. m.), also applies to irrigation waters. Should it happen that all or almost all of this were gypsum and Epsom salt, only a large excess of the latter would constitute a bar to irrigation, while, on the contrary, if a large proportion of the solids consists of sodium carbonate or common salt, even a much smaller proportion of salt might preclude its regular use, depending upon the nature of the soil to be irrigated.

Forbes[1] feels that 0.25 per cent of salts in the soil is a more or less dangerous quantity of alkali, even when composed of the less harmful salts. Any addition of alkali in the irrigation waters should be carefully controlled. He states further that water containing 1000 to 1500 p. p. m. of salts as sulfates and chlorides has often embarrassed the agriculture of the farmer and in some cases it has led to the abandonment of farms. Forbes therefore considers "that under the conditions of water supply, drainage, and climate found in the principal irrigated districts of Arizona and with prevailing agricultural practice, waters containing 1000 p. p. m. of salts of average composition are liable to cause in a few years harmful accumulations of alkali."

The Bureau of Soils[2] states that 5000 p. p. m. of soluble salts when added to the Pecos Valley soils may be taken as the extreme limit of endurance by plants, while 250 to 300 marks the danger zone; however, in this case about 50 per cent of these salts are harmful. At Carlsbad about 300 p. p. m. marks the limit of safety.

Means,[3] however, claims that the amount of alkali salts permissible in irrigation water has been underestimated by American writers, and calls attention to the fact that the Arabs in Sahara, Africa, use irrigation water containing over 800 parts per 100,000, more than one-half of which is sodium chloride. He also quotes from an earlier publication: "The limit of endurance for most cultivated plants in a water solution is about 1 per cent, or 1000 parts of the readily soluble salts in 100,000 parts of water."

There is considerable truth in Means' contentions, for many of the early workers on soil alkali failed to take into consideration the effect of balanced solutions on plants and the antagonistic action of one salt to the other.

Viewed in the light of Hilgard's interpretation, we find only thirteen streams the alkali content of which is dangerous, or, if interpreted in the light of Forbes' experience, only two, but according to the work of the Bureau of Soils none should be condemned.

But the fact which must be borne in mind is that even though plants may tolerate large quantities of alkalies in solution if they be in a balanced condition, the great danger comes from the accumulation of the salts in the soil from their continual application. Many saline waters when first applied to a soil may furnish nutrient to the plant and actually stimulate plant growth, but later, due to their accumulation within the soil, have an opposite effect. Hence, users of saline waters must never lose sight of the fact that these waters, if injudiciously used, may be a very potent factor in ruining valuable land.

UTAH AGRICULTURAL COLLEGE
LOGAN, UTAH

[1] U. S. Department of Agriculture, Bureau of Soils, *Circular* **10**.
[2] California Experiment Station, *Bulletin* **128**.

[1] Arizona Experiment Station, *Bulletin* **44**.
[2] *Report*, **64**, page 19.
[3] U. S. Department of Agriculture, Bureau of Soils, *Circular* **10**.

ON CONSTITUENTS OF OIL OF CASSIA—II

By Francis D. Dodge

Received June 13, 1918

The examination by the writer and A. E. Sherndal[1] of the alkali-soluble portion of oil of cassia showed the presence of several compounds not hitherto recognized as constituents of the oil. More recently the writer has had occasion to make a further study of this oil, and especially of the aldehyde constituents.

Two samples were examined: one, A, a redistilled oil made in this laboratory from apparently pure commercial oil; the other, B, a commercial U. S. P. oil. The results of the preliminary tests were as follows:

	A	B
Sp. gr. at 25°.....	1.0528	1.0514
Aldehyde (by vol.).....	88 per cent	80 per cent
Rotation.....	Slightly +	Slightly +
Rosin test.....	Negative	Negative

One pound of each of the samples was shaken with sufficiently strong sodium bisulfite solution to ensure complete extraction of the aldehydes, the reagent being added in portions of about one pound, waiting after each addition until the crystalline compound had completely redissolved. About 5 lbs. of bisulfite were required for each lot, and when the supernatant oil was found to be free from aldehyde the aqueous solution was separated, and heated on the water bath for several hours to ensure the conversion of the bisulfite compound into the more stable sulfonate. On cooling, the solution was filtered to remove traces of oil. This solution had a slight acid reaction; a portion made alkaline with sodium carbonate became slightly turbid, and showed by odor the presence of aldehyde other than cinnamic, the latter not being liberated by soda.

The entire solution was accordingly made strongly alkaline with sodium carbonate, and extracted with ether. The ether solution was washed with *N* sodium hydroxide to remove salicylic aldehyde, and then with strong bisulfite to separate other aldehydes. From the alkaline solution the salicylic aldehyde was obtained by acidifying and extraction with ether, and the other aldehydes similarly by neutralizing the bisulfite, and treating with ether. The first ether solution, after treatment with bisulfite, left a small residue of the non-aldehyde portion of the oil, which had remained dissolved in the original bisulfite solution. The results on the two samples were:

	A	B
Original.....	453 g.	453 g.
Non-aldehyde.....	About 50 g.	About 80 g.
Salicylic aldehyde.....	0.985 g.	1.110 g.
Other aldehydes.....	3.850 g.	4.860 g.
Cinnamic aldehyde.....	Not recovered	...

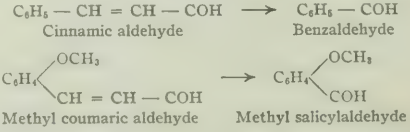
The small portion of saturated aldehydes thus obtained was, in each case, a heavy, slightly yellow liquid with strong odor of benzaldehyde. That it was not entirely the latter was shown by the behavior with bisulfite solution, in which the aldehyde mixture was completely soluble with evolution of heat, but with only a slight formation of crystals on standing. Benzaldehyde under similar conditions is immediately converted into a crystalline mass. On exposure to the air, the aldehyde mixture oxidized readily, but not completely to a crystalline acid, melting at 91–93°, which was found by the usual tests to be impure benzoic acid.

A small portion oxidized by permanganate gave an acid which, after crystallization from benzene, melted at 120°, and was evidently benzoic acid. This suggested the possibility of the presence of hydrocinnamic aldehyde, and with the view of limiting the oxidation to the aldehyde group, another portion was oxidized with hydrogen peroxide as follows:

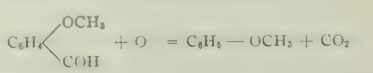
3 g. aldehyde mixture were treated with 30 cc. official peroxide, with a few drops of ferric chloride solution, keeping the mixture slightly alkaline with sodium hydroxide, and adding peroxide until all the aldehyde was in solution. The temperature was kept at 30 to 50°, with frequent agitation. At the end a distinct odor of anisol was noted, which proved significant. Finally the alkaline solution was filtered and concentrated to about 20 g. On acidifying, a crystalline acid mixture, melting below 100°, was precipitated. The characteristic odor of hydrocinnamic acid was not observed, and a separation of the acids by recrystallization from water was not successful.

For further information as to the nature of the aldehydes present, a portion was converted into oxime. One gram aldehyde with one gram hydroxylamine hydrochloride and 33 cc. *N*/2 alcoholic potassium hydroxide was allowed to stand 3 days, heated to 70° for 3 hrs., neutralized with HCl, diluted to 100 cc., and extracted with ether. On evaporation of the ether solution, long white needles were deposited, which, after pressing and drying, amounted to 0.35 g., and melted at 90° (corr.).

It seemed probable that this oxime might be the oxime of hydrocinnamic aldehyde (m. p. 93–94°), or, more likely, the oxime of methyl salicylic aldehyde (m. p. 92°). The occurrence of the latter could in fact almost be assumed as an oxidation product of the methyl ortho-coumaric aldehyde already noted as a constituent of the oil by Bertram.[1] A similar reaction would explain the occurrence of benzaldehyde.



The occurrence of anisol as an oxidation product would also find an obvious explanation:



To identify the oxime, a portion was converted into nitrile by treatment with acetic anhydride, and the nitrile saponified with alcoholic potassium hydroxide. The reaction, however, did not appear to be smooth; an oily acid was obtained and the result was inconclusive. The conversion into the corresponding acid was, however, attained by the direct oxidation of the oxime with permanganate, a method apparently not previously suggested for this purpose, but which seems

[1] This Journal, 7 (1915), 1055.

[1] *J. prakt. Chem.*, [2] 81, 316.

to be applicable in cases in which the acid formed is comparatively stable toward the reagent.

0.231 g. oxime, dissolved in a few drops of methyl alcohol, was mixed with 2 cc. $N/2$ potassium hydroxide, and 5 per cent permanganate added gradually until no further oxidation took place. The manganese oxide was then dissolved by sufficient sulfurous acid, the mixture strongly acidified, and the acid taken out with ether. 0.145 g. acid was obtained, which, as it was still contaminated with an oily impurity, was again treated in the same way with permanganate. The acid solution was not extracted with ether, but was allowed to evaporate. After a few days, the greater part of the acid had separated in two large, well-formed prismatic crystals, apparently monoclinic, melting at 89° (corr.), and evidently methyl salicylic acid. A careful comparison with the synthetic acid showed the identity of the preparations, both crystallizing from alcohol in distinct characteristic prisms, showing under the microscope oblique extinction, and a β-angle of about 49°, as described by Graebe.[1]

EXAMINATION OF THE NON-ALDEHYDE SECTION

The portions of the oil insoluble in bisulfite showed the following properties:

	A	B
Sp. gr. at 25°	1.020	0.9966
Rotation	+0.50°	+0.75°
Acid value	4.0	6.0
Saponification value	170.0	110.0
Calc. as cinnamyl acetate	53.4 per cent	34.5 per cent

For further light on the composition of this section, 38 g. of non-aldehyde A were saponified and distilled with steam. About 12 cc. of light oil were obtained, the greater part of the alcoholic product remaining dissolved in the aqueous distillate. To remove alcohols, the oil was washed with 50 per cent resorcin solution, which left a residue of 6.25 cc. light oil, very insoluble in alcohol, and almost unattacked by permanganate. This, in fact, appeared to be a petroleum section, evidently due to an adulteration of the crude oil.

The aqueous distillate, on ether extraction, yielded a small amount of heavy oil, which gave benzaldehyde on oxidation with permanganate, and was probably, in part at least, cinnamyl alcohol. The alkaline residue from the distillation was found to contain acetic and cinnamic acids, and the liquid acid with fruity odor, previously noted.

A comparatively large amount of resin was formed in the saponification, the cause of which remains unexplained.

To conclude, oil of cassia has been found to contain the following compounds:

Previously known:	Cinnamic aldehyde, 75 to 90 per cent
	Cinnamyl acetate
	Phenyl propyl acetate (?)
	Methyl ortho-coumaric aldehyde
Found by the writer and Sherndal:	Salicylic aldehyde, 0.1 to 0.2 per cent
	Coumarin
	Benzoic acid
	Salicylic acid
	Liquid acid of fruity odor
Found by the writer:	Benzaldehyde
	Methyl salicylaldehyde

LABORATORY OF THE DODGE AND OLCOTT COMPANY
BAYONNE, NEW JERSEY

LABORATORY AND PLANT

METHODS OF ANALYSIS USED IN THE COAL-TAR INDUSTRY. IV—BENZOLS AND LIGHT OIL

By J. M. Weiss

Received October 24, 1918

BENZOLS

TEST E2—SPECIFIC GRAVITY (SPINDLE)

APPARATUS—Hydrometer.[2] The necessary ranges for this class of compounds are 0.79 to 0.87, 0.86 to 0.94, and 0.93 to 1.01.

METHOD—See B4.[3] Benzols shall always be taken at 15.5° C. (60° F.) and no correction shall be made of a reading taken at a different temperature.

NOTE—As under B4.

TEST E3—SPECIFIC GRAVITY (WESTPHAL)

All matter as to apparatus, method, precautions, and notes as given under H4[4] apply to this test on these materials.

SPECIAL NOTE—This method is the reference method for benzols and must be used in all cases where accuracy is required as in cases of dispute or check testing.

TEST E4—DISTILLATION OF PURE PRODUCTS

APPARATUS—Flask: The distillation flask shall be a 200 cc. side neck distilling flask having the following dimensions:

Diameter of bulb	73 mm. (2.881 in.)
Outside diameter of neck	24 mm. (0.945 in.)
Inside diameter of neck	21 mm. (0.826 in.)
Length of neck	105 mm. (4.134 in.)
Inside diameter of side tube	5 mm. (0.197 in.)
Length of side tube	127 mm. (5.000 in.)
Side tube joined to neck above the base of the neck	52 mm. (2.047 in.)

The side tube shall be set so that the smaller angle where it joins the neck is 75°.

The allowable variation from the above dimensions shall be not more than 5 per cent. See Fig. XVI.

Thermometer: This shall be graduated from 70° to 120° C. at intervals of 0.2° C. It shall be made of a suitable quality of glass so as not to change its reading under conditions of use. It shall be provided with an expansion chamber, and a ring at the top for attaching tags. It shall conform to the following dimensions:

Total length	Not over 305 mm.
Bulb length	Not over 20 mm.
70° mark to bottom of bulb	80 to 100 mm.
Graduations per inch	Not over 35 mm.
Stem diameter	5 to 7 mm.
Bulb diameter	5 to 7 mm.

The thermometer shall be accurate to 0.2° C. at total immersion and shall be compared before use with a similar thermometer calibrated at full immersion by the Bureau of Standards, and proper correction applied.

It is preferable that this instrument shall not have

[1] *Ann.*, **139**, 137.
[2] See Fig. II, Paper I, THIS JOURNAL, **10** (1918), 735.
[3] THIS JOURNAL, **10** (1918), 735.
[4] *Ibid.*, **10** (1918), 911.

a supplementary bulb situated between the lowest graduation and the main mercury reservoir. However, if such a chamber is present, its lowest point shall be not more than 1 mm. above the top of the main reservoir.

Condenser: The distillate shall be condensed in a straight tube of $^1/_2$ in. internal diameter and 24 in. in length, set at an inclination of 75° to the vertical. At least 15 in. of tube shall be cooled with cold water in a trough condenser.

Burner: The heating flame shall be derived from a Bunsen burner and the entire flame shall be blue.

Cylinder: An ordinary 100 cc. cylinder, graduated at intervals of 1 cc., shall be used for the receiver. Graduations must be clear cut and distinct. The graduate shall be approximately 1 in. in diameter. The mark for each 10 cc. shall be longer than the intermediate markings and shall be plainly numbered.

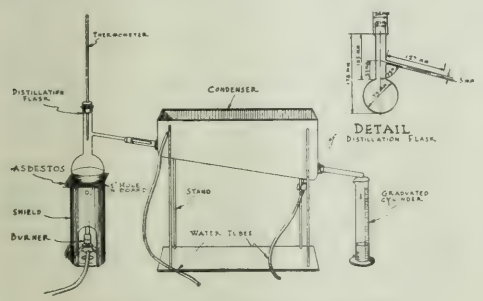


FIG. XVI—ASSEMBLY OF BENZOL DISTILLATION TEST

Assembly of Apparatus: Shown in Fig XVI. The flask shall be supported on a sheet of $^1/_8$-in. asbestos board, 6 in. × 6 in., with a hole in the center 1 in. in diameter. The asbestos board shall be supported on a circular metal shield enclosing the Bunsen flame. The flask shall be so placed that the vapor tube will extend at least 2 in. into the condenser tube.

The thermometer shall be held in the neck of the distillation flask by means of a cork stopper in such a position that the top of the bulb shall be opposite the lower side of the side tube and central in the neck of the flask.

METHOD—The sample to be tested shall be poured into a 100 cc. graduated cylinder and 100 cc. of the material shall be carefully measured and transferred to the distilling flask. The flask shall be put in connection with the condenser and the thermometer introduced through a tightly fitting cork. The graduated cylinder which was used to measure the oil shall not be rinsed out but shall be placed under the lower end of the condenser tube to catch the distillate. The flask shall be heated up slowly, especially after ebullition has begun, so as to allow the mercury column of the thermometer to become fully expanded before the first drop distils off.

The flame shall then be turned up and the distillation conducted at the rate of 5 cc. per min. (2 drops per sec.). This rate must be exact. The distillation shall be continued to dryness. The total yield of distillate shall not be less than 95 per cent.

A temperature reading shall be taken when the first drop of distillate falls into the receiving cylinder. Additional temperature readings shall be taken when 5 per cent and 95 per cent of distillate have distilled over. A final reading shall be taken of the "dry" point, which is the point at which liquid just disappears from the bottom of the flask.

PRECAUTIONS—Care must be taken to quickly remove the burner as the last bubble is evaporated, otherwise, too high a dry point may be produced by superheating.

NOTES—The method given applies to pure benzol and pure toluol.

The specifications for pure benzol and pure toluol require that distillation from first drop to dry shall be complete within a 2° C. range and, further, that the true boiling point of the product in question shall lie within that range.

To be sure that the true boiling point is strictly within this range it will be necessary, of course, to correct the observed temperature readings for variations from the standard thermometer, both for inaccuracy and for stem immersion; also correction should be made for differences in barometric pressure.

The barometric correction factors for each mm. of difference are as follows, these factors being applied directly as the difference in the barometric pressure may be greater or less than 760 mm.

Benzol	0.043°
Toluol	0.047°
Xylol	0.053°

It is not necessary in ordinary works practice to require the chemist to apply these corrections to each test. For instance, if the material is one which boils entirely within a 2° range, around, say, from 77° to 81° C., when the corrections are applied the results will all fall within a similar 2° range. The same applies to a 2° range between 108° and 112° C.

It is recommended, however, that such corrections be applied when the sample is to be checked against results obtained by another investigator, and in reporting results in such a case, a notation should be made to the effect that these results have been corrected for the variations mentioned.

An examination of all available literature on such subjects will show that the authorities vary materially in their report of findings of the true boiling points of benzol, toluol and the three xylol isomers. The following figures, however, are considered sufficiently accurate for all commercial practice.

Benzol	80.2° C.
Toluol	110.4° C.
Para-xylol	137.5° C.
Meta-xylol	138.5° C.
Ortho-xylol	142.3° C.

The emergent stem corrections should be made as follows:

Let C = Number of degrees centigrade to be added to the observed temperature.
N = Number of degrees of the stem exposed.
T = Average temperature of the bulb.
t = Average temperature of the stem.
K = Correction factor for the thermometer, i. e., the difference between the coefficients of expansion of mercury and glass

Then $C = KN(T - t)$.

EXAMPLE.

Observed temperature	= 80° C.
Stem temperature	= 25° C.
Degrees emerging from top of flask to 80° C.)	= 15° C.
Thermometer coefficient	= 0.000154
80° C. — 25° C.	= 55° C.
15° × 55° × 0.000154	= 0.12787 = 0.13° C.
Temperature corrected for emergent stem	= 80.13° C.

TEST E5—DISTILLATION OF COMMERCIAL BENZOLS

APPARATUS—Exactly as given for E4 with the following exceptions: (1) The thermometer shall be a standard 0° to 400° C. thermometer (see C9)[1]; (2) For materials boiling substantially below 145° C. a 1-in. hole shall be used in the asbestos board on which the flask is supported. For materials boiling substantially above 145° C. a 2-in. hole shall be used.

METHOD—The distillation shall be conducted exactly as given under E4.

"Special Specification Xylol" shall be read first drop, 5 per cent off, 50 per cent off, 95 per cent off, and dry, as under E4.

All other materials, except "Pure Xylol," shall be read at first drop, and then volumé readings taken at every even 5° C. up to the dry point, thus:

Deg. C.	Per cent
77	1st drop
80	10
85	65
90	78
95	83
100	90
105	98
108	Dry

"Pure Xylol" shall be read, first drop, every 1° C., and dry.

PRECAUTIONS—Same as under E4.

NOTES—In light fractions it is well also to determine loss by pouring the liquid that recondenses in the flask into the graduated cylinder and noting the total volume. The difference between the reading and 100 gives the approximate result for "loss."

In some cases on the xylols where special accuracy is required a thermometer graduated from 110° to 160° C. in 0.2° C. intervals is used. This is not necessary for ordinary practice. The specification, except for scale range, is the same as for the 70° to 120° thermometer given under E4.

This test, as well as E4, has been compiled from our experience and also from matter given in the Gas Chemists' Handbook, page 180, the standard method for distillation of paint thinners (A. S. T. M., D–28–17), and the article[2] by F. W. Sperr, Jr., of the H. Koppers Co.

TEST E6—SULFURIC ACID WASH

APPARATUS—Standards: The set of color standards against which wash tests shall be compared shall consist of fifteen bottles (French square flint glass, glass stoppered, one ounce capacity) each containing one of the colored solutions made up as given below, the bottle being sealed.

For making up the standards the following basic solutions shall be used:

A—59.4965 g. $CoCl_2.6H_2O$ (nickel-free) made up to 1000 cc. with a mixture of 25 cc. 31 per cent HCl and 975 cc. H_2O.

B—45.054 g. $FeCl_3.6H_2O$ made up to 1000 cc. with a mixture of 25 cc. 31 per cent HCl and 975 cc. H_2O.

C—3.5 volumes of Solution A + 36.5 vol. Solution B + 90 vol. of H_2O.

D—3.5 volumes of Solution A + 36.5 volumes of Solution B. (No water is added.)

E—Solution of K_2CrO_4 saturated at 21° C.

F—One volume of a solution of $K_2Cr_2O_7$ saturated at 21° C. + one volume of H_2O.

As standard color solutions to be used for comparison the following shall be made up and numbered from 0 to 14:

No. 0—Pure water.
No. 1—One volume of Solution C + 1 volume of H_2O.
No. 2—5½ volumes of Solution C + 2 volumes of H_2O.
No. 3—Solution C as such.
No. 4—One volume of Solution D + one volume of H_2O.
No. 5—5½ volumes of Solution D + two volumes of H_2O.
No. 6—Solution D as such.
No. 7—5 volumes of Solution E + 2 volumes of water.
No. 8—Solution E as such.
No. 9—7 volumes of Solution E + ½ volume of Solution F.
No. 10—6½ volumes of Solution E + one volume of Solution F.
No. 11—5½ volumes of Solution E + two volumes of Solution F.
No. 12—One volume of Solution E + one volume of Solution F.
No. 13—Two volumes of Solution E + 5 volumes of Solution F.
No. 14—Solution F as such.

These standard solutions shall, in all cases, remain stoppered and sealed to prevent evaporation.

Test Bottles: These shall be one-ounce, French square, glass-stoppered, flint glass bottles identical in every respect with those containing the standard solutions. (A suitable bottle is shown in the Whitall Tatum 1910 catalogue, p. 21.)

METHOD—7 cc. of 96 per cent C. P. sulfuric acid shall first be placed in a test bottle and approximately 21 cc. of the material to be tested shall be added. The bottle after being stoppered shall be thoroughly and vigorously shaken for 15 to 20 sec. and allowed to stand for the specified time. (See Notes.)

The resulting color of the acid layer shall be compared with the set of standards and the number of the bottle in the standard set corresponding to the test bottle shall be noted.

[1] THIS JOURNAL, 10 (1918), 819.
[2] *Met. & Chem. Eng.*, Nov. 15, 1917, p. 586.

PRECAUTIONS—If the color of the acid layer is not uniform, it should be carefully mixed by slowly inverting bottle once or twice.

96 per cent sulfuric acid must be used. Some C. P. acid obtained is only 94 per cent and care must be taken to see that the strength is of the proper degree.

NOTES—In pure benzol and pure toluol testing the benzol or toluol layer must remain white, and the color of the acid layer, after standing 15 min., must not be darker than No. 4.

For 90 per cent benzol and all grades of benzol and toluol other than pure, the benzol or toluol layer must remain white, and the color of the acid layer after standing 15 min. must not be darker than No. 6.

For solvent naphtha the acid layer color only is noted, and after standing 5 min. it must not be darker than No. 14.

It is well to note that the above schedule shows the limit of color allowable in the sales specifications, and it is to be expected that to consistently pass the test, works practice should call for a limit of at least one number lighter in each case.

This test is not used on crude benzols. The color standards are a modification of the old Barrett Company standard practice made by the Semet-Solvay Company.

SPECIAL NOTE—In making the wash test upon an agitator charge, this being recommended as a guide in determining whether material in question has been sufficiently washed to warrant making final distillation, it is necessary to first make the sample alkaline by shaking with some of the caustic soda solution which will be used in the factory upon the wash.

This is best carried out in a separatory funnel. After shaking, the mixture is allowed to settle and the soda solution drawn off as thoroughly as possible. 100 cc. of the neutralized oil are then measured in a graduated cylinder and transferred to a 200 cc. distilling flask.

No thermometer need be used in this distillation, but care should be taken to make the distillation through a condenser which has been used for pure products, so that the distillate may not be contaminated in the condenser.

The first 5 cc. distilled off are rejected. Then 70 cc. are distilled off and caught in a clean graduated cylinder. The cylinder which was used to measure the material into the flask should not be used for this, as it would tend to contaminate the distillate. The 70 cc. of distillate thus caught are filtered through a clean, dry, white filter, and tested for wash as described.

If the resulting test is entirely satisfactory, the factory alkali wash and result in distillation may be safely relied on.

TEST E7—CARBON BISULFIDE

APPARATUS—Erlenmeyer flask, rough balance, burette, separatory funnel 250 cc. capacity.

REAGENTS—Solution of alcoholic caustic potash, prepared by dissolving 110 g. of potassium hydroxide in 900 g. of absolute alcohol. Standard solution of copper sulfate (1 cc. equivalent to 0.0075 g. CS_2), prepared by dissolving 12.475 g. of $CuSO_4.5H_2O$ in one liter of distilled water. Potassium ferrocyanide solution. Acetic acid solution.

METHOD—Exactly 50 g. of the benzol to be tested shall be weighed into an Erlenmeyer flask, mixed well with 50 g. of alcoholic potassium hydroxide solution, the flask stoppered and the mixture allowed to stand for 5 or 6 hrs. at the ordinary temperature. The carbon bisulfide by this treatment is converted to potassium xanthate. The mixture shall then be shaken up with about 100 cc. of water and the aqueous layer separated from the benzol. This washing shall be repeated several times with 30 cc. portions of water, adding the washings to the original water solution. The solution shall then be diluted to 250 cc. and an aliquot portion removed, neutralized with acetic acid, and titrated with copper sulfate solution. The end-point shall be determined by placing a drop of the solution on a filter paper next to a drop of potassium ferrocyanide solution. The completion of the titration is indicated by a reddish brown zone of copper ferrocyanide.

CALCULATIONS—$$\frac{\text{Cc. } CuSO_4 \text{ soln.} \times 3.75}{\text{Cc. taken for titration}} = \text{per cent } CS_2.$$

NOTE—The above quantity of alcoholic caustic potash is sufficient if the benzol contains less than 5 per cent of carbon bisulfide. If it contains more, a smaller sample should be taken. In this case, the formula for calculation must be modified accordingly.

TEST E8—PARAFFINS

APPARATUS—Babcock milk bottles. Centrifuge. Pipette, 10 cc. funnel, with capillary stem.

REAGENTS—Fuming sulfuric acid, 20 per cent free SO_3.

METHOD—10 cc. of the benzol to be tested shall be measured into the Babcock bottle, and 10 cc. of the fuming sulfuric acid slowly added to it, cooling the bottle in a bath of ice water during the addition of the acid, and shaking the bottle vigorously after each addition in order to thoroughly mix the contents. After the addition of the acid is complete, the bottle shall be removed from the ice bath, shaken until the temperature rises to about 40° C., and then alternately cooled and shaken for a period of 15 min., keeping the temperature below 40° C. Then the mixture shall be cooled again, 10 cc. more of the fuming sulfuric acid added, the whole mixed thoroughly and shaken and cooled as above, keeping the temperature below 40° C. Finally the mixture shall be allowed to stand for 30 min. at a temperature of about 35° C. Then the bottle shall be cooled in ice water and water added through the capillary stem of the funnel so that it enters below the surface of the acid. The water shall be added in small portions very cautiously and the bottle thoroughly shaken and cooled after the addition of each portion. When sufficient water has been added to bring the level of the liquid well up on the graduated portion of the neck, the bottle shall be placed in the centrifuge and whizzed for 5 min.

The paraffins present will rise to the surface and their volume shall then be read off in terms of the

graduations on the neck of the bottle. This reading (in major divisions) multiplied by 2 gives directly the volume per cent of paraffins in the original material.

PRECAUTIONS—The graduated portion of the bottle should be 2 cc. divided into 10 major divisions. These are further subdivided into 5 or 10 divisions each. The readings should be taken in terms of the major divisions (0.2 cc. each).

NOTES—On diluting the sulfonation mixture with water it will frequently happen that a small quantity of solid sulfone will be formed, which, on centrifuging, will form a layer between the paraffins and the acid layer. This sulfone should not be mistaken for paraffins.

In benzol work we have found it necessary to carry on the dilution with water rather than concentrated sulfuric acid in order to prevent solution of paraffins in the mixture.

TEST E9—HYDROGEN SULFIDE

APPARATUS—Balance. Separatory funnel, 250 cc. Beakers, funnels, desiccator, crucibles, etc.

REAGENTS—Sodium hydroxide C. P., 10 per cent solution. Bromine water, sulfur free, saturated solution. Barium chloride, 5 per cent solution.

METHOD—100 g. of the benzol shall be shaken thoroughly in a separatory funnel with 25 cc. of sodium hydroxide solution, the liquids allowed to settle and the lower layer drawn off into a beaker. The water layer shall be diluted to 400 cc., about 20 cc. of the bromine water added, the mixture acidulated with hydrochloric acid, the excess bromine boiled off and the sulfuric acid in the solution precipitated in the usual manner with barium chloride. The barium sulfate shall be filtered and weighed. A blank determination shall be made on the same amounts of the materials used in the analysis and the weight of barium sulfate deducted from that obtained from the benzol.

CALCULATIONS—Weight of barium sulfate $\times$ 0.1460 = per cent of H_2S.

NOTES—Before proceeding with determinations of H_2S and SO_2 a qualitative test should first be made in order to determine which of the two is present. This can best be done at the time of performing the distillation test, E4 or E5, by hanging strips of moistened lead acetate paper and starch iodate paper on the end of the condenser tube. If the lead acetate paper shows discoloration, H_2S is present, but not SO_2. In this case both papers will usually be discolored. If the lead acetate paper shows no discoloration but the starch iodate paper develops a blue color, SO_2 is present but not H_2S. If neither paper shows discoloration, neither is present. As H_2S and SO_2 mutually react both cannot be present simultaneously.

TEST E10—SULFUR DIOXIDE

Apparatus, reagents, and method of analysis are precisely the same as E9.

CALCULATIONS—Weight of barium sulfate $\times$ 0.2744 = per cent SO_2.

TEST L11—SOLIDIFYING POINT OF PURE BENZOL

APPARATUS—Test-tube 5 in. long by 1 in. inside diameter. Thermometer, 0° to 80° (see D6).[1] Beaker, 400 cc. capacity.

[1] THIS JOURNAL, **10** (1918), 820.

METHOD—About 20 cc. of the benzol to be tested shall be poured into the test-tube and cooled in a bath of ice and water contained in a beaker, stirring continuously with a thermometer. When the solid benzol begins to separate the temperature will remain constant for some time. This temperature shall be taken as the solidifying point.

ACCURACY— $\pm$ 0.05°.

LIGHT OIL

This material is tested for water, specific gravity, tar acids, and tar bases as described under heavy oil tests.[1] Other special tests are made as follows:

TEST F5—BULB DISTILLATION

All matter as to apparatus, method, precautions and notes as given under E5 for materials boiling substantially above 135° C. apply to this test on these materials.

SPECIAL NOTE—With light oil, a dry point is ordinarily not taken, the distillation being continued only until about 95 per cent of the material has distilled over. Readings should be taken at first drop and every even 10° C.

TESTS F6 AND F7—TAR ACIDS (CONTRACTION AND LIBERATION METHODS)

These should be carried out exactly as given under H11 and H12.

TEST F8—HEMPEL DISTILLATION

APPARATUS—Flask, short ring neck, 200 cc. Hempel tube. Condenser and stand. Thermometer, 0° to 400° (specifications as under C9).[2]

The assembly of the apparatus is shown in Fig. XVII.

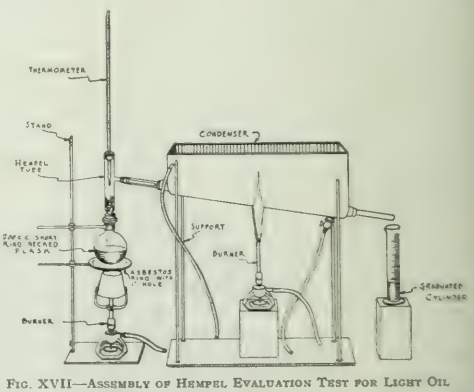


FIG. XVII—ASSEMBLY OF HEMPEL EVALUATION TEST FOR LIGHT OIL

METHOD—After the extraction of tar acids from 100 cc. of oil the residual oil shall be placed in the 200 cc. bulb and the apparatus assembled as in Fig. XVII. Heat shall be applied and the distillation conducted at the rate of 1 to 2 drops per sec. The volume which has distilled at 130° C., 170° C., and 200° C., shall be noted and recorded. The flame shall be removed when the thermometer reaches 200° C.

[1] THIS JOURNAL, **10** (1918) 911.
[2] *Ibid.*, **10** (1918), 819.

NOTES—This test is a very rough evaluation test used for comparison purposes between oils. The 130° fraction roughly represents crude benzol and toluol; the 130° to 170° fraction, crude solvent; and the 170° to 200° fraction, heavy naphtha. If more exact information is desired, the test given under F10 should be used. The residue in the bulb should be preserved for Test F9 if this is desired.

TEST F9—CRUDE NAPHTHALENE

APPARATUS—Same as used under H17.[1]

METHOD—The residue above 200° C. obtained in Test F8 shall be transferred to the copper beaker, cooled to 15.5° C., and held at this temperature for 30 min. It shall then be filtered and pressed as described under H17. The weight of dry solids divided by the specific gravity of the original oil gives the per cent by weight of crude naphthalene.

TEST F10—DETERMINATION OF BENZOL AND TOLUOL

APPARATUS—Distillation apparatus shown in Fig. XVI. Partial condenser distillation apparatus shown in Fig. XVIII. We shall be glad to furnish a detailed drawing of this apparatus to any who desire to procure the outfit. Three thermometers, 0° to 200°, previously standardized, and accurate to at least 0.5°. One thermometer, 70° to 120°, graduated in 0.2° intervals. One thermometer, 110° to 160°, graduated in 0.2° intervals. Three graduated cylinders, capacity 100 cc. One separatory funnel, capacity 2 liters. Westphal balance. Hempel distillation apparatus shown in Fig. XVII. Steam distillation apparatus.

REAGENTS—Sulfuric acid, 60° Bé., commercial. Sulfuric acid, 66° Bé., commercial. Caustic soda solution, 10 per cent. Pure toluol, boiling within $1^1/_2$° C., sp. gr. at 15.5° C. not less than 0.870.

METHOD: *Preparation of Sample*—100 cc. of the sample to be analyzed shall be distilled following the procedure of E5. A larger sample of the oil, accurately measured at 25° C., shall now be distilled, using a Hempel column and collecting the fraction boiling below 160° C. The difference between this fraction and the original sample shall be noted as "heavy oil." The size of sample taken shall be so regulated by the results obtained in the preliminary boiling test that about 1000 cc. are obtained in this distillation. If the preliminary distillation shows 90 per cent or more at 160° C., the Hempel distillation may be omitted.

Acid Wash—The fraction up to 160° C. shall now be washed in a separatory funnel with 1 per cent by volume of 60° Bé. sulfuric acid, care being taken that the oil is kept cool during the washing. The acid sludge shall be drawn off and the oil washed with three successive portions of 2 volumes each of 66° Bé. sulfuric acid, the acid sludge being drawn off after each washing. The oil shall finally be washed with a dilute solution of caustic soda and this drained off. The washed oil shall be put into a steam distillation apparatus and distilled with steam until no further oil comes over. The upper oil layer shall be carefully separated from the water in a separatory funnel and measured at 25° C. The difference between this volume and the volume before washing is noted as "loss in washing" and represents unsaturated hydrocarbons. The refined fractions so obtained should consist entirely of benzol, toluol, solvent, and possibly saturated paraffin hydrocarbons.

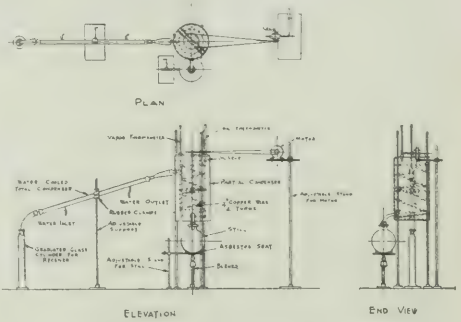


FIG. XVIII—ASSEMBLY OF PARTIAL CONDENSER

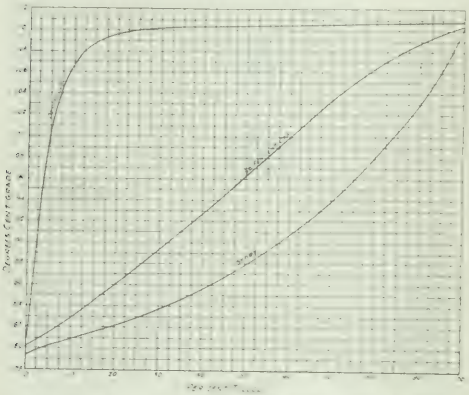
If the preliminary distillation showed less than 40 per cent distilling between 100° C. and 120° C., *this refined fraction should be mixed with an equal volume of pure toluol before being subjected to analysis.* In this case the quantity of material originally taken for analysis need be only about half that normally necessary, since the volume of the total oil to be fractionated should be 700 to 1000 cc.

Fractionation of Material—The refined fraction, which should approximate one liter, shall now be introduced into the $1^1/_2$ liter bulb of the partial condenser apparatus. The tank of the partial condenser shall be filled with a high boiling oil agitated by means of a small motor-driven agitator. The oil in the tank shall be heated up to 70° C. and the distillation of refined oil begun. The material in the flask shall be kept boiling vigorously so that the flame under the partial condenser may be turned off and the temperature continue to rise from condensation of vapors. The distillate shall be collected in 100 cc. cylinders, these being changed when nearly full, brought to a temperature of 25° C., and measured. As the temperature of the oil approaches 80° C. the distillation will very nearly stop and when very near the temperature of 80° C. a sudden increase in the rate of distillation will be noticed. This is when the benzol begins to come over in large quantities. The receiver shall now be changed and all fractions up to this point combined. This shall be called Fraction A.

The distillation shall be continued, allowing the temperature of the oil in the oil bath to gradually rise. The rate of distillation will gradually slacken until just below 110° C., when it is again practically stopped. At about this temperature the rate will again suddenly increase, the toluol coming over. When about 50 cc. of material have distilled beyond this point, the receiver shall be again changed and the fractions between the benzol cut and the toluol cut combined into Fraction B.

[1] THIS JOURNAL, **10** (1918), 916.

As the temperature of the oil bath continues to rise the rate of distillation will again decrease and will suddenly increase when the xylol boiling range is reached at about 137° C. The third cut shall be made when about 50 cc. of this material have distilled over. The distillation shall be stopped at this point, this combined fraction being Fraction C. It is generally necessary during the latter part of the distillation to place a small flame under the oil bath to take care of loss of heat by radiation. The entire time for the fractional distillation should be about 2 hrs.



CURVE 1—TEST F10. DISTILLATION OF BENZOL, TOLUOL MIXTURES

Interpretation of Results—100 cc. portions of Fractions B and C shall be submitted to distillation following the procedure of E4, temperatures being observed at start, 50 per cent off, and dry. The distillation of Fraction B shall be made using a 70° C. to 120° C. thermometer, and the distillation of Fraction C using a 110° C. to 160° C. thermometer. All temperatures shall be corrected for barometric reading; the correction factors for one millimeter of difference being as follows:

Fraction B—0.045° C.; Fraction C—0.050° C.

Fraction A should contain no toluol and shall be regarded as benzol.

Fraction B is a mixture of pure benzol and toluol with a very small amount of xylol. Its composition shall be estimated by reading on Curve 1, giving the boiling tests of benzol-toluol mixtures, the percentage of toluol corresponding to the temperature at which 50 per cent of the material was distilled off. The dry point of the distillation shall then be compared with the dry point curve of Curve 2 and the per cent xylol estimated. This percentage shall be deducted from the toluol. (This fraction should not contain more than 2 per cent of xylol.) From the percentage composition of the fraction so obtained and from its volume the actual amount of benzol, toluol, and xylol in it are figured.

Fraction C shall be similarly distilled and the percentage of toluol in it obtained from Curve 2 by the temperature at which 50 per cent was distilled off. This fraction should contain nothing but toluol and xylol. The actual amount of toluol is calculated from this figure and the volume of the fraction. From these figures the total volume of benzol and toluol in the original oil are determined. The toluol figure so obtained must of course be corrected for any pure toluol added before the fractionation.

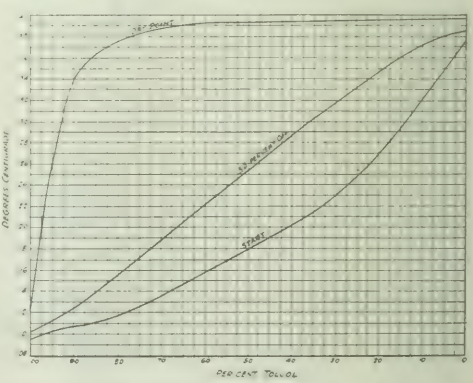
Correction for Paraffin Hydrocarbons—If paraffin hydrocarbons are present in the original oil they will of course appear along with the benzol and toluol and their presence here can be corrected for. This correction is made by determining the gravities of the three fractions, B, C and D, accurately at 15.5° C. by means of the Mohr-Westphal balance following the procedure of H4.[1] Assuming a specific gravity of 0.884 for pure benzol, 0.871 for pure toluol, and 0.869 for pure xylol, the theoretical gravity of the three fractions can be calculated as follows:

$$\frac{0.884 \times \text{per cent benzol} + 0.871 \times \text{per cent toluol}}{100} = \text{theoretical gravity of fraction}$$

The specific gravity of the aliphatic hydrocarbons corresponding to the three fractions would be, respectively, 0.720, 0.730, and 0.740. The percentage paraffin in the fraction can now be calculated as follows:

Theoretical sp. gr. of the fraction	$= a$
Actual sp. gr. of fraction	$= b$
Sp. gr. of corresponding aliphatic hydrocarbons	$= c$
Per cent aliphatic hydrocarbons in fraction	$= \frac{a - b}{a - c} \times 10$

The per cent paraffin so obtained must of course be corrected for in the benzol and toluol figures.



CURVE 2—TEST F10. DISTILLATION OF TOLUOL-XYLOL MIXTURES

PRECAUTIONS—Care should be taken throughout all the operations that proper precautions are taken to prevent loss both in distillation and in handling. Corks should be tight and the distillate kept cool and covered as much as possible. For making cork connections, shellac is recommended.

REPORTING RESULTS—All results obtained are figured back to the original oil as follows:

$$\frac{\text{Volume of constituent} \times 100}{\text{original volume of oil}} = \text{per cent constituent}$$

THE BARRETT COMPANY
17 BATTERY PLACE, NEW YORK CITY

[1] THIS JOURNAL, **10** (1918), 911.

A NEW ILLUMINATOR FOR MICROSCOPES[1]

SECOND PAPER

By Alexander Silverman

Received September 25, 1918

Since the publication of the first paper[2] about one year ago, a number of important improvements have been made in the illuminator[3] for microscopes therein described.



Fig 1

In the first paper the lamp holder was attached to the tube of the microscope by a clamp. In the newer form (Fig. 1) three fingers fasten the holder directly to the objective (Fig. 2). The fingers are iris-like in operation and are controlled by springs, so that it is possible to attach the illuminator to any objective.

The lamp described in the earlier paper was a 6 volt, 0.7 ampere unit operated by dry or storage cells. The new lamp is a 9 volt, 0.7 ampere unit of blue (daylight) glass and gives about 50 per cent more light. A rheostat has been devised which screws into an ordinary lighting socket. The rheostat has three taps, 107 volt, 112 volt, and 118 volt. A rheostat for 220 volt circuits is in preparation. If a greater light intensity is desired one can connect with a lower voltage tap. This is of advantage in photography. The normal voltage connection suffices for visual work.

Recent experiments with a colorless, one ampere, 13 volt lamp show that it can be employed safely. The lamp was placed in the holder, clamped to various objectives, and allowed to run continuously for half an hour, a period of time far exceeding any employed in actual operation. The objectives were not affected although the lamp carried an overvoltage of 15 per cent. Further, a colorless 0.7 ampere, 20 volt lamp was silvered instead of enameled. The silvered reflector reduces the amount of heat radiated towards the objective. Blackening the outer surface of the reflector also reduces the heat traveling towards the objective. Both lamps yielded a light of much greater intensity than any hitherto employed. Results obtained will be discussed later.

The lamp reflector is placed at an angle of 45° to the plane surface of the stage. Low power objectives may be an inch or more above the stage, so a tube has been designed which may be clamped to the stage. The lower end of the tube will support the lamp at a constant distance from the object under examination and the objective may be raised or lowered inside the tube. The inner surface of the tube is dull black.

A shutter may at times prove desirable to cut the light off from one-half of the circular source. The experimental shutter employed for this purpose is a dull black disk which covers half of the lamp and is attached by prongs which are held by the lamp. Details are sometimes visible by this method which are obscured when the entire lamp is bare.

The illuminator may be attached to a microscope together with a vertical illuminator, thus affording a comparison of the separate effects of oblique and vertical light on an object. There is a marked difference in the appearance of metallurgical specimens under the two illuminators, the new one facilitating the study of depressions and showing details not hitherto revealed. In blow-holes and pits the slag content, etc., may be seen. The pits appear black by vertical light.

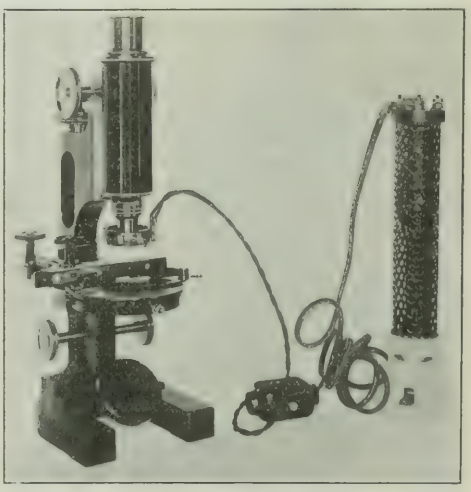


Fig. 2

When paper, textiles, insulating materials, biological specimens, etc., with light-absorbing surfaces, are examined by vertical light, little or none of the structure is visible. Under the new lamp a wealth of detail is seen which astonishes the observer who employs the device for the first time.

Should one wish to employ the new illuminator alone, and remove the vertical illuminator, it is necessary to

[1] Presented at the Cleveland Meeting of the American Chemical Society, September 11, 1918.

[2] This Journal, 9 (1917), 971.

[3] U. S. Pat. 1,267,287. Can. Pat. 185,283. Other U. S. and foreign patents pending.

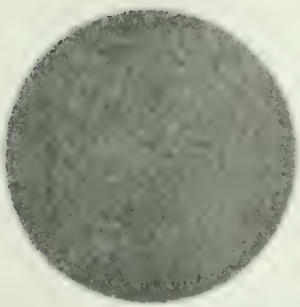


FIG. 3

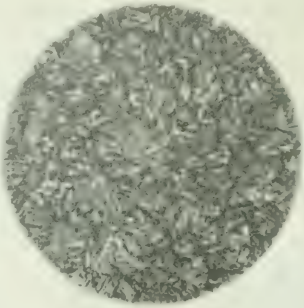


FIG. 4

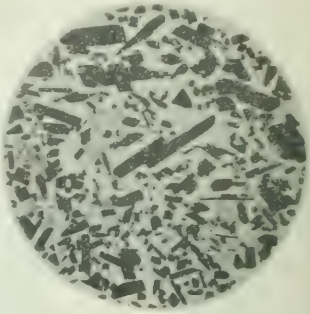


FIG. 5

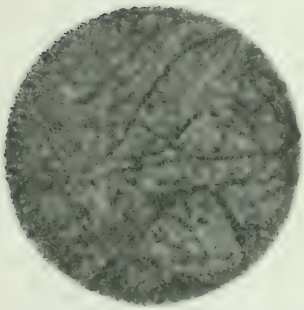


FIG. 6

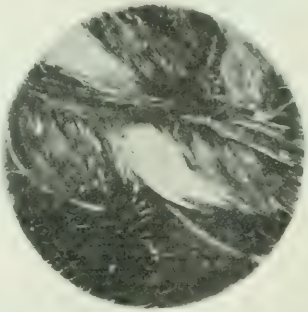


FIG. 7

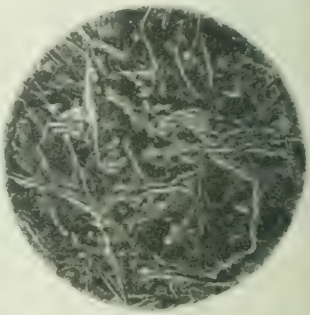


FIG. 8

extend the draw-tube of the microscope to about the 176 mm. point for clear images, as most microscopes at present on the market are corrected for the normally interposed vertical illuminator.

Questions have arisen repeatedly regarding the use of a lamp of such low wattage for photomicrography. Experiments conducted in the writer's laboratory prove that good results are obtainable with the 0.7 ampere, 9 volt daylight lamp with 8 and 16 mm. objectives and those of lower power, when the eyepiece is removed. With the colorless 0.7 ampere, 20 volt silvered lamp or the one ampere, 13 volt lamp it is unnecessary to remove the eyepiece, as the light intensity is ample to yield clear images on the ground glass.

Focusing may be facilitated by greasing the ground glass with a little vaseline, subsequently rubbing it as dry as possible with a cloth. Bronzes, highly polished ball bearings, enamel, paper, etc., have been photographed in this way. The best results were obtained with Hammer Ortho extra fast and Hammer Ortho nonhalation plates.

Figs. 3, 4, 5, 6, 7 and 8 show results obtained with the 0.7 ampere, 20 volt silvered lamp with exposures of from 15 to 30 seconds, using a 16 mm. objective and 10*X* eyepiece. Fig. 3 is a blue enameled steel; 4, a steel casting, 0.37 carbon, not pressed or heat treated; 5, an iron-zinc alloy obtained in zinc manufacture; 6, a piece of blue cover paper; 7, a piece of cloth; 8, a cast iron specimen.

In conclusion, the writer wishes to express his appreciation to the scientists in various fields who have experimented with the new device and made suggestions which have resulted in valuable improvements in methods of application.

SCHOOL OF CHEMISTRY
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PA.

A SPECIAL STOPCOCK FOR DROPPING LIQUIDS ARRANGED FOR EQUALIZING THE PRESSURE ABOVE AND BELOW THE OUTLET IN THE STOPCOCK[1]

By HARRY L. FISHER

Received June 4, 1918

The stopcock described herein was designed in connection with a generator for carbon dioxide which was to be used alternately with pressures below and above atmospheric in the final preparation of cupric oxide and for the determination of nitrogen by the Dumas method according to the modification of Fieldner and Taylor.[2]

Ordinarily an outside tube connecting the top of the reservoir of acid with the upper part of the container of the carbonate is used. In this new apparatus the connection is made by means of an annular groove in the key of the stopcock so that no matter which position the key occupies there is always communica-

[1] Presented at the Boston Meeting of the American Chemical Society, September 10–13, 1917.

[2] Fieldner and Taylor, THIS JOURNAL, 7 (1915), 106.

tion between the atmosphere in the lower flask and the atmosphere in the upper flask. One arm of the stopcock is extended until it opens above the liquid in the upper container. The liquid enters at an aperture in the lower part of this extended arm and is delivered through a small glass tube sealed in at this opening. The entire arrangement is more clearly understood by a glance at the accompanying diagram. Two different styles were made, using the same principle in each.

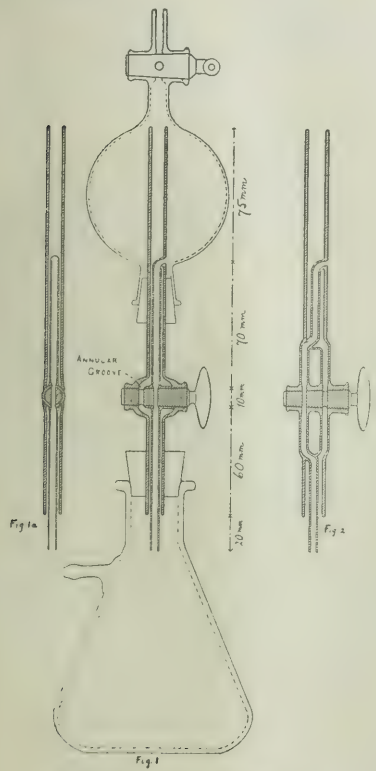


FIG. 1 —LONGITUDINAL SECTION
FIG. 1a—CROSS SECTION AT CENTER
FIG. 2 —LONGITUDINAL SECTION

ADDITIONAL DIMENSIONS

	Fig. 1 Mm.	Fig. 2 Mm.
Length of stopcock barrel	35	35
Outside diameter of inner tube	5	5
Inside diameter of inner tube	3	3
Outside diameter of outer tube	10	13
Inside diameter of outer tube	7	9.5

If the flasks are used as shown they must be securely fastened by clamps close to the lips. The upper flask can be filled through a funnel attached by means of a piece of rubber tubing. The liquid will flow down the inside walls and not drop into the extended tube. The arrangement and kind of flasks can be changed as desired, and it is believed that the apparatus will be of service elsewhere.

I wish to acknowledge my thanks to Mr. W. Wiegand of the firm of Eimer and Amend, New York City, for his interest and skill in making these two stopcocks.

LABORATORY OF ORGANIC CHEMISTRY
COLUMBIA UNIVERSITY, NEW YORK CITY

A NEW TIMING DEVICE FOR SIMPLIFYING THE THERMOMETRIC READING OF CALORIMETRIC DETERMINATIONS

By CHAS. A. MYERS, JR.

Received May 18, 1918

At the beginning of the war the chemical laboratory of the New York Navy Yard was called upon to do all the chemical analyses of coal used by the fleet and its auxiliaries in the northern district. This wrought a tremendous increase in the work which the laboratory in normal times was expected to do; but notwithstanding the increase in the number of analyses it was essential that there should not be any sacrifice in the accuracy to which these operations were ordinarily accustomed. The writer, who has for some time been engaged in the work in question, has developed an electrical timing device for calorimeters which he believes would be of great assistance to anyone called upon to determine calorific values under such circumstances, where radiation factors are involved.

One of the chief advantages of this timing device is its absolute accuracy in giving the operator the exact second at which to read the thermometer. The instrument, moreover, relieves to an almost unbelievable

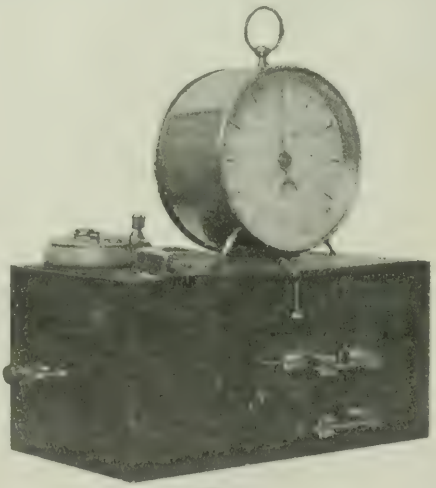


FIG. 1

extent the strain on the operator who may be called upon to make constant readings over an extended period of time. With this device it is no longer necessary to divide attention between the stop watch and the thermometer, first looking at one and then the other, as an audible warning signal is given 5 seconds before the time to read, and a second signal at the moment at which the reading should be taken.

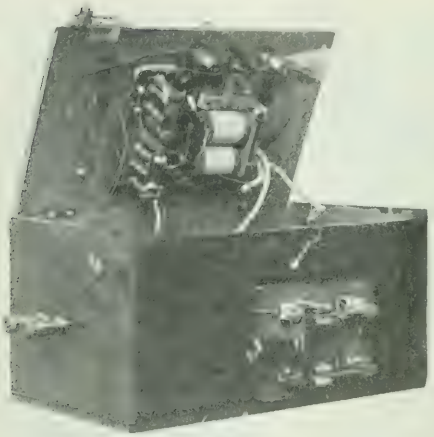


FIG. II

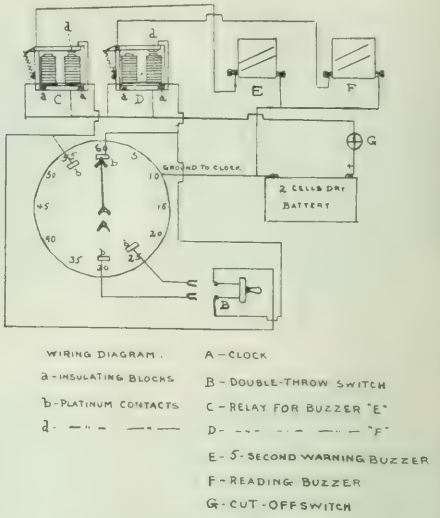


FIG. III

A further advantage is that almost any number of calorimeters may be operated at one time by this device, it being simply necessary to have the signals loud enough to be heard by all of the operators.

The device consists of a clock put out by one of the large photographic supply houses which has a large second hand making one complete revolution every minute. On the face of this clock are cemented four platinum-foil squares arranged so that contact will be made 5 seconds before the minute and half-minute, and again exactly on the minute and half-minute. Contact is made by a fine platinum wire soldered to the second hand of the clock. Two buzzers are used to give the signals, one of high pitch and the other low. The writer selected the high-pitch buzzer to give the warning signal 5 seconds before the time to read and the low-pitch buzzer for the signal to read. As the buzzers consume a relatively large amount of current it is impossible to make contact for them directly through the platinum wire and the contacts really operate two relays and these in turn pass the current through the buzzers. The relays are made from common nails about $1^1/_2$ in. long turned down in a lathe and wound with eight layers of No. 36 double silk covered copper wire. A small piece of platinum is soldered to the end of one of the magnets of each relay (the one furthest from the hinge) and this makes contact with another piece of platinum soldered to the armature, thus closing the circuit to the proper buzzer. The relay magnets and their supports are mounted on a hard rubber base which insulates the armature from the magnets when current is not flowing through the latter. A double switch is provided to cut out the half-minute readings when these are not desired and a single point switch to shut off all readings. The details of the wiring are shown clearly in Fig. III.

CHEMICAL LABORATORY
NAVY YARD
BROOKLYN, N. Y.

ADDRESSES

SOME APPLICATIONS OF PHYSICAL CHEMISTRY IN THE COAL-TAR INDUSTRY

By WILBERT J. HUFF

This paper will be divided into two distinct parts, the first of which deals with volume relations in solidifying creosotes, while the second applies to the vapor densities of coal-tar fractions.

I—VOLUME RELATIONS OF SOLIDIFYING CREOSOTES

Since liquid coal-tar products are regularly sold by volume, the exact determination of the variation of volume with temperature is of great economic importance to both distiller and consumer. The standard temperature for oil measurements is usually 60° F., although in the case of creosote oil 100° F. has been somewhat generally adopted. Since it is obviously impossible to bring tank car quantities to the standard temperature before gauging their volume, the shipper determines the volume at the shipping temperature and calculates the volume at 60° F. by means of a coefficient of cubical expansion; the receiver invoices at the temperature at which he happens to get the car and calculates by means of the same coefficient to the same temperature.

Now the trade has found it difficult to obtain concordant results between measurements taken at shipping and receiving points on creosote oil in tank cars and tank vessels. The discrepancies have in some instances amounted to as much as 5 per cent of the volume of oil handled.

Adjustments, however, were necessary not only in company-consumer shipments, but also in inter-plant shipments, and even in inventory calculations at the same plant. Clearly, something was wrong.

Some earlier work on volume relations in creosote oil was car-

[1] Read before the New York Section of the Society of Chemical Industry, May 24, 1918.

ried on by Mr. H. E. Lloyd, of The Barrett Co., and the results obtained by him, although not conclusive, fully indicated the need for a more searching investigation into the problem.

One of the first things that attracted my attention while considering this problem was the mental haze of the practical employee when dealing with the simple mathematical relations involved in calculating coefficients of cubical expansion. I have found by personal observation and experience that very many chemists (strange to relate) do not relish the mental gyrations of the mathematician. Even engineers had been somewhat lax, for the trade had been making no correction for the coefficient of cubical expansion of the container and in consequence did not calibrate the container at any definite temperature.

Although it is a repeating of very elementary matter, I will give here the formulas which are used in determining and applying coefficients of cubical expansion.

The change in volume per unit volume per degree change in temperature is called the coefficient of cubical expansion.

Thus:

$$V_2 = V_1(1 + at)$$

in which a is the coefficient of cubical expansion.

Since in practice the container is always an expanding material, the apparent expansion is less than the real. The container expands, partly compensating for the expansion of the material.

The relations are generally expressed by the equation

$$A + C = T$$

in which A is the apparent coefficient of cubical expansion of the liquid, C is the coefficient of cubical expansion of the container, while T is the true coefficient of cubical expansion of the liquid.

This relation is strictly true only for the case where the container is always kept full, as in most specific gravity determinations with a pycnometer. When the liquid rises and falls in a steel container the deviation in the apparent coefficient from this relation can be shown mathematically to be about 3 parts in 100,000 per degree Centigrade.

This is of course much smaller than the errors of measurement in practice. Consequently the form given above (which is exceedingly simple) may be regarded as correct for all cases.

One of the first points cousidered was the relative effects of the variations in conditions in a large container, as for instance: stratification, sedimentation, inequalities of temperature, etc., which would not be pronounced in the small volume of a specific gravity bottle in which the previously used coefficient of cubical expansion of creosote oil had been determined. Accordingly, a hollow iron container with a capacity of about $2^1/_2$ gal. was fitted with a screw cap carrying a glass tube to serve as the neck of a pycnometer, and with three thermometers placed at different distances from the center. This was placed in a 50-gal. water bath provided with an agitator, and suitable burners, etc., for applying heat. A glass pycnometer was placed in the same bath in order to duplicate the work in a small volume. No essential difference in results was obtained, showing that the difficulty lay somewhere else.

The iron container was twice calibrated with water and the apparent coefficients of expansion of water in iron calculated over the ranges: 15.5–25° C., 25–38° C., 38–60 C., 60–80° C.

These observed values were then subtracted from the true zero ones, giving by difference the coefficient of cubical expansion of iron. The mean of one set of experiments gave 0.000037 for this, while the mean of another set gave 0.000036. These results were considered very satisfactory, for the accuracy of 0.00001 to 0.00002 is from 5 to 10 times more than the previously accepted coefficient of cubical expansion of creosote oil (0.00079 per degree C.). The subsequent work with oils, however, was probably not quite so accurate, for the oils were much harder to bring to a constant volume, probably because of a lower heat conductivity.

In the work with oils the container was filled at 80° C. and later made to the mark at about 60°, 38°, 25°, 15.5°, with weighed water. The pycnometer was made to mark with the oil when used with liquid oils. With solid oils it was filled at 80°, made to mark with oil at 60°, and then with water at temperatures below 60°.

Two creosote oils were examined: A refined liquid creosote oil, hereafter referred to as No. 1, which does not solidify in the range covered, and an oil representing a commercial grade of creosote oil according to the standard specifications of the American Railway Engineering Association, hereafter designated as No. 2, which gave a small amount of crystals at 15.5° C. The coefficients found for these oils checked very satisfactorily in duplicate experiments both in the large container and the small specific gravity bottle. The mean true coefficients found (0.000703 for No. 1 and 0.000724 for No. 2) were slightly lower than the previously accepted value (0.00079). The apparent coefficients in steel tank cars would be even lower. These findings, however, did not explain the discrepancies encountered in practice.

The thing which was especially interesting to me was the absence of variation in the coefficients with temperatures. The coefficient of cubical expansion of water shows a huge variation over the interval in question (15°–80° C.). This variation amounts to from 200 to 300 per cent.

The influence of salts upon the coefficients of cubical expansion of these oils was next studied by salting the same oils with pure naphthalene for a limpid point of about 40° C.

This mixture consisted of No. 1 oil 71.5 per cent and naphthalene 28.5 per cent by weight. A little more than 30 per cent distilled below 235° C. In the upper ranges this mixture contracted regularly with descending temperature and gave the coefficients found for the original No. 1 oil. At temperatures below 38° C., however, the crystallization caused an enormous shrinkage. In one experiment the average coefficient between 38° and 25° was from 4 to 5 times as great as that for liquid creosotes. In a duplicate experiment the value was from 3 to 4 times as great. This abnormal behavior was always exhibited below 38°, that is, below the temperature at which crystallization became important. The expansion and contraction observed was of course the resultant of three factors: (1) The mechanical expansion or contraction of the liquid phase. (2) The mechanical expansion or contraction of the solid phase. (3) The volume change due to the solution or crystallization of the solid phase. Now it is very probable that the coefficient of cubical expansion of solid naphthalene is much less than that of the liquid creosotes. (Beilstein reports the density at 4° and 15° C. to have practically the same value.) Undoubtedly these huge and irregular coefficients are caused by the crystallization.

Naphthalene dissolves in creosote oil with an increase in volume; 1 qt. of naphthalene and 3 qts. of a salt-free creosote oil will make more than 1 gal. of mixture.

The magnitude of the volume change accompanying the solution or crystallization is unfortunately very large. Some of the experimental results obtained showed that an error of as much as 404 gals. per 10,000 gals. in a temperature interval from 110° to 70° C. might easily be possible, using the old coefficient of cubical expansion.

The word "unfortunately" is used advisedly. The process of crystallization and solution is very slow when contrasted with the mechanical expansion or contraction of the solid and liquid phases. In consequence, with varying temperatures there may be, and probably often will be, incomplete equilibrium between the two phases. Accordingly, the observed volume of the total will vary a great deal with the immediate past history

of the mixture. It is only to be expected, therefore, that the results obtained in measuring the coefficient of expansion of a partially solid oil will not check unless great care and a sufficiently long time is allowed to elapse at each temperature to insure that the crystallization or solution has attained equilibrium. Since in actual practice it is very often not desirable or even possible to maintain a tank or tank car at exactly the same temperature for a sufficiently long time to insure equilibrium between the solid and liquid phases before determining the volume, the practical value of such a coefficient, even when obtained with the greatest care, is very doubtful. Variations in the amount of crystallizable substances from time to time in the same grade of oil will seriously affect the coefficient.

Another possible complication is the variation in the character of the crystallizing solid. Suppose anthracene crystals appeared instead of naphthalene crystals, what would happen then?

This point was investigated by dissolving crude anthracene in the No. 1 oil. The work was abandoned, however, because of the extremely slight solubility of this compound in this oil; less than 5 per cent of the solid gave a limpid point of 40° C., while it took more than 28 per cent of naphthalene to give the same limpid point. With less than 5 per cent of anthracene present, it was not deemed worth while to examine the volume relations of the mixture.

Naphthalene is, of course, the most important solid. Moreover, its similarity in physical properties, composition, and structure to other coal-tar compounds leads one to believe that an analogous effect occurs when most of the other solids crystallize or dissolve.

The magnitude of the error, and the inherent insurmountable obstacles encountered when one attempts to predict the volume of an oil at a temperature at which it may be partly solid, may ultimately revolutionize the present practice of buying and selling oils by volume.

The simplest expedient, of course, is to buy and sell by weight. At present, however, such a departure is so radical that it is practically impossible.

It is probable that a temperature of 100° F. will be widely adopted as the standard, displacing the 60° F. of the present, since at 100° F. the creosotes are liquid. The trade situation was somewhat amusing—we had been buying and selling gallons at 60° F without knowing the volume relations which relate 60° F. to the customary temperatures of trade.

II—THE VAPOR DENSITIES OF COAL-TAR FRACTIONS

Although the composition of the higher fractions from the distillation of coal tar has long been a subject for study and speculation, and many of the compounds present have been isolated and identified, the quantitative composition of these interesting mixtures still remains a matter of mystery. It is probable, however, that the number of compounds present is very great.

This question was of especial concern to the engineering department of The Barrett Company in the design of large capacity condensing systems, since a knowledge of the exact composition would give by a simple calculation the vapor density of any fraction, and in turn a key to a design for a condenser embodying economical construction and efficient fractionation.

It fell to the lot of Mr. Gainey and myself to investigate these vapor densities which, of course, could be ascertained only by experiment.

Of all the methods for determining vapor densities, the Victor Meyer is the best suited for a problem of this kind, since it is applicable over a very wide range of temperatures and pressures and is equally useful for pure compounds and mixtures. Other methods afford some of these advantages but not all. Thus the Dumas could be used at the temperatures and pressures desired but, unfortunately, is inapplicable to mixtures whose components have different boiling points. The Dumas, you will remember, calls for a light glass bulb drawn to a point and weighed. The substance under examination is introduced and the bulb is then placed in a constant temperature bath while a certain pressure is applied (generally atmospheric) until the bulb is completely filled with vapor and the excess vapor has been removed. The bulb is then sealed off and weighed. In this procedure, the lower boiling components would probably be removed from the bulb before the higher were completely vaporized, so we could not employ this to determine the vapor densities of fractions of the coal-tar distillate. The Gay-Lussac-Hofmann method, which consists in the introduction of the substance into the vacuum above an upright barometer, can be employed equally well for pure compounds or mixtures, but is unfortunately limited to temperatures where mercury exerts no appreciable vapor tension, that is, below 150° or 175° C., and could not be used for coal-tar fractions whose boiling points in some cases are higher than 400° C.

For the sake of a clear understanding of what follows, I will recall the principles which are involved in the Victor Meyer method of determining vapor densities by air displacement.

In its simplest form the apparatus for this method consists of a long "pear-shaped" glass tube provided with two side tubes near the upper end. One of these side tubes is connected through a rubber tube to a gas burette. The lower portion of the glass pear is brought to a temperature which is sufficiently high to insure complete volatilization of the test material. This material is then introduced through the stoppered opening in the top of the tube and dropped at the proper moment by withdrawing a glass rod thrust through one of the side tubes. Upon reaching the hot portion of the pear, the material vaporizes, driving up ahead of it and over into the gas burette, air, which, of course, does not condense and can be measured as soon as the system reaches equilibrium. From a knowledge of the weight of the material, the volume of the air driven over into the gas burette, and its temperature and pressure, it is possible to calculate the density of the test material in the vapor form.

A modification of the method consists in attaching the pear to a manometer and measuring the increase in pressure at constant volume caused by the volatilization of the test material. This modification is particularly useful when it is necessary to employ a diminished pressure to insure complete volatilization, since it is very difficult to measure an increase in volume in a system maintained at a very low pressure.

Such considerations are so preliminary and general that I feel compelled to apologize for presenting them to you.

The first consideration peculiar to the vaporization of these coal-tar distillates was the question of coking. To throw suddenly these hydrocarbon-containing mixtures upon glass surfaces heated to several hundred degrees Centigrade without cracking and coking them was indeed a problem, especially when the boiling point ranges ran above 350° and 400° C. Decomposition by cracking and coking had to be guarded against in the distillation which gave the test fractions also.

A composite oil typical of the distillate from coal tar, between first runnings and hard pitch, was distilled in the laboratory and cut to 50° C. fractions. This oil began boiling at 200° C. under atmospheric pressure, and the distillation was continued under atmospheric pressure for two fractions until the vapor temperatures reached 300° C. In order to forestall cracking, the distilling bulb was then allowed to cool and an absolute pressure of 50 mm. of mercury was then applied. The oil began to distil once more at 175° C. and continued to distil until a temperature of 370° C. was attained. Further heating only produced decomposition into non-condensing vapors. In all, 87 per cent of the oil distilled and five 50° fractions were obtained.

VAPOR DENSITY RESULTS

COMPOUND	Formula	B. P. at 760 mm.	Vapor density at 0° C. and 760 mm. G. per cc. Calculated	Obtained	COAL-TAR FRACTIONS Boiling Point Ranges
Naphthalene di-hydride	$C_{10}H_{10}$	200–210° C.	0.00579		
Naphthalene	$C_{10}H_8$	218° C.	0.00572	0.00579	199–249° C. under 755 mm. Hg
Methyl naphthalenes	$C_{11}H_{10}$	240–243° C.	0.00634		
Diphenyl	$C_{12}H_{10}$	254° C.	0.00688		
Acenaphthene	$C_{12}H_{10}$	278° C.	0.00688	0.00667	249–296° C. under 755 mm. Hg
.....	...	.....	.....	0.00691	180–229° C. under 50 mm. Hg
Anthracene	$C_{14}H_{10}$	360° C.	0.00794	0.00867	229–276° C. under 50 mm. Hg
Methyl anthracene	$C_{15}H_{12}$	Above 360° C.	0.00858	0.1047	276–322° C. under 50 mm. Hg
Chrysene	$C_{18}H_{10}$	436° C.	0.00902	...	

A number of preliminary experiments were made to fix a method of procedure. It was found advisable to confine the test fractions in Woods metal bottles which melted immediately and threw the entire contents in contact with the hot glass surface. Glass containers were unsatisfactory; the lower boiling material passed into the vapor form, reached the cool portion of the tube and condensed, before the higher boiling material was completely volatilized. Considerable time was spent investigating the possible coking of the fractions in the Victor Meyer pear. The criterion for coking was the appearance of the glass pear, which became badly discolored with carbon when the pear was heated much above 360° C. In a mercury vapor bath (giving a temperature of 357° C.), however, no coking occurred. This was extremely fortunate, for it permitted the use of this vapor bath as the heating agency, giving a temperature which remained constant without attention and was easily reproduced.

The discovery that coking became serious above some 360° or 370° C., coupled with the fact that two of the fractions had boiling point ranges higher than this when under atmospheric pressure, rendered it imperative that an apparatus capable of measuring vapor densities under diminished pressure be fitted up.

Accordingly a flexible mercury manometer made from two glass tubes, a rubber hose, and an upright meter stick was attached to the Victor Meyer tube and the tube evacuated to a low pressure by means of a vacuum pump, the fraction volatilized and the change in pressure noted. The calculations for this low pressure work involved a factor known as the tube constant. This constant depended upon the size of the tube; thus, when a tube of a certain size is used half as much pressure is developed by a given amount of vapor as is developed when a tube of only half that certain size is used, *i. e.*, in a tube twice as large, only half the pressure is developed.

The constant was determined by volatilizing in the tube at the temperature of the experiment a known amount of a compound possessing a known vapor density. The determination of this constant proved quite a bugbear to Mr. Gainey and myself. The slow deliveries on special glassware due to war conditions compelled us to blow our fragile tubes at the blast lamp. We would often carefully standardize a tube in duplicate (consuming several days in the operations) only to break it by some accident before we could use it for a determination. You can then imagine us sweating over the blast lamp in the heat of last August while we blew another tube, hoping for better luck the next time.

In the above table are given our vapor density results, compared with the calculated vapor densities of a few well-known hydrocarbons whose boiling points place them in the range of the appropriate fraction.

The vapor densities of the first two fractions were obtained by determining the volumes of air driven into a gas burette in the standard Victor Meyer method, the third was obtained by packing the tubes with hydrogen whose rapid rate of diffusion into the volatilizing oil insured complete vaporization, the last two were obtained by the use of the manometer and the low pressure system. Mercury vapor was used as the heating medium for all the experiments.

ACKNOWLEDGMENT

The experimental material presented in this paper was obtained while I was engaged in physical chemistry research for The Barrett Company and is the product not only of my own efforts but also of the efforts of Mr. John Gainey, who so ably assisted me in the latter part of the work and who is now still engaged in extending it. My debt, however, is not limited to Mr. Gainey. It is owed to the administrative officers of the Research Department of The Barrett Company, to whom I extend my thanks for direction and advice.

It is my belief that physical chemistry is afforded no richer field for research and development than the coal-tar industry, so economically important to the country in peace and so prominent in the scheme of modern warfare. My short connection with this industry has led me to believe that it is only in its infancy and that many of its latent possibilities will be realized by the aid of physical chemistry.

RESEARCH DEPARTMENT
THE BARRETT COMPANY
NEW YORK CITY

A MANUFACTURER'S EXPERIENCE WITH GRADUATE CHEMICAL ENGINEERS[1]

By S. R. CHURCH

Received July 15, 1918

The writer has often objected to the term "Chemical Engineer." It seems to place chemical engineering alongside of civil, mechanical, and electrical engineering as one of the natural divisions of the engineering profession. We would define chemistry as the science of the composition of materials, and engineering as the science of works. Chemistry is therefore the fundamental science, as without some knowledge of the composition of materials an engineer will fail.

For the purpose of this paper the writer will consider that a chemical engineer means a graduate in engineering who has had at least four years of college training at an institution recognizing the engineer's need for knowledge of the composition of materials

During the past two years we have employed in our General Manufacturing Department 100 student engineers. These men were employed, not to occupy at first a definite position, but to undergo a course of study in the Company's business and to fit themselves for positions in the engineering, operating or experimental departments of manufacturing, after a period of at least 6 months' training. In this training period the men receive instruction in the form of lectures on various products and processes by heads of the manufacturing and technical staff and are given special assignments for personal study of a product, process, manufacturing unit, laboratory, or works experiment, etc.

It is our purpose to have at all times about 10 to 20 men in the training period and at the end of about 6 months to assign a student to a definite position, or release him, or under certain conditions to continue his probationary period.

The men are in general selected with a view to their apparent fitness to become assistant superintendents or foremen, but in a

[1] Paper submitted for the Proceedings of the American Association for the Advancement of Science.

few cases men have been employed because of special ability in line of designing apparatus, etc. These men ranged from 21 to 40 years of age and from newly graduated students to men having 10 years' industrial experience. Among them are civil and mechanical engineers, but a majority are graduates from chemical engineering courses. In the number are graduates from most of the engineering colleges and universities east of the Mississippi.

While the results have of course been almost as varied as the number of men engaged, yet certain observations have been made which may reflect the influence of the institutional training received by these men. It seems especially true of the chemical engineers that they lack ability to correctly evaluate measurements. They seem to have been taught that a result must be accurate to a certain decimal fraction, and attempt to apply this without reasonable sense of proportion.

They are usually careful and fairly good in the technique of experimental work but lack ability to discern from an unsuccessful experiment the suggestive feature that should point the way to further experiments. They appear not to have been impressed with the importance of qualitative results. They often fail to discern the value of an indicative result in an experiment that has partly or wholly failed in its primary object and lack the imagination which enables the exceptional student to see his way through an accumulation of data that to another is only material for a progress report.

At this point we might note that ability to write a really good comprehensive report is not possessed to a satisfactory degree by the majority. In some cases this is so serious that men entirely capable of doing good work have utterly failed to make good. Instructors do not perhaps realize to what a large extent the graduate will, during his first 6 months or year in commercial life, be judged by his written reports.

Another common failing of many of our chemical engineers is poor training in the graphic presentation of experimental data. The superiority of a well-planned chart over a series of tables, both in facility of interpretation and suggestiveness, does not appear to be well grounded in them. Many lack a good sense of relative values, such as enables the exceptional man to consider a sample of material, the report of a day's run on a still or mixer, only for what it is worth; and to avoid the loss of time and effort that the average student would expend on carrying out elaborate analysis or calculations on a premise having obvious limitations. A greater familiarity on the student's part with the general principles common to works practice might seem to be reasonably expected. As for instance that the value of accuracy in laboratory analysis depends absolutely on the accuracy with which the sample represents a given lot of material, and that knowledge of the limitations of accurate measurements or sampling outside the laboratory may save much time in eliminating refinement of procedure and calculation.

The writer is of the opinion that a comprehensive course in Chemical Engineering should cover at least 5 years and preferably six. He realizes that for various reasons, not the least of these being the tremendously increased demand for chemical engineers, many colleges will not extend their courses to a 5 or 6 year basis. He urges that especially in the shorter courses every effort be made to give the student a sense of values, a better touch with the work, and to develop his imagination so that he will see in the problem assigned to him not the possibility of solving the value of X and writing Q. E. D., but of coming to his employer with a suggestion that by raising the temperature of this reaction we may obtain an increased yield of 5 per cent; or by putting a worm conveyor here we can eliminate the work of two men.

The writer is a firm believer in long and thorough schooling, in painstaking, and in accuracy; but the man who has not been taught at school to eliminate the unnecessary in his work and way of thinking will be slow to perceive the value of the short cut in manufacturing.

It is too much to expect that all of the defects herein noted, which are in some degree common imperfections in all of us, can be cured in a 4, 5, or 6 year college course. The writer felt that criticism rather than commendation would be more helpful and has purposely omitted reference to the many good qualities possessed by the men we have employed.

THE BARRETT COMPANY
17 BATTERY PLACE
NEW YORK CITY

CURRENT INDUSTRIAL NEWS

By A. McMILLAN, 24 Westend Park St., Glasgow, Scotland

BURMESE MONAZITE SANDS

The Geological Survey of India reports that an analysis made of the monazite sands of Mergui and Tavoy in Tenasserim, Lower Burma, taken from 28 locations, shows but 0.18 per cent of thoria in the heavy concentrates, which is equivalent to 0.00216 lb. of thorium oxide per cubic yard of the ground sampled and adds that such minute fraction is, of course, of no practical utility.

INCANDESCENT LAMPS

A new edition of their "Incandescent Lamp Handbook, No. 1A" has been sent out by the British Thomson-Houston Co., London, and contains particulars and prices of lamps of both the vacuum and the half-watt types, for standard lighting service. In addition, there is a great deal of information about the terms and definitions used in the lamp trade and the photometric units and standards employed in illuminating engineering. The lumen, which has been adopted as the unit of light rating for electric lamps by the engineering societies and lamp manufacturers of the United States and Canada and by the leading British lamp makers, is explained at considerable length and examples are given showing how lighting calculations are simplified by its use.

ALUMINUM AND ITS ALLOYS

Dr. W. Rosenhain, lecturing recently in London on aluminum and its alloys, said that the possibilities of aluminum and its alloys depended primarily on the lightness of aluminum. Lightness of itself, however, was of little value. What was required was a combination of great strength and lightness. This had been attained to an astonishing degree in the modern aluminum alloys. There were many moving parts in light machinery, such as cycles and sewing machines, in which the extensive use of light alloys would appear to offer a great field for real advance. For air craft and other purposes, it has the importance of a "key" industry.

PEAT FUEL

A method of treating peat for fuel purposes proposed by Mr. S. C. Davidson, Belfast, consists in disintegrating it, mixing it with 15 per cent of pitch and submitting it to a pressure of at least two tons per square inch in a hydraulic press. In this way its bulk is reduced to about one-third and it comes out of the press in a solid block looking like polished hardwood which burns with a steady yellow flame. From his experiments, Mr. Davidson believes that the peat will require only a short period of air-drying before treatment by this process.

OILS FROM COAL TAR

Prof. Carl Goldschmidt, of Essen, and R. Friedlaender, of Berlin, both members of the recently formed Kohlchemie Konsortium, have recently issued a pamphlet, says the *Oil and Color Trade Journal*, **54** (1918), 962, calling attention to the advantages and possibilities of their so-called coal Liquefaction Process, *i. e.*, the synthetic manufacture of benzolenes, lighting, engine, and lubricating oil from lignite, generator tar, crude oil, and crude oil derivatives. They mention the cracking and separating processes of Zern, Walther, and Graele, whereby the constituent parts of tar boiling at higher temperatures are transformed into benzolenes. They also deal largely with the somewhat related Bergin process whereby with the aid of heat and hydrogen, both benzolene and lighting oils are obtained of a quality equal to those obtained from natural sources.

The chief primary raw material, lignite-tar, can be obtained from the heating of generators, for instance, in lignite briquette factories in which some 20,000,000 tons of lignite are worked up, glass kilns, paper mills, and the like, in which some 12,000,000 tons are used to fire boilers instead of being gasified. In this way alone, 1,500,000 tons of tar are obtained for distillation, etc., and the gasification of lignite alone would suffice to supply Germany with all her requirements in enriched oil products. Until such gasification plant has been established everywhere steps should be taken to secure a steady importation of raw oil and more especially of raw materials for the synthetic manufacture of benzolene and oil. Such a raw material is a by-product in Russian, Roumanian, and Galician distilleries, which use large quantities of it as an inferior kind of fuel.

SODA AND SULFITE PULP

The *Paper Maker*, quoting from a German contemporary, states that in the sulfite process certain residues of the wood substance survive and are found in the paper, whereas by the alkaline process the purification is far more complete. These residues of cell content which are particularly to be found in the cells of the medullary rays, may be made visible by staining, and serve for the differentiation of soda and sulfite pulps. The residues are found even in bleached sulfite pulps and exist as aggregates or chains of small spherical elements. Their staining capacities depend on the presence of resin. With an aqueous alcoholic solution of Soudan III, with a little glycerin added, they are stained red; with zinc chloride-iodine solution, sulfur-yellow. In preparing the pulp for microscopic examination care must be taken to avoid dissolving the resin by the caustic soda. Medullary ray cells are so numerous that the presence of even 5 to 10 per cent of sulfite pulp in a mixture can thus be detected. For quantitative estimation of mixtures of sulfite and soda pulps a solution of rosaniline sulfate with a little alcohol and sulfuric acid is of service. The contents of the pitted pores are strongly stained in the case of the sulfite pulps, but not with soda pulps. The inner side of the fiber wall of sulfite pulp is more strongly dyed than the outer. In zinc chloride-iodine solution the sulfite fibers show a characteristic variation.

FERROMANGANESE MANUFACTURE IN SPAIN

There is a note in the *Boletin Oficial de Minas* by the engineer of the district of Vizcaya saying that for the refining of the 294,000 tons of steel produced, 3,000 tons of ferromanganese are required. The article formerly was imported from abroad, but the extraordinary rise in the price of this product from 312 pesetas per ton in the year 1913 to over 2,000 pesetas at present and the almost insuperable sea transport difficulties have made it indispensable to have it produced in Spain and the necessary furnaces and engineering plants have been provided for the purpose.

ELECTRIC LAMP INDUSTRY IN FRANCE

In a recent communication to the *Bulletin of the Société Interaationale des Electriciens*, Mr. A. Larnaude remarks that the present capacity of French glow-lamp factories amounts to 15–20 million lamps per annum, but this figure may be doubled in the near future. The tonnage required for the transport of material in this industry is small, as one ton of ore will provide sufficient material for 3,000,000 lamps. An important element in the manufacture of gas-filled lamps has been the production of argon required for the smaller types. This gas is now being made in considerable quantity by the process of Mr. Claude.

GERMAN ENTERPRISE IN THE UKRAINE

The firm of Krupp, says *Engineering*, is usually ready to step in where there appears to be a chance of a business worth doing. Its latest move is the formation of a concern with a capital of $5,000,000 and an additional guaranteed capital of $16,000,000 for the purpose of exploiting Ukraine industrially. A number of undertakings in the iron and steel industry in the machinery and electrical branch are also interested in the venture. At the same time, a number of banks and financiers have formed a syndicate for the exploitation of Ukraine financially and, it is added, in the matter of railway construction. The latter concern has so far a capital of only $1,000,000 and its works will, in the first instance, be confined to a close study of the country and the possibilities it offers. The fact that the two concerns have not joined hands has caused some surprise, but the reason is stated to be that the banks wanted a concern which comprised all industries and did not find it expedient to coöperate with one which only represented a limited number. The two undertakings are understood not to clash in their Ukraine ventures.

ANNEALING ALUMINUM

At a recent meeting of the Institute of Metals held in London, Mr. R. J. Anderson, in a paper on the above subject, urged consideration of the possibility of abbreviated exposure at various temperatures being able to confer workable properties upon cold-rolled aluminum sheet, with less fuel, in a shorter time, and with a smaller percentage of defectives in subsequent drawing. He gave particulars of a number of experiments in which various gauges of cold-rolled aluminum sheet were exposed for three minutes at a series of temperatures varying from 400° to 500° C. He concluded that exposure to 370° C. for 24 hrs., as is usual in commercial mill practice, is unnecessary, and that the lighter gauges can be softened by such an abbreviated exposure as three minutes at 400° C. He stated that tests in the mill have demonstrated that aluminum softened by short exposures to heat fulfils the draw-press requirements and that the percentage of defective shapes is smaller than with similar metal annealed for, say, 24 hrs. at 370° C. In the manipulation of certain shapes by the draw-press the sheet is ordinarily cut into circles or other geometric patterns and annealed before being drawn and, in one instance, the number of defective shapes was observed to be 30 per cent out of 4,400 blanks drawn, the metal having been annealed by long exposure. As a test of the effectiveness of long annealing, 200 cold-rolled No. 22-gauge circles were annealed for three minutes at 475° and drawn by a typical draw-press operation into a given shape; only one defective shape resulted from rupture in the press, or a scrap loss of 0.5 per cent. Other tests on sheets of various gauges which had been annealed for relatively short times, ranging from 5 to 60 min., gave scrap losses of less than one per cent in all cases. He pointed out, that, if the annealing can be effected by relatively short exposures, a continuous annealing furnace for aluminum becomes possible, provided certain minor details can be overcome.

TANNING MATERIAL IN GERMANY

The German Government, according to the *Chemical Trade Journal*, is offering prizes for the solution of the following three problems:

(1) A method for the currying and dressing of leather without the use of cod oil and other fish oils, as these oils are almost unobtainable.

(2) A substitute for chrome salts for the production of leather of the nature of chrome-tanned leather, also a substitute for the production of leather by means of other mineral salts or mineral salts combined with vegetable material which will produce a leather similar to combination-tanned leather.

(3) A method that can be used during the war which will result in a saving of vegetable tanning material without affecting the quality of the leather so produced.

A first prize of $5,000 and a second prize of $1,250 are offered in these cases. The offer is an indication that Germany is badly suffering from a lack of fish oils and grease for stuffing leather and from a shortage of chrome salts and vegetable tanning materials. The judges include Prof. E. Fischer, Dr. Fahrion, the oil chemist, Prof. Paeffler, a leather trade chemist, and five tanners.

JAPANESE CAMPHOR

The manufacture of camphor in Japan proper and Formosa during the fiscal year ending March 31, 1918, amounted to 10,678,800 lbs., of which 10,362,000 lbs. were sold by the camphor monopoly office. The latter figure shows a decrease of 4,989,600 lbs., as compared with the preceding year. The monopoly office has received many offers from Europe and America, but is unable to execute all because of the growing demand for camphor on the domestic market. Of 10,362,000 lbs. sold by the monopoly office, 4,276,800 lbs. were supplied to camphor manufacturing companies, 831,600 lbs. to celluloid companies, while 343,200 lbs. were placed on the market. The remainder, 4,910,400 lbs., were shipped abroad. The authorities, says the *Chemical Trade Journal*, are now encouraging the export of manufactured goods and preventing the shipment of camphor as far as possible.

NICKEL STEEL

In a recent issue of the *Elektrotechnische Zeitschrift* it is stated that the magnetic properties of nickel steel caused it to be used by the German navy for the construction of parts of ships near to the compass in order to prevent variable effects on the compass field. It has, however, recently been stated in the same journal that this use of nickel steel is by no means new and, in fact, is a very costly method of obtaining good compass fields. On this account the method has been almost completely discontinued. The compasses are now almost entirely gyroscopic. The use of this type of compass has the further advantage of saving large quantities of nickel which is so expensive and difficult to obtain.

GAS-FIRED BRAZING TABLE

A self-contained, gas-fired brazing table designed by the Davis Furnace Company, Luton, England, especially for the aeroplane industry and certain toolmakers' work, has a firebrick table 3 ft. 10 in. by 1 ft. 6 in., mounted on a strong cast iron stand. There are two blowpipes, 19 in. long with $^7/_{16}$ in. nozzles and 1 in. heads, each swivel-mounted on a vertical pillar with suitable adjustment for height. For lateral adjustment the pillars slide along a machined bar of square section fixed horizontally along the front of the table. The air-blast is provided by a high pressure blower mounted on a shelf below the table and driven by belt or by electric motor. The gas and air are conveyed to the blowpipe by flexible metallic tubes, each with its separate main control cock.

A CHINESE PERFUME PLANT

The plant locally known as Lang-rhoa (*Cymbidium ensifolium*), one of the finest orchids known, is regarded in China as the queen of flowers. An account of its cultivation has recently been published by Yang-Tsen Kia, as its scent is so exquisite that it holds great possibilities for the perfume industry. So valued is this plant that the greatest care and attention are devoted to its cultivation. Each plant is grown in a separate pot, the temperature during the day being maintained at 17° to 20° C. and during the night at 12° to 14° C. Ventilation must be abundant and only rain water used for watering. The perfume is very powerful and very sweet and it is possible that the essential oil may be distilled from the plant, when it would become available to European perfumers.

THE SCHOOP METAL-SPRAYING PROCESS

From Zurich comes the news of considerable improvement in the Schoop spraying process, says *Engineering*. Instead of melting the metal, which is generally applied in the shape of wire by the oxyhydrogen flame or the blow-pipe, electric fusion is now used and is said to be both simpler and cheaper. The pistol apparatus is used as before, but two ends of the wire are placed in the pistol instead of one and they are approached to one another as electrodes of an electric circuit. When the arc strikes, the wire fuses and the air current tears the fine metallic particles away. Zinc sprays in particular have been produced in this way, according to an article in *Z. angew. Chem.* The electric heating may be simple, but the prevention of the oxidation of the sprayed metal will probably be as difficult as before.

NEW SOURCE OF ALCOHOL

Among the substitutes for fibrous material to which German manufacturers have been compelled to have resource is the black millet (*Sorghum vulgare*). It has found a place in paper making and it is now suggested as a material for the production of alcohol. The food value of the grain is high, between that of peas and lentils, so that its cultivation, which costs no more than that of wheat or rye, is recommended to the farmer on the ground of its being a paying crop. If the straw be used as a source of cellulose or of alcohol, the crop becomes doubly valuable.

BICHROMATE MANUFACTURE IN SWEDEN

The British Commissioner at Stockholm reports that a large new factory has just been started at Malmo for the production of bichromate, chrome alum, and other chromium salts. The undertaking has been financed by Swedish and Danish interests and the proposed scale of operation is sufficiently great to render importation of these materials unnecessary. Hitherto these have been imported from Germany and the United Kingdom to the value of $1,220,000 per annum.

BEECHNUT OIL IN THE NETHERLANDS

The Dutch Minister of Agriculture, Industry and Commerce plans to increase the supply of edible oils in the Netherlands by using the domestic beechnut crop. He estimates that between 2000 and 2500 metric tons of these nuts can be collected and that this amount of raw nuts will yield 300,000 to 400,000 kilos of oil, a valuable addition to the dwindling stocks of edible oils in the Netherlands. The *Zulphen Gazette* reports that school children are to be used to gather the nuts. Owners of private lands on which beechnuts are gathered will receive 5 per cent of the sums paid to the gatherers and will have the right to purchase cattle cake prepared from the pulp of the nuts from their own property.

SCIENTIFIC SOCIETIES

FRENCH SECTION, AMERICAN CHEMICAL SOCIETY

Chemical Warfare Service
A. P. O. No. 717, American E. F.
October 21, 1918

DEAR DOCTOR HERTY:

I know that the members of the AMERICAN CHEMICAL SOCIETY will be interested in the following communication from Prof. V. Grignard. The letter is self-explanatory.

Ministere de l'Armement
et des Fabrications de Guerre

Inspection des Études
et Expériences Chimiques

Paris, September 28, 1918

MY DEAR COLONEL:

Allow me to acknowledge with thanks the receipt of the documents which you sent to my laboratory: Doctor Parsons' letter to you, including membership blanks for the AMERICAN CHEMICAL SOCIETY, and the charter which was granted by that Society for the formation of a French Section.

I can assure you that French chemists will welcome the opportunity to cultivate advantageous relations with their American colleagues, and I am convinced that the French Section of the A. C. S. will shortly become a worthy complement to the American Section of the Société de Chimie Industrielle.

I feel deeply honored by the privilege of transmitting the charter to the new Section, and I shall do everything in my power to further this matter.

With sincere regards, believe me to be,

Most cordially yours,

V. GRIGNARD, *Directeur*

LABORATOIRE CHIMIQUE MILITAIRE DE LA SORBONNE 1

We are all extremely busy just now, but arrangements have been made whereby the French Section of the AMERICAN CHEMICAL SOCIETY will be formally organized.

Our colleagues at home will also appreciate this note from M. Landowski, President of the Société des Chimistes Français, of which the General Secretary is M. Arpin, and the Treasurer, G. Sellier.

SOCIÉTÉ DES CHIMISTES FRANÇAIS

Paris, July 4, 1918

COLONEL:

At this solemn hour, when all France, as a single soul, proclaims her eternal gratitude to the Sister Republic whose citizens have unanimously responded to the call of their immortal President by coming to the aid of Right and Liberty, the Société des Chimistes Français, recognizing the importance of the rôle played by chemists in the liberation of the world, wishes to transmit, through the Chief of the Chemical Warfare Service of the American Army, fraternal greetings and an expression of its admiration for all American chemists who have placed their learning and their lives at the service of liberty

Receive, Colonel, the assurance of my very highest regards,

The President,

H. LANDOWSKI

With kindest regards from Major Hamor and myself,

Cordially yours,

R. P. BACON, *Colonel*, C. W. S.
Chief of Technical Division

IOTA SIGMA PI

The first national convention of the Iota Sigma Pi, an honorary chemical society for women, was held at the University of Nebraska, Lincoln, Nebraska, in the new Chemistry Hall, just opened. Five of the eight chapters which constitute the fraternity at present were represented by delegates.

The object of the Society is not to take the place of Sigma Xi, AMERICAN CHEMICAL SOCIETY, or any other organization, but is to foster and stimulate interest in chemistry among college women and to advance the standard of personal accomplishment in chemical fields, thus making the work of women in science more effective.

The spirit of the society may perhaps be best illustrated by quoting a few suggestions made by the National Convention:

1—In view of the present emergency, the Convention recommends that every member of Iota Sigma Pi encourage all young women to train themselves for scientific work.

2—In order to further the ideals of this organization the Convention recommends that every member, as soon as she is able, join the AMERICAN CHEMICAL SOCIETY.

The national officers elected were as follows:

President: Mary L. Fossler, Nitrogen Chapter, University of Nebraska.
Vice President: Miriam E. Simpson, Hydrogen Chapter, University of California.
Secretary: Edith Hindman, Oxygen Chapter, University of Washington.
Treasurer: Icie Macey, Tungsten Chapter, University of Colorado.
Editor: Helen Keith, Iodine Chapter, University of Illinois.

A directory of the Society is in the process of preparation and will be sent out to each Chapter when completed. Bulletins will also be sent out from time to time by the Editor.

SOCIETY OF CHEMICAL INDUSTRY NEW YORK SECTION

At the meeting held in Rumford Hall on Friday evening, October 25, 1918, Major W. H. Dudley of the British-American Anti-Gas Liaison Office spoke on "Gas Warfare both Offensive and Defensive." Having already printed the address of S. J. M. Auld on "Methods of Gas Warfare,"[1] covering more or less the same ground, we do not give Major Dudley's address in full; but because of the interest of the explanations they contain, his introductory remarks are given here..

It is now a matter of common knowledge that the Germans introduced the use of asphyxiating gases in warfare by launching clouds of chlorine gas against the unsuspecting and unprepared Allies in the neighborhood of Ypres on April 22, 1915. In spite of this well-established fact they have from time to time attempted to saddle the Allies with the responsibility of having started this latest horror of modern warfare. On July 17, 1918, their official wireless sent out a communiqué to this end. This wireless message stated that "the idea of using poison gas originated with the British Admiral Dundonald."

The Admiral Dundonald to whom reference is here made is probably an Admiral of that name who was born in 1775 and died in 1860. He was a man of considerable chemical knowledge and warned the British Government of that date that it might be possible to employ asphyxiating gases in warfare. This possibility has, of course, been known to all the Great Powers, and because of this knowledge the Hague Convention of 1899 expressly forbade the use of gas. It remained for Germany deliberatcly to violate this stipulation in the early stages of the present war.

The German wireless message further states that "poison gases were first used in the war on March 1, 1915, by the British and French, whereas the French and British Army could not announce a German attack with poison gas until April 24, 1915." (The attack actually took place on April 22, 1915.) This statement is a deliberate lie and will not bear examination. It would mean that in a period of about eight weeks the Germans developed sufficient material in organization to carry out an extensive gas attack. This is an absolute impossibility.

The best answer to this typical German falsehood is given in the words of Lord French, who, as Commander in Chief of the British Army at the time, in his report of May 3, 1915, stated as follows: "A week before the Germans used this method (gas attack) they announced in their official communiqué that we were making use of asphyxiating gases. At that time there appeared to be no reason for this astounding falsehood but

[1] THIS JOURNAL, 10 (1918), 297

now, of course, it is obvious that it was part of the scheme. It shows that they recognized its illegality and were anxious to forestall neutral and possibly domestic criticism."

It is interesting to realize that as late as July of this year the Germans should still be attempting in a most unscrupulous way to place the responsibility of initiating gas warfare to the account of the British and French.

At this meeting the Section unanimously adopted the following resolution:

WHEREAS, for many years the German Government has fostered the chemical and other "key industries" with the object of reducing other nations to dependency upon her, and at the same time rendering herself independent of others, and establishing industries which in time of war would give her an enormous advantage over those she was planning to attack and rob; and

WHEREAS, from the very beginning of her outrageous attack upon the civilized nations of the world, Germany has pursued a deliberately organized course, having for its object the permanent economic injury or destruction of other countries who had been her competitors in the world markets; and

WHEREAS, in pursuance of this course Germany has deliberately

First: Stolen and carried away whatever machinery she could;

Second: Destroyed whatever machinery and property she could not steal or carry away;

Third: Deported or destroyed communities of skilled artisans;

Fourth: Murdered or by studied brutal ill treatment permanently injured prisoners of war and innocent civilians, so as to deprive their countries of their skill and labor; and

WHEREAS, it is essential that the allied civilized nations must, as a matter of self-protection, render Germany impotent to do further harm from a commercial as well as from a military standpoint, and prevent her, although defeated on the field of battle, from reaping a commercial triumph as the result of her deliberate wickedness above referred to;

Therefore be it Resolved, that the New York Section of the Society of Chemical Industry requests that the proper authorities of the various allied governments take special note of the above facts, and insist that Germany, where possible, be compelled to restore the stolen machinery and other property, or replace the stolen property and also whatever machinery or property has been destroyed by equivalent machinery or property taken from German factories; and that they furthermore see to it that all allied industries are fairly and justly safeguarded under the ultimate terms of peace, against the machinations of an insidious and conscienceless enemy, whose express intention is to reduce other nations to industrial subservience and dependence.

NOTES AND CORRESPONDENCE

AN OPPORTUNITY TO HELP THE FRENCH

A communication has been received from the chairman of the American Ouvroir Funds, 681 Fifth Avenue, New York City, asking the AMERICAN CHEMICAL SOCIETY to interest itself in securing among our members the "adoption" of children whose fathers were technical men and who have been orphaned by the death of their fathers, graduates of l'École Polytechnique who have fallen at the front.

In using the word "adoption" it is not, of course, intended to bring the children to this country and immediately adopt them, but to help the officers' widows educate their children and bring them up as nearly as possible as would have been done had their fathers lived. L'École Polytechnique has among its graduates some of the most illustrious, brilliant, and educated men in the French Army. Many of them were poor and are among those whose families now most need help. Although America has lost many men on the French front, they have, with few exceptions, been young men without dependents; so that we shall not realize in our own country the great need which has come to France where the families in many cases have been left entirely dependent.

The American Ouvroir Funds will be glad to submit to any responsible man or woman who requests it, a selection of histories of these technical graduates, with photographs of the war orphans, the citations of their fathers, their addresses, and all the facts which may be of interest to anyone who may "adopt" them. "Adoption" means an annual expenditure of from $100 to $250 a year, according to the circumstances of the family whose child is "adopted." Such expenditure will insure board, lodging, and education for a child whose father has been killed in the war.

The following is taken from a communication sent to the Secretary by the American Ouvroir Funds:

SAVING CHILDREN FOR THE FRANCE OF TO-MORROW

In the midst of the overtaxing burdens of war, men and women of France, with international reputations for achievement and character, have found a way, in spite of the thousands of orphaned children, to give a personal accounting of individual cases. These men and women are associated with various French Societies long established for the care of orphans.

The American Ouvroir Funds as the chosen link with America of these well-established organizations in France, stands for the French idea of personal service and contact. It asks for a definite sum for an individual orphan, whose story one may have, whose photograph may be seen, to whom one may write, from whom letters will be received. No personal gift contributed as an individual fund through the American Ouvroir Funds is lost in the great melting pot of war benevolence. It goes straight from you, bearing your message of sympathy, and brings directly back to you a warm response from the heart of a child or its mother. What a glorious privilege for us to be able to help preserve to these children their precious heritage; to give as nearly as possible to them the same chance for environment and education that would have been theirs had their fathers lived. We give with some understanding of the varying individualities and circumstances of the orphaned children.

Our aim is not just to clothe and feed a quantity, but to preserve to France, the children of the men who in every rank of life represented what was most noble, most worthy, and most high-minded in their country.

We reward a brave soldier who has died fighting for the cause of individual liberty, of America as well as of France, by giving the aid that is necessary to keep his child out of an institution and under the protection of the mother or some loving guardian; to be brought up in his own faith and to the same opportunities that would have been his had the free life of France been uninterrupted by war.

France asks nothing of the world. She fights, has fought from the beginning of this war, with her eyes to the front, her head lifted proudly in the assurance of the righteousness of her cause. She says nothing of what she has endured, utters no outcry for the needs of her people. France is proud. But we who look on must see those scars, must see the needs of her orphaned children, and, since she is fighting for America's cause also, they should be as our orphans.

We owe it to her that her children at least should not suffer, should not lose, as the result of their father's sacrifice, one jot of that individuality, that freedom, which is the priceless heritage of their country.

The above was brought before the Advisory Board of the AMERICAN CHEMICAL SOCIETY at its recent meeting in New York. The Secretary was instructed to inform the members through THIS JOURNAL. "Adoption" can be made by a number of individuals as well as by one individual, if necessary.

President and Mrs. Nichols have "adopted" the first two, a boy and a girl. Four others are promised. You will be put in personal touch with the child you "adopt."

Many American citizens, both men and women, have welcomed the opportunity thus offered to relieve in some measure the burden of the war that has fallen on the women and children of France. The informal "adoption" of one or more of these little children entails no obligation other than a contribution to the child's maintenance for one year.

It puts the adopter into immediate personal relations with

a French family, and brings the joy of helping a little child to become a worthy citizen of France.

The several French Societies transmit the full amount received for the children, without deduction for expenses or cost of any kind.

Local sections will please take up this matter. Members may send to the Secretary, who will either choose for them or secure the photographs of the children and history of the family helped.

CHARLES L. PARSONS, *Secretary*

NEW AFTER-WAR PREPARATIONS IN THE CHEMICAL INDUSTRY OF GERMANY[1]

THE AGREEMENT BETWEEN THE DYESTUFF TRUST AND THE CARTEL OF EXPLOSIVES. REDUCTION OF THE TAX ON WAR PROFITS IN FAVOR OF PRODUCTS MANUFACTURED FOR EXPORT. THE NEED FOR AN INTERALLIED TECHNICAL ORGANIZATION.

The organization which has been called the German Dyestuff Trust is already old; but recently its development has been completed by an agreement with the Cartel of Powders and Explosives. This latter, before the war, was controlled by the Nobel Trust Co. of London, but at the end of 1915 elimination of the English company was effected by an exchange of the German shares which it owned for English stock held by German firms. The Cartel of Powders and Explosives then comprised only houses of German nationality whose nominal capital represented a total of about 100 million marks. At the present moment, however, the financial strength of the group is considerably greater; the profits made, the reserves established, and the enlargement of plants are all proofs. In fact, during the war, such factories as the Bayer and Badische have produced almost exclusively explosives, gases, and acids, and these have been furnished as raw materials to companies manufacturing powders and explosives. Hence the two cartels which have concluded an agreement have an output of very similar products. There is no doubt that the installations made and developed for the manufacture of explosives, gases, and munitions will be maintained as they are, ready to function from the start of the next war. Therein lies an urgent counsel of M. Rathenau, and German technicians declare on every occasion that never before did they begin a war with such an inferior industrial organization, that it is necessary to be better prepared for the next one—a provision for the future which will not prevent them from employing, in the meantime, the factories and materials in the manufacture of chemical and pharmaceutical products, synthetic perfumes, etc. Thus, the aim and object of the organization of the Dyestuff Trust is to give its directors the mastery of trade, domestic and foreign; it is to preserve this that the Trust has concluded an agreement with the Cartel of Explosives.

Accordingly there is now in Germany a single concern selling dyestuffs, chemical and pharmaceutical products, a single purchaser of prime materials for these industries, and this Trust is already assured of the ownership or control of several lignite mines of importance. This concentration should permit the reduction to a minimum of the cost price and the fixing of export sales prices at a figure which will enable products to pass over tariff barriers. Preparations for beginning exports when hostilities have ceased are complete, reaching the point where the merchandise is already packed and labelled, either in French or English, while catalogues in both languages have already been printed.

But the efforts made in Great Britain and France to establish and develop the dye industry and manufacture of organic products, the rapid and unexpected development of this industry in the United States and in Switzerland, have caused a feeling of uneasiness in the Trust, and also, in the Imperial Government, which considers dyes to be one of its best economic weapons. Even those who rely on a free trade restocking Germany with raw materials, in view even of guarantees in this respect in the future treaty of peace, even these men cannot be ignorant of the fact that in many foreign countries German products will meet with hostility which no text of treaty will be able to prevent. Hence they proclaim the necessity of still greater production and at a lower price. The particular interest which the Imperial Government takes in the dye industry has probably still another cause due to the knowledge that it has become the stockholder and associate of the great companies such as the Bayer, the Badische, etc.

When it became necessary to enlarge the existing works and to establish new factories equal to the task of making munition of war, the State made the considerable advances of money required, because the times were pressing, and it was impossible to think of increasing the capital of the companies. At the end of 1917, the majority of the firms belonging to the Trust had increased the capital of their concerns 150 million marks in round figures, the flotation of the new stock to take effect January 1, 1918. It is to be noted, however, that the Bayer and Badische companies each asked for the listing on the Berlin stock exchange of 18 millions of new stock and not 36 millions, the amount actually issued. Similarly, the Gesellschaft für Anilinfabriken issued 12 millions and asked for the listing of only 5.8 million marks. In view of the debt contracted by these companies with the State and the zeal of the latter for the interests of the public treasury, the natural conclusion is that the repaying of the sums advanced by the Empire was effected by remittance of new stock, which, of course, was not admitted to dealings on the Bourse. The result is that the Empire has made an excellent investment (the last dividend of the Badische was 25 per cent), it will be represented on the boards of directors, and becomes directly interested in the prosperity of these companies. They are now certain that all the powers of the government will be exerted in their favor.

The first result of this association is that, from this moment the Imperial Government will grant the remittance of a large part of the tax on war profits to the manufacturers of dyestuffs and chemical and pharmaceutical products which are actually being made for export as soon as hostilities have ceased.

Under such conditions the chemical industry of the enemy will be in a position to produce merchandise of various kinds at a price which costs the manufacturers nothing. From the first day of peace they will export this merchandise and will be able to deliver it in Great Britain, France, Switzerland, Italy, and the United States at a price which will not represent even the customs duties, however high, imposed by these different countries. The budding industries of the Entente nations will thus be placed in a position in which it is impossible to live, and their competition so much feared by the enemy will be killed in the germ. The Germany monopoly once reconstituted and become definite in aim, cost prices which are remunerative will be fixed, and the products of its chemical industry will again serve as excellent articles of "compensation" to obtain favorable treatment for other merchandise.

We must not deceive ourselves as to the grave danger presented by this Machiavellian combination, especially for France, Great Britain, and Italy, for in Switzerland and in the United States the dyestuff industry is more developed, while the United States possesses raw materials as compensation, such as copper and cotton, which will afford the means of an economic struggle. But in France and Great Britain it is scarcely likely that manufacturers will be in a position to supply the necessary dyes and pharmaceutical products when peace is made. Industries which utilize dyestuffs will find themselves in the presence of German offers, ready for delivery at an extremely low price, whereas British and French firms will have, in the case of many articles of manufacture, only promises or very high prices. It is more

[1] Translation of an article in *Chimie et Industrie* for June 1, 1918.

than doubtful whether a considerable number of these consumers will postpone business activity until the moment when they will be able to obtain the products of national industry. In every way all possibility of exportation will be extinguished, Germany having recaptured her clientele in every country where chemical industry has not been solidly established.

In France and Great Britain men are strongly individualistic and opposed to concentrations of industry; we talk readily of good relations between commercial houses or the laboratories, but the bonds between factories remain loose for the most part, and those between companies belonging to different countries are far more relaxed. In face of the German Trust which, thanks to its organization, can sell at any price whatever, it is to be feared that there are concerns of more or less financial strength, several of which will manufacture the same article and will perhaps compete with each other while other articles of merchandise will be lacking. In this case tariffs are not a remedy, for duties, however high, will be powerless to prevent the penetration of articles which the Germans will be able to sell at an insignificant price and which cannot be supplied by other countries. We wish to point out that, in relying on high tariffs, we may be mistaken, while their establishment against neutrals will raise grave difficulties. It is well known that, for this reason, the intervention of neutrals is part of the German program.

Does this mean that we must be resigned, or expect everything from the prohibition of imports of enemy chemical products? Certainly not, but it is necessary to resort to energetic measures, however rigorous they may appear to our habits of independence and liberty.

The first thing to realize is the methodical re-allotment of labor and the specialization of manufactures in the countries of the Entente. For this purpose it would suffice if, in these countries, the entire group of corporations which manufacture dyestuffs, pharmaceutical products and derivatives were in agreement to accept a central committee of technical directors. This committee, knowing the needs of each country and versed in the material and technical resources of its works and factories, would introduce a special organization into each, of such a kind that each product would be manufactured by one or two works, which would permit the most economical production and an output nearest to the centers of demand. The same technical committee would effect likewise a specialization of the munition factories before they are used for after-war purposes. Under these conditions the business and administrative freedom of all these companies would remain untouched, but the technical direction would be the work of one board—a system which implies the minimum of interference with the life of the most individualistic of concerns. The technical committee would all be experts trained to receive the communication of researches made in the laboratories and to indicate those which appear to them useful. It would seem that with such an organization our manufacturers might arrive at a point where they could make themselves independent of Germany in the matter of nearly all the products which she counts upon supplying at the end of hostilities, either directly or by the intermediary of a borrowed neutral name. Then custom duties might be raised until they reached a prohibitive level.

Measures of this order certainly constitute an assault on the independence of corporations, but it must not be forgotten that it is a question of life or death for our infant chemical industry; it was permissible, in a rigorous sense, to hope for success in face of the German trust, but before the perspective of a combine which will permit the enemy to make a pretense of renouncing dumping, under the guise of selling for almost nothing, the struggle of isolated industries becomes impossible, and hence a technical organization is a necessity, we may even say, a duty.

R. Petit

Professor of the Faculty of Sciences of Nancy

THE AMERICAN DYESTUFF INDUSTRY AND ITS PROSPECTS[1]

With the advent of 1918 the American chemical works, and especially the dyestuff factories, were confronted with numerous problems. Owing to the requirements of home and Allied industries they found themselves in a difficult position, for, despite all promises, they were not able to command a sufficient, nor even a moderately satisfactory supply of the most important fundamental materials. Americans, induced by the promises of company promoters, and with an eye to great expansion of the markets, have invested, since the outbreak of the war, about 225 million dollars in dye works, and yet, as they expressly give out, have produced only dyes which hitherto have been made only in Germany. How much of this vast sum has been actually paid in, it is not possible to judge, but it may be admitted that the companies are very much "watered." In order to provide security for this capital, those interested clamor for a protective tariff, by which, after the war, they are to be preserved from a destroying competition. The interested circles point out that war requirements have diminished stocks of raw materials throughout the world, so that the prices of dyestuffs and technical chemicals even after the war will hold at an abnormal figure. The same circles trot out the old fable according to which Germany has accumulated important quantities of dyestuffs and chemicals with which to inundate the world's markets after the war. Experts, however, with keener insight, do not support this view, suspecting that Germany herself has experienced a certain shortage of raw materials for this purpose. The greatest concern of the American producer is the fear that, after the war, Germany will purchase large quantities of raw materials in the United States. Although the industry has a specious appearance, as if some of the leading factories had achieved a fair amount of success in making some products, the position of a portion of the industry is regarded as insecure, and even as distinctly a hazard. A feeling of decided irritation was observable when the Government in 1917 commandeered all supplies of methyl alcohol at a fixed price, since methyl alcohol forms the basis of many dyestuffs. At the same time the Government took over the entire output of toluol, and all gas companies were required to set up ovens for the preparation of tar products. In spite of the efforts of the dye manufacturers, consumers complain that the prices of dyes are still very unfairly differentiated from those existing before the war. In addition to this, the quality of the dyes, in the judgment of the textile industry, leaves much to be desired; the textile products, especially for military purposes, are not satisfactory, as their fastness to light and water is uncertain.

The general opinion is that, *so long as no foreign competition breaks down its development*, the American dye industry may well be in a position to satisfy a demand restricted by defects of quality and fastness. But in its present proportions the American industry has not grown up to the demands of fashion and of other individual consumers, so that its development in 1918 will run in the grooves of the past year, and this means that only staple dyes without much variety will be produced.

[1] Translation of an article reprinted in the *Zeitschrift fur angewandte Chemie*, March 19, 1918, from the *Norddeutsche Allgemeine Zeitung*.

THE JOURNALS OF THE AMERICAN CHEMICAL SOCIETY

Editor of the Journal of Industrial and Engineering Chemistry:

It has often occurred to the writer that the journals of the American Chemical Society show a peculiar dissimilarity in the headings of the solid pages of reading matter, and might possibly with slight changes be made a little more convenient for one using them in reference. Presumably the present arrangement follows custom or precedent and is designed to

give a balanced and neat appearance to the page, but probably none of us will mind sacrificing a little in this respect, if necessary, if there is a compensating advantage in using the journals.

The *Journal of Industrial and Engineering Chemistry* carries on the left-hand page of reading matter its own name, the volume, and number; on the right, the date and its name again. The *Journal of the American Chemical Society* has on the left the name of the author, and on the right the subject of the article. *Chemical Abstracts* has the name of the journal on the left and the branch of chemistry on the right.

Without going too far into specific suggestions, the writer would like to see the headings of the pages arranged so that one can get as far as possible the references without, for example, turning back to the front cover to find the volume number each time, and then perhaps having to translate a Roman numeral. There is little difference in looking up one or two references, but for a larger number it is distinctly easier to use the *Journal of Industrial and Engineering Chemistry* than either of the others. Even the addition of the volume number to the pages of the other two journals would be a real convenience. Without expanding too far, the point to be emphasized is the rather strange dissimilarity of headings, each of which has a part, but only a part, of the essential data used in index or reference work. Could we not with little effort modify our headings to fall in with the present spirit of efficiency and at the same time answer all the practical and esthetic requirements of the printed page?

CHAS. F. GOLDTHWAIT

WEST DULUTH, MINN.
October, 28, 1918

THEFT OF PLATINUM

The following notice has been sent us by Mr. G. D. Buckner, chemist of the Kentucky Agricultural Experiment Station:

$100 00 REWARD

For the recovery of the platinum dishes and crucibles answering the following descriptions stolen from the Kentucky Agricultural Experiment Station, Lexington, Kentucky, during the week following October 17, 1918, or for information leading to the conviction of the thief:

Platinum Dish No.	Weight Grams	Platinum Crucible No.	Weight Grams
2	11.9750	1	46.4689
3	11.9703	11	32.5709
10	16.0273	12	33.0927
13	8.4319	14	49.1097
18	15.8232	15	48.6788
22	15.7905	20	48.5347
26	15.7580	22	48.3856
	18.9421	23	47.2223

The urgent need for this material at this time deserves your earnest effort and coöperation in its recovery. Address J. J. Reagan, Chief of Police, Lexington, Ky.

CHEMICALS FOR RESEARCH WORK

Editor of the Journal of Industrial and Engineering Chemistry:

In your issue of August 1 you were good enough to insert a letter announcing that the Research Laboratory of the Eastman Kodak Company were undertaking the preparation of chemicals for research work, and asking the coöperation of the manufacturers of intermediate products and of organic chemists either in the industries or the universities who were preparing materials which might be of use to others or who had need of organic reagents. As a result of that letter and of the endorsement of the sections of organic and industrial chemistry at the Cleveland meeting of the AMERICAN CHEMICAL SOCIETY we have received a great deal of assistance and feel most grateful to the chemists of the United States for the hearty response which they have given to our request. The manufacturing concerns have proved willing to supply us with the various raw materials and intermediates which they produce, and a considerable number of university and other research chemists have written to us offering their assistance in preparations.

A special department of the Research Laboratory has now been established under the name of the "Department of Synthetic Chemistry," and has been staffed with women chemists, who are proving most enthusiastic and capable in this work.

Up to the present time we have not found it possible to issue a list of the chemicals which are available, though a considerable number are now in stock on our shelves. The University of Illinois has supplied us with the chemicals which it prepares. We have already obtained a few from other sources. We have prepared a number of new reagents ourselves, and we are engaged in the purification of a number of intermediates, some of which are purified with ease, while in the case of others the process of purification is proving extremely difficult and expensive. We hope to issue our first price list of chemicals by the first of December and shall be glad to receive applications for copies of this price list when issued. At first it will probably be necessary to issue new price lists monthly, adding reagents as they become available.

It is our purpose to stock chemicals eventually of three grades of purity. The first class will embrace chemicals only of the highest purity which it is possible to obtain, and we propose to distinguish these by the name of "Eastman" chemicals. In our first list we shall include chiefly these chemicals of the highest purity, since the supply of these appears to be most urgent. The second class will be prepared of the purity necessary for the greater number of synthetic organic preparations. The amount of purification which the technical product must undergo will depend both on the technical product and on the reaction for which it is generally used, and the greatest care will be taken to see that the chemicals supplied under this class are really suitable for the purposes for which they are likely to be employed. We propose to state, as far as possible, their purity and the impurities which they contain. We shall distinguish these chemicals under the term of "Practical Synthetic" chemicals. The third class will consist of crude technical intermediates should there prove to be a demand for these, as we expect will be the case In Germany these technical intermediates have been supplied by the firms who supply chemical reagents and for many purposes it is advantageous for chemists to be able to obtain them in small quantities. We find that the makers of intermediates would prefer that we should retail them rather than fill orders for small quantities of these materials themselves. We shall designate these "Technical" chemicals. In some cases the "Practical" and "Technical" products will naturally be identical.

Unless there is great objection shown to the course, we propose to sell chemicals by metric weights only, listing them by the hundred grams and kilogram. We believe that this will meet with the approval of the majority of chemists, although up to the present almost all orders have come in for pounds. We have dealt with this by handling an order for 1 lb. as if it were for 500 grams. If our action in this is not endorsed by our prospective customers we shall be willing to alter it if necessary.

In this undertaking we regard ourselves primarily as serving the chemists of the United States and especially the members of the AMERICAN CHEMICAL SOCIETY, and we shall most heartily welcome any criticisms or suggestions.

C. E. K. MEES

RESEARCH LABORATORY
EASTMAN KODAK COMPANY
November 11, 1918

COOPERATION BETWEEN MANUFACTURERS AND UNIVERSITIES

Editor of the Journal of Industrial and Engineering Chemistry:

We are building up a collection of analyzed samples of raw materials and intermediate and finished products of our typical chemical industries, and expect to use these specimens as practical

material in our courses in quantitative and technical analysis.

It has been our experience that the work in analytical chemistry is greatly strengthened by the use of such material, but at present the time of most instructors is too occupied to devote the time necessary to make the analyses required to check the results of the students. The laboratories of many of our chemical manufacturers make such analyses as a matter of routine, and it would be a very helpful method of coöperation if they could turn over to us and to other universities laboratory samples together with their analytical data on the same. You have advocated a closer coöperation between the manufacturers and the universities and it appears to me that here is a chance for a definite service involving little extra work on the part of the works laboratory forces. Samples of one to two pounds are sufficient for a year's supply, and different samples of the same material are useful in diversifying the work of different students of the same class.

We shall be glad to pay the transportation charges. The standard samples issued by the Bureau of Standards are too expensive for general use and their range is too limited.

We shall be grateful for any aid you can give us in this matter and shall welcome any suggestions as to an efficient presentation in the proper quarters.

R. E. Oesper
Associate Professor of Analytical Chemistry
University of Cincinnati
Cincinnati, Ohio
October 15, 1918

INVENTION PROBLEMS

The Invention Section of the General Staff of the United States Army has submitted to the War Committee of Technical Societies a list of seven problems requiring scientific and inventive talent for solution. Problem V is of chemical interest and is reprinted here.

PYROTECHNIC SMOKE SIGNALS

It is desired to secure, if possible, a suitable chemical substitute for Red Saxony Arsenic now used for the manufacture of Yellow Smoke Signals. The characteristics of such a chemical are that it should produce the effect required, that it should be procurable in large quantities, and that it should be perfectly stable in combination with other chemicals, such as potassium chlorate. The effect desired is a rather deep orange-yellow. There is no objection to the use of dyes should these give the effect required and be procurable in large quantities at a reasonable price.

A suitable formula for a Red Smoke Signal is also a desideratum. The effect required is a pronounced and positive shade of red. As in the case of the Yellow Smoke Signal, chemicals composing it should be readily procurable and should be stable. Since, however, the requirements for this signal are considerably smaller than for the Yellow Smoke Signal a greater latitude may be allowed in selecting slightly less readily available and higher priced material for this signal.

The smoke signals outlined above are displayed from rockets, Very cartridges, Viven-Bessiere cartridges and 35 mm. cartridges. The rockets now used by our forces weigh about 2 lbs. with an approximate length of 18 in. The V-B, Very cartridges, and 35 mm. cartridges have an average length of about 6 in. with a diameter, respectively, of 2 in., 25 mm., and 35 mm. The V-B cartridges are thrown from the rifle grenade discharger, and the Very cartridges and 35 mm. cartridges from the 25 mm. signal pistols.

Should any person accredited by the Inventions Board become interested in the two pistols outlined above, this office would be very glad to give all the information in its possession.

It should be noted that Auramine has already been tried as a dye for the Yellow Smoke Signal and that Paratoner has been used in the Red Smoke Signal.

All communications regarding this matter should be addressed to Inventions Section, General Staff, Army War College, Washington, D. C., Attention of Captain Scott.

SAFETY OF TNT AS AN EXPLOSIVE

Editor of the Journal of Industrial and Engineering Chemistry:

There have been quite a few cases in this country where trinitrotoluol has exploded under conditions which would lead us to believe that it is not the safe explosive that it is ordinarily supposed to be in contradistinction to picric acid which is known to form rather unstable compounds with metals.

I would like to call attention to the fact that it is perfectly possible for trinitrotoluol to contain highly nitrated phenolic derivatives which could form salts with metals, thereby rendering the trinitrotoluol very much more subject to outside influences than if it were absolutely pure. I remember in the ordinary manufacture of nitrotoluol some ten years ago, we often isolated from our sodium carbonate wash liquors notable amounts of a red crystalline body which, at that time, I identified as a sodium salt of one of the nitrophenols.

In my reading, I recently came across a confirmation of this in *Berichte*, **18**, p. 2668, *et seq.*, in an article by Nolting and Forel on an investigation of the six isomeric xylidenes. In speaking of the formation of the nitrophenolic bodies in the nitration of xylols on page 2670, he says (free translation):

If one treats crude nitrotoluol, as obtained in the factory by nitration with mixed acid, with soda, a similar solution is obtained from which by sufficient concentration, a red and yellow mass of crystals separates. I have investigated and found that it consists of the sodium salts of the two dinitro cresols (the 1-methyl, 3,5-nitro, 4-hydroxy; and the 1-methyl, 3,5-nitro, 2-hydroxy derivatives), about $^4/_5$ being made up of the first mentioned. The dinitro cresols are formed, according to my idea, from cresol which can result during nitration by the oxidation of toluol by nitric acid or oxides of nitrogen. From the ordinarily formed 1,2,4- and 1,2,6-dinitro toluols, the above isomers cannot be formed. It might be possible that small amounts of 1,3,4,5- or 1,2,3,5-trinitrotoluols are formed which could go over, under the influence of alkali, into the corresponding dinitro cresols by replacement of the 2 or 4 nitro groups with hydroxyl, but this assumption seems to me to be improbable.

I am sending you this information for publication in the Journal as I believe it will be of considerable interest to all those manufacturing trinitrotoluol and that these facts will be certainly worth taking into consideration in the manufacture and handling of the material if they are not already clearly recognized.

Research Department
The Barrett Company
New York City
November 7, 1918.
J. M. Weiss

WOMEN IN THE CHEMICAL INDUSTRIES OF ENGLAND

The British Ministry of Munitions has issued a circular containing a list of processes in which women are successfully employed in connection with the following industries:

Charcoal	Oil Seed, Cake Feeding	Waste Bleaching
Chemical	Paper Making	Also in the Electrical
Distilling	Rubber	Trades as Trades-
Explosives	Salt	men's Laborers on
Gas	Soap	General Laboring
Mineral Oil Refining	Tar Distilling	Miscellaneous

Note—The possibility of employing female labor on some of the operations scheduled herein depends on local circumstances such as lay-out of plant, locality, type of labor available, etc.

The operations here scheduled may, in general terms, be classified as follows:

A—Simple laboring operations.

B—Operations requiring care, intelligence, and, or, resourcefulness.

C—Skilled operations.

D—Dangerous operations or operations requiring resistance to unpleasant conditions, *e. g.*, heat, dust, fumes, odor, etc.

The different sections of the chemical industry in which women are successfully employed, and the departments of each section, are as follows:

ACETONE
B—Tankhouse: Charging tanks with mash
B—Tankhouse: Blowing steam through vats
B—Tankhouse: Noting temperature of fermenting mash
A—Tankhouse: General laboring
B—Cooking house: Charging cookers with maize meal
A—General laboring

ALUM
A—General laboring

ALUMINUM SULFATE
A—General laboring

AMMONIA (concentrated) at Gas Works
B—All operations

ANILINE SALTS
A—General laboring

BARIUM CHLORATE
A—Assisting in concentration and crystallization
A—Chipping out crystals with chisel and hammer
A—Crushing, drying, and packing

BLEACH
B—Making up lute, making cell heads, cleaning up, oiling bearings in electrolysis house

BUTYL ALCOHOL
B—Attending mixer
B—Adding salt to alcohol
A—General laboring

CAUSTIC SODA
BD—Fusing caustic soda
BD—Ladling fused caustic soda from melting pots and casting into stick form
A—"Detaching," *i. e.*, breaking up caustic in cooling trays with hammer
BD—Packing powdered caustic; labelling tins
A—General laboring

ELECTROLYTIC PROCESSES
A—Making up lute
B—Making cell heads
B—Preparing cell diaphragms
B—Assisting in dismantling, repair, and assembly of cells
B—Attending cells
B—Attending switchboards
B—Regulating voltages
B—Recording switchboard readings

ETHER CAMPHOR
B—Final dressing and preparing of camphor tubes

FERTILIZERS
BD—Grinding slag in cake mill
BD—Grinding phosphate in Kent mill
AD—Mixing guano
A—General laboring

IODINE
A—Screening salt in extraction of iodine from kelp

LABORATORY
C—Research chemists
C—Routine testing
B—Laboratory attendants
C—Controlling chemical laboratory
C—Acting as chemist-in-charge
B—Assisting in making up culture-tubes
C—Mounting organisms on slides and noting their condition

MAGNESIUM SULFATE
B—Crushing magnesite
B—Charging dissolvers
B—Attending evaporators and crystallizing vats
B—Whizzing

MAGNESIUM CARBONATE
A—Discharging filter presses
B—Packing presses for moulding

MISCELLANEOUS
A—Helping on press for compressed sal ammoniac
B—Operating machine for tableting ammonium chloride
B—Control of acid circulation pumps
B—Assembling parts in drum-making shop
C—Control testing on plant
A—Feeding and attending dissolvers
B—Charging and discharging drying ovens
A—Assisting in repacking condensers and towers (ground work only)
B—Assisting in repairs to decomposers
B—Controlling valves for blowing liquids from vats

NITRIC ACID
A—Charging nitrate, attending and emptying rotary drier
B—Weighing charges of nitrate for stills
BD—Charging stills, luting manhole and pipe joints
B—Running on acid
BD—Firing still and controlling temperatures
B—Attending and greasing acid pumps

NITRIC ACID (*concluded*)
A—Breaking dumped niter cake, barrowing, and tipping into barge
A—Breaking up niter cake in cooling pans
C—Sampling and testing
AD—Filling, sealing, and packing carboys
BD—Working on Valentiner nitric acid still
A—General laboring

OLEUM
AB—Unloading pyrites, attending breaking machine
AB—Hauling broken pyrites, weighing charges of pyrites on sulfur
B—Charging and attending sulfur burners
C—Sampling and testing
AD—Grinding and calcining magnesium sulfate
B—Impregnating granulated anhydrous magnesium sulfate with platinum chloride
AD—Filling, sealing, and packing carboys
A—General laboring

PHENOL
A—Washing and stencilling drums
A—Unloading empty drums, testing, and stacking
A—General laboring

PHOSPHORUS
AD—Finishing
AD—Packing amorphous phosphorus

REFINED BICARBONATE OF SODA
A—General laboring

REFINED SODA CRYSTALS
A—Tipping soda ash into dissolvers
B—Cleaning filter presses
B—Filling, operating, and emptying centrifugal driers
A—Grading crystals
A—General laboring

RESPIRATORS
B—Operating press tools for stamping out frames on plates
B—Mechanically cleaning same
B—Dipping in acid
B—Nickel plating
B—Cleaning and polishing
B—Mounting with tapes and elastic bands
A—Packing

SILICA
A—Drying on open floors
A—Crushing and bagging

SILICATE OF SODA
A—General laboring

SODA ASH
A—Charging vats with black ash
A—General laboring
B—Taking distiller temperatures

SODIUM BISULFITE
BD—Dissolving sulfur dioxide in caustic soda
BD—Concentrating sodium bisulfite solution

SODIUM (METALLIC)
BD—Charging and dipping from electric furnaces

SODIUM SULFIDE
A—Stripping and breaking from detaching beds
A—General laboring

SULFUR
A—Melting crude sulfur
A—Breaking out sulfur from sulfur beds
A—Emptying sublimers, dressing flowers of sulfur
B—Preparing moulds for roll sulfur
A—Removing from moulds after casting
A—General laboring

SULFURIC ACID
A—Feeding and attending pyrites breaking machine
A—Sieving pyrites
B—Weighing out charges
B—Charging furnace (or burners)
C—Controlling valves on de-arsenicating plant
AD—Filling and sealing and packing carboys
C—Sampling and testing
BD—Coking Kessler concentrators
BD—Helping on cascade concentrators
BD—Operating Gaillard tower concentrators
B—Feeding Kessler producers, including winding and wheeling material
B—Pumping vitriol over Gay Lussac and Glover towers
B—Working iron oxide briquette plant
A—General laboring

TUNGSTEN
A—Crushing, sieving, and packing

WASTE ACIDS
BD—Operating denitration plant, all operations

ZINC DISTILLATION
B—Making fireclay moulds and condensers

TWO LETTERS ON EFFECT OF COAL ASH ON THE NATURE OF CEMENT MILL POTASH

Editor of the Journal of Industrial and Engineering Chemistry:

In a recent article by Messrs. Potter and Cheesman,[1] attention has been called to the fact that in some cases the coal used as fuel for the burning of cement carries sufficient potash to affect both the total amount of potash driven from the kiln and the nature or condition of the potash occurring in the resulting flue dust. The statement is made that the so-called "recombined potash," which has previously been assumed to be the result of a combination of the potash vapor and the floating coal-ash particles,[2] is only that potash held in the ash and originally contained in the coal, together with the undecomposed and insoluble potash contained in the dust or raw mix mechanically blown out of the kiln.

Investigations conducted in this laboratory by the writers, and at the factory of the Security Cement and Lime Company, in coöperation with Mr. Haff, chief chemist for that company, have led to conclusions which are at variance with those above set forth. As these questions may in some instances become very important in the future the following data are submitted so that they may form a part of the printed literature available to the cement mill chemist and engineer.

Coals from nine different cement plants, both in this and foreign countries, have been analyzed at this laboratory for ash and potash, with the following results:

No. of Plant	Location	Ash in Coal Per cent	K_2O in Ash Per cent	K_2O in Coal Per cent
1	Ohio	10.45	0.66	0.069
2	Maryland	9.23	1.43	0.132
3	Michigan	10.60	1.96	0.208
4	Michigan	14.55	1.90	0.276
5	Michigan	10.38	2.08	0.216
6	Michigan	17.75	4.64	0.824
7	Michigan	12.07	1.73	0.209
8	South America	19.65	0.71	0.140
9	New Zealand	11.02	0.89	0.098
AVERAGE		12.85	1.77	0.241

It will be noted that the highest potash content of the coals, represented by these nine samples, is equivalent to 0.82 per cent K_2O, while the average is equivalent to only 0.241 per cent K_2O. Ignoring the abnormally high potash sample marked No. 6, the average of the eight remaining samples becomes only 0.1687 per cent K_2O. On the other hand, the potash content of the resulting ash of the full nine samples is equivalent only to 1.77 per cent K_2O, and should we ignore sample No. 6, the average potash content of the ash becomes only 1.42 per cent K_2O. From this it would appear that the samples investigated by Messrs. Potter and Cheesman have an abnormally high potash content, particularly as determined by analysis of the ash.

The amount of coal consumed per barrel of cement burned varies greatly in the different mills throughout the country, and it is very difficult to strike an average. As indicated in Messrs. Potter and Cheesman's article, the coal consumption varies possibly from 80 lbs. per barrel to 250 lbs. per barrel, as the extreme limits. The average coal consumption for the plants from which the above nine samples were taken is 135 lbs. of coal per barrel of clinker produced. This figure also holds approximately for the remaining eight samples, should we ignore the high potash Sample No. 6. Using these eight samples as the basis for calculation, we find that there is introduced into the kiln with the coal, an amount of potash equivalent to 0.23 lb. of K_2O for every barrel of clinker produced. Since the average potash content of the cement raw material used in these eight plants is approximately 0.75 per cent K_2O, there is introduced into the kiln with the raw material, an amount of potash equivalent to 4.5 lbs. K_2O for every barrel of clinker produced. It would seem from this that the potash introduced with the coal is approximately only 5 per cent of the total potash entering the kiln.

Meade, in his book on Portland cement, states that probably half of the ash from the coal drops in the kiln, and is then carried out with the clinker. It is difficult to determine, with accuracy, the amount of coal ash that actually is carried out with the clinker, or that which is blown out with the gases. Messrs. Potter and Cheesman assume that only 25 per cent of the coal ash is carried out with the clinker, even in a wet kiln, which is probably a very low figure. However, should we assume this minimum figure, as used by Potter and Cheesman, and also assume only a 40 per cent volatilization of the potash carried by the raw material, it follows that even then less than 10 per cent of the total potash carried out with the gases can possibly come from the coal. It is evident, therefore, that the coal ash is of relatively minor importance, so far as the total potash blown from the kiln is concerned. The relatively small amount of potash introduced with the coal also makes it improbable that this can effect any material change in the nature or condition of the total potash material collected.

The authors referred to, state in their article "that taking into consideration the K_2O content of the ash, and the K_2O in the raw mix carried over mechanically, there is apparently no recombination of the volatilized K_2O with siliceous ash particles." In connection herewith, the following figures taken from a factory where potash is actually being collected commercially, may be of interest, particularly as these figures are representative of the nature of the material collected over a period of several months. During the period of operation represented by the samples, the coal burned in the kilns had a potash content equivalent to 0.132 per cent K_2O. Approximately 80 lbs. of this coal were burned per barrel of clinker produced. There was thus introduced into the kiln with the coal, an amount of potash equivalent to 0.11 lb. K_2O per barrel of cement burned, while about 6 lbs. of K_2O per barrel were introduced with the raw material. During this period the dust collected from the stack gases carried, as insoluble and slowly soluble potash, an amount of potash equivalent to 0.88 lb. K_2O per barrel of clinker produced in the kilns. The terms "insoluble" and "slowly soluble" are used here in the sense that the so-called insoluble portion is not affected by long boiling, and is only appreciably soluble in weak hydrochloric acid, while the so-called slowly soluble portion is completely dissolved by either method, both insoluble and slowly soluble being differentiated, however, from the soluble potash, which dissolves readily in hot water. Of this total of 0.88 lb. of insoluble and slowly soluble potash, approximately 0.30 lb. was in the insoluble form, and 0.58 lb. in the slowly soluble form.

The insoluble potash, equivalent to approximately 0.30 lb. of K_2O per barrel, can be accounted for on the assumption that it represents the potash in the dust or raw mix mechanically blown out of the kiln. The total amount of dust recovered during this period, per barrel of clinker produced, is equal to approximately 20 lbs. The analysis of this dust indicated it was 50 per cent calcined, which would give a potash content of this dust of approximately 1.4, on the assumption that none of its potash had been volatilized. This latter assumption can unquestionably be made, as none of this dust had at any time been subjected to a high temperature. This dust should, therefore, contain 0.28 lb. of K_2O in insoluble form, which figure checks fairly accurately with the insoluble potash determined by analysis.

This indicates that the slowly soluble potash present in an amount equivalent to 0.58 lb. K_2O per barrel of cement burned, must have come from sources other than the dust mechanically blown out of the kiln. Should we make the improbable and extreme assumption that all of the coal ash was carried out with the gases, and that none settled in the kiln to be carried

[1] THIS JOURNAL, **10** (1918), 109.
[2] *Ibid.* **9** (1917), 646.

out with the clinker, this would still account for an amount of potash equivalent to only 0.11 lb. K_2O, as arising directly from the coal ash. This extreme assumption that the total coal ash is carried out of the kiln, therefore, still makes it necessary for us to account for 0.47 lb. K_2O per barrel of clinker produced. It follows then that this must have come from sources other than the dust blown out of the kiln or the coal ash carried out with the gases. The only other source from which potash could have been derived is the potash vapor resulting from the volatilization of the potash from the kiln burden. The assumption that the incandescent siliceous coal-ash particles react with this potash vapor is not an unreasonable one, and from the information at hand it appears that this is the explanation of the cause or source of the greater part of the "slowly soluble" potash occurring in the collected dust, as outlined in the former paper above referred to.

Moreover, as was pointed out in that paper, such an explanation is not new. Thus, Henry S. Spackman, in a patent dated October 24, 1916, states that it is well known that the considerable portion of the alkali in the collected dust from cement kilns that is insoluble is due to the union of the volatilized alkali with highly heated, finely divided, siliceous dust to form glass.

From analyses made of dusts from several other cement factories it appears that the figures given above for the plant in question do not represent abnormal conditions, for some flue dusts have even a much larger amount of "slowly soluble" potash as compared with the amount of potash carried into the kiln with the coal.

Considering further that for every barrel of cement burned there is introduced into the kiln with the raw material an amount of potash equivalent to 6.00 lbs. of K_2O, while only 0.11 lb. of K_2O are added with the coal, it will be readily seen that the potash introduced with the coal has a relatively small bearing upon the question of by-product potash manufactured in rotary kilns, where only the soluble potash comes into consideration. In making accurate potash calculations, however, where the total "potash" is of interest, the potash introduced with the coal and carried by the coal ash should be carefully considered, as pointed out by Messrs. Potter and Cheesman.

SUMMARY

I—The coal used in cement burning carries comparatively small amounts of potash, the average being only 0.24 per cent K_2O for the nine plants investigated.

II—The amount of coal-ash potash introduced into the kiln is ordinarily very small as compared with the amount of potash entering the kiln with the raw material.

III—The sum of the insoluble and slowly soluble potash collected from coal-burning kilns, exceeds the sum of the total potash contained in the coal and in the raw material mechanically blown from the kiln.

E. ANDERSON
R. J. NESTELL
LABORATORIES OF THE
WESTERN PRECIPITATION COMPANY
LOS ANGELES, CALIFORNIA, April 15, 1918

Editor of the Journal of Industrial and Engineering Chemistry:

In February 1918, there appeared in THIS JOURNAL, page 109, an article by N. S. Potter, Jr., and R. D. Cheesman, entitled "Effect of Coal Ash on the Liberation and Nature of Cement Mill Potash." In this paper, the authors make the following statement: "The potash collected from the kiln stack gases where coal is used for burning appears in practically two forms, water-soluble potash and the insoluble or slowly soluble potash. The insoluble potash has been attributed to two causes: the potash in the unburned or partly calcined raw material carried over mechanically in the gases and to a recombination of the volatilized potash with the finely divided ash particles of the coal." Potter and Cheesman refer to an article[1] in which appears this statement: "In some plants where coal is used for burning, the extent to which the potash occurs in the 'recombined' form may be considerable, while in certain other plants where oil is used for fuel this combination of the potash is present in comparatively small amount." From this statement they deduce, "It is evident that the potash content of the coal ash has been quite neglected."

From the experimental data which are recorded in this article, Potter and Cheesman arrive at the following conclusions:

"I—K_2O content of coal ash is considerable.

"II—K_2O content of coal ash must not be disregarded in calculating the liberation in kilns.

"III—K_2O content of coal ash appears in 'treater dust' as insoluble K_2O.

"IV—Taking into consideration the K_2O content of ash and the K_2O in raw mix carried over mechanically there is apparently no 'recombination' of the volatilized K_2O with the siliceous ash particles."

The above deductions do not agree entirely with observations that have been made and experimental data that have been collected at the plant of the Security Cement and Lime Company, Hagerstown, Md. Therefore, these observations and data are discussed in connection with the conclusions derived by Potter and Cheesman.

"I—K_2O content of coal ash is considerable," In support of this contention Potter and Cheesman analyzed four samples of coal ash (each representing the average for one week) and found that "the average potash content figures close to 5 per cent" from which they conclude that the amount of potash introduced by the coal per barrel of clinker produced lies between 0.4 lb. and 1.25 lbs., depending upon the type of plant. In Table I are given the results obtained by the analysis of six samples of Fairmont gas coal used by the Security Cement and Lime Company.

TABLE I

Average Sample for 24 hours ending	Ash in Coal Per cent	K_2O in Ash Per cent
10–29–17	8.50	1.77
10–30–17	8.85	1.68
10–31–17	9.00	1.23
11–1–17	9.25	1.95
11–2–17	9.25	1.84
11–3–17	9.01	1.65
AVERAGE	8.98	1.68

Numerous determinations of the K_2O in coal ash have been made at the laboratory of the Security Cement and Lime Company since the above table was prepared, and in no case did the result exceed 2 per cent.

If the coal consumption at different plants ranges from 80 to 250 lbs. per barrel of clinker, the average of the results given above would show the possibility of the introduction of only 0.12 to 0.37 lb. of K_2O per barrel of clinker as contrasted with 0.4 to 1.25 lbs., according to the calculations of Potter and Cheesman.

The following data were secured from information furnished by the Bureau of Mines.

TABLE II—ALKALIES IN ASH OF WEST VIRGINIA COALS

County	Town	K_2O in Coal Ash Per cent
Barbour	Century	1.91
Fayette	Dunloop and Prudence	1.92
Fayette	Dunloop and Prudence	1.43
Fayette	Dunloop and Prudence	2.72
McDowell	Vivian	0.69
McDowell	Big Four	0.34
McDowell	North Fork	0.82
Mercer	Freeman	1.89
Mercer	Freeman	2.09
Monongahela	Morgantown	1.00

Table III, in which are given the per cent ash and per cent K_2O in ash for ten samples of Fairmont gas coal as they are presented on pages 334 and 335, Bulletin 2, West Virginia Geological Survey, 1911, is also of interest in this connection.

[1] W. H. Ross and A. R. Merz "The Recovery of Water-Soluble Potash as a By Product in the Cement Industry," THIS JOURNAL, 9 (1917), 1035

TABLE III

Sample No.	Ash Per cent	K_2O in Ash Per cent
1	5.72	1.23
2	6.64	0.63
3	7.42	0.92
4	8.22	1.25
5	6.42	1.03
6	6.04	0.89
7	8.14	0.75
8	7.22	0.84
9	7.11	0.96
10	7.50	0.95
AVERAGE	6.94	0.94

The figures presented in Tables II and III substantiate the results of the analyses made at the laboratory of the Security Cement and Lime Company.

"II—K_2O content of coal ash must not be disregarded in calculating the liberation in kilns." By percentage liberation is meant the per cent of K_2O contained in the raw material which is volatilized in the kiln during the process of burning. At the plant of the Security Cement and Lime Company it is calculated as follows:

$$\text{Percentage liberation} = \frac{580 \times \text{per cent } K_2O \text{ in raw mix} - 380 \times \text{per cent } K_2O \text{ in clinker}}{580 \times \text{per cent } K_2O \text{ in raw mix}}$$

It is considered that 580 lbs. of raw material must be actually burned in the kiln to make 380 lbs. of clinker.

Potter and Cheesman assume that in a dry process plant 90 per cent of the coal ash passes up the flue with the gases. If, in addition to this, we were to assume that (1) 90 lbs. of coal are burned per barrel of clinker, (2) the coal contains 10 per cent ash, and (3) the potash content of the ash is 2 per cent, then the amount of K_2O deposited in the kiln by the ash would be 0.018 lb. per barrel of clinker, or 0.0047 per cent of the weight of the clinker. If it were found by analysis that the raw material contained 1.2 per cent K_2O and the resulting clinker 0.60 per cent, as ordinarily calculated, the percentage liberation would be

$$\frac{580 \times 1.2 - 380 \times 0.6}{580 \times 1.2}, \text{ or } 67.2 \text{ per cent.}$$

If from the per cent K_2O determined to be present in the clinker 0.0047 per cent be subtracted (assuming that all of the potash deposited by the coal ash in the kiln emerged with the clinker), the percentage liberation would become

$$\frac{580 \times 1.2 - 380 \times 0.5953}{580 \times 1.2}, \text{ or } 67.5 \text{ per cent.}$$

Even though the K_2O content of the coal ash were 5 per cent, the percentage liberation would be only 67.7. Therefore it would seem that the effect on percentage liberation of the K_2O in the coal ash, in dry process plants at least, is negligible.

"III—K_2O content of coal ash appears in 'treater dust' as insoluble K_2O." At this point, attention is directed to the fact that instead of two there are in reality three forms of potash present in treater dust.[1] They are designated as water-soluble, acid-soluble or slowly water-soluble, and acid-insoluble. In speaking of insoluble potash, a distinction should be made between that which is acid-insoluble and that which is often referred to as insoluble in water, for the latter includes both the acid-soluble or slowly water-soluble and acid-insoluble portions. It is evident that Conclusion III refers to water-insoluble potash, since in an earlier portion of their paper Potter and Cheesman state, "the potash collected from the kiln stack gases where coal is used for burning appears in practically two forms, water-soluble potash and the insoluble or slowly soluble potash."

"IV—Taking into consideration the K_2O content of ash and the K_2O in raw mix carried over mechanically there is apparently no 'recombination' of the volatilized K_2O with the siliceous ash particles." In order to determine the accuracy of this statement, several tests were conducted at the plant of the Security Cement and Lime Company, using a kiln and treater that comprise one of the units of the plant. In each case the duration of the test was 24 hours. Necessary precautions were taken to determine as accurately as possible the weights of clinker, stack-, base-, and treater-dust produced, and to obtain an average sample of each. A sample of coal representing the average for the entire period of each test was secured by an automatic coal sampler.

In Table IV are given the data that were obtained from the analysis of the various samples collected in three of the tests; in Table V are the results of calculations based on the data in Table IV.

TABLE IV

Test number	1	2	3
Barrels of clinker made	498.73	553.94	551.53
Coal:			
Tons used	22.44	24.93	24.81
Per cent ash	6.95	7.77	8.97
Per cent K_2O in ash	0.42	1.51	1.38
Treater dust:			
Tons drawn	6.75	7.75	6.8
Per cent water-soluble K_2O	8.82	10.18	8.42
Per cent acid-soluble K_2O	1.80	0.64	1.30
Per cent acid-insoluble K_2O	0.48	0.84	1.38
Per cent total K_2O	11.10	11.66	11.10
Stack-base dust:			
Tons drawn	2.15	3.30	0.90
Per cent water-soluble K_2O	3.06	4.58	3.53
Per cent acid-soluble K_2O	1.09	1.17	1.36
Per cent acid-insoluble K_2O	0.43	0.22	0.43
Per cent total K_2O	4.58	4.97	5.32

TABLE V—POUNDS K_2O PER BARREL OF CLINKER

Test number	1	2	3
In treater dust + stack-base dust:			
Water-soluble	2.651	3.275	2.192
Acid-soluble	0.581	0.318	0.365
Acid-insoluble	0.167	0.261	0.354
Total	3.399	3.854	2.911
In coal ash entering kilns	0.026	0.105	0.111

According to Potter and Cheesman, the K_2O content of the coal ash and the K_2O in the raw mix carried over mechanically should account for all the water-insoluble potash collected. In this connection the figures presented in Table VI are of interest.

TABLE VI—POUNDS K_2O COLLECTED PER BARREL OF CLINKER

Test number	1	2	3	4
Water-soluble potash (K_2O)	2.651	3.275	2.192	2.706
Water-insoluble potash:				
Acid-insoluble (raw mix blown over)	0.167	0.261	0.354	0.260
Acid-soluble (slowly water-soluble):				
Coal ash blown over (90 per cent)	0.023	0.094	0.099	0.072
Partially burned material	0.558	0.224	0.266	0.349
Recombined	...	...	...	...
TOTAL K_2O	3.399	3.854	2.911	3.387

It will be observed that, after deducting from the total K_2O the water-soluble potash and the sum of the potash content of the raw mix and of the coal ash carried over by the flue gases, there still remains a portion, the average of which for the three tests amounts to 0.349 lb. per barrel of clinker, or 10.31 per cent of the total potash collected. Moreover, the sum of the potash content of the raw mix carried over mechanically and of the coal ash blown over (which amounts to 0.332 lb. per barrel of clinker) is sufficient to account for only one-half of the water-insoluble portion. As indicated in Table VI, the other half may not all be recombined potash; it is reasonable to suppose that it may be made up, in part at least, of raw material that has been only partially burned, thus making the potash compounds which it contains acid- or slowly water-soluble. That such partial decomposition does take place is clearly shown by an analysis, given in Table VII, of a sample of treater dust obtained by W. H. Ross and A. R. Merz[1] from the plant of the Riverside Portland Cement Company.

TABLE VII

Combination	K_2O in Treater Dust Per cent	Total K_2O in Dust Per cent
Water soluble	9.8	91.59
Slowly soluble	0.7	6.84
Acid-insoluble	0.2	1.87
TOTAL	10.7	100.00

[1] W. H. Ross and A. R. Merz, U. S. Dept. Agriculture, *Bull.* 572 (1917), 10.

[1] W. H. Ross and A. R. Merz, THIS JOURNAL, 9 (1917), 1035.

At the Riverside plant, oil is used as fuel. Since in such a plant no coal ash is present with which the volatilized potash may recombine, the small amount of slowly-soluble potash that is found in the treater dust must be due either to partially burned material or to a recombination of some of the volatilized potash with siliceous material in the raw mix.

At the plant of the Security Cement and Lime Company (where powdered coal is used for fuel) it is now customary to add a small proportion of sodium chloride to the raw mix for the purpose of decreasing recombination. A patent covering this process has been applied for by R. C. Haff, Chief Chemist, and R. D. Cheesman, formerly assistant chief chemist of the Security Cement and Lime Company. Before this practice was started, the treater dust produced contained a high percentage of water-insoluble potash, and yet at that time the operation of the kilns was practically the same as at present, approximately the same quantity of coal was consumed per barrel of clinker, and probably about the same quantities of raw and partially burned materials were carried out of the kilns. Therefore the sum of the quantities of K_2O in the coal ash and in the raw and partially burned material carried over in the kiln gases must have been approximately the same as now, but the amount of recombined potash was considerably higher and the water-soluble portion correspondingly lower.

In Table VIII are given the analyses of two samples of Security treater dust. The first was obtained by Ross and Merz before the practice of adding sodium chloride to the raw mix was started; the second is the sample from Test No. 1, the data for which are given in Tables IV, V, and VI. These particular samples were chosen because they are almost identical in their respective percentages of total and acid-insoluble potash, therefore making it possible to compare accurately the percentages of recombined and water-soluble potash which they contain.

TABLE VIII

	Before Addition of Sodium Chloride	After Addition of Sodium Chloride
Water-soluble K_2O, per cent.....	6.80	8.82
Acid-soluble K_2O, per cent.....	4.10	1.80
Acid-insoluble K_2O, per cent.....	0.50	0.48
Total K_2O, per cent.....	11.40	11.10

It will be noted that (1) the potash content of the treater dust due to raw material carried over by the flue gases (indicated by the amount of acid-insoluble K_2O determined) is approximately the same in each case, (2) there has been a decrease of approximately 2.3 per cent in the amount of acid-soluble potash, with a corresponding increase in the amount of water-soluble K_2O.

Assuming that the amount of partially burned material carried over with the flue gases is approximately the same at the Security and Riverside plants, and that this amount of the Riverside plant as shown in Table VII is approximately 6.54 per cent of the total potash recovered, the percentages of this material present in the treater dust must have been about 0.74 before and 0.73 after the addition of salt to the raw mix. Subtracting these amounts from the percentages of slowly-soluble K_2O given in Table VIII, the recombined K_2O present in the treater dust collected at the Security plant must have been approximately 3.37 per cent before and 1.07 per cent after the addition of sodium chloride, showing a reduction in recombination of approximately 2.3 per cent of the weight of the dust or 20.3 per cent of the total potash collected. In other words, by the introduction of sodium chloride vapors into the zone of combustion, thereby causing the preferential formation of potassium compounds which answer the official requirements as to "soluble potash," the Security Cement and Lime Company has decreased recombination approximately 68.0 per cent and at the same time has obtained an increase of 32 per cent in the percentage of water-soluble K_2O present in the treater dust which amounts to 20.3 per cent of the total potash collected.

SUMMARY

Results obtained at the Security Cement and Lime Company do not substantiate the conclusions regarding potash liberation reached by Potter and Cheesman.

The effect on potash liberation as here calculated is not greatly influenced by the low percentages of K_2O present in the coals used.

When salt is added to raw mix the percentage of water-soluble K_2O in the treater dust increases at the expense of acid-soluble K_2O.

This is explained satisfactorily only on the assumption that recombination to the extent of about 68 per cent has been prevented.

Grateful acknowledgment is made to Mr. H. S. Bair who assisted in the experimental work, and to C. H. Miller, H. C. Mackenzie, and J. E. Baker who made the analyses reported, under the direction of Mr. R. C. Haff.

E. O. RHODES AND J. J. PORTER

THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH
UNIVERSITY OF PITTSBURGH, PA.
THE SECURITY CEMENT AND LIME COMPANY
HAGERSTOWN, MD.
May 1, 1918

WASHINGTON LETTER

By PAUL WOOTON, Union Trust Building, Washington, D. C.

So unexpected was the collapse of the enemy, just at a time when the Government's war machine was most intent on quantity production, that the armistice caught the authorities without a reconstruction policy. In fact, there was not a single definite plan for the conversion of the war machine to a peace basis.

Strenuous efforts are in progress to evolve definite reconstruction policies but nothing comprehensive has come out during the week following the signature of the armistice. Individual ideas, however, are beginning to become available which indicate the general trend of thought. The most important single development is that there is to be no wholesale cancelling of contracts. The curtailment is to be allocated in much the same manner as that in which the contracts were let. This work is to be engineered by the War Industries Board with special coöperating agencies within the departments interested. Due recognition is being taken of the labor situation, both in the curtailing of contracts for raw materials and in the mustering out of the Army. Before cancelling or reducing any contract, reports must be made to the War Industries Board showing the following:

(*a*) The effect of the proposed cancellation on the industry.
(*b*) The effect on labor conditions.
(*c*) The effect on the given locality.
(*d*) The effect on the given contractor.

By far the most comprehensive statement as to the industrial aspects of the reconstruction period has been made by Benedict Crowell, director of munitions for the War Department, as follows:

With the signing of the armistice the War Department is faced with an intricate problem and great responsibilities. The industries of the country, which have responded whole heartedly to the call of the Government for increased production and which were going at a rate never before attained, must be diverted from war-time production to their normal occupations in times of peace.

The first and primary consideration in getting back to this normal basis is to make this readjustment with as little inconvenience as possible, and with a continuous employment of labor.

It is also essential that the production of material for war, which means now a waste of material which could be used for civilian population both here and for the purposes of reconstruction in Europe, should be

stopped as speedily as is consistent with the primary consideration of labor and the industries.

Instructions have therefore been issued to all Bureaus of the War Department, governing the methods of slowing down of production, so that as far as possible there should be a tapering off of war work, giving time for industrial readjustment and for the industry to take up civilian work.

So that manufacturers might as rapidly as possible get into work on civilian needs, at our request the War Industries Board have withdrawn all priority ratings on army work.

No order is being suspended or cancelled by the War Department without consideration of the nature of the work or the locality in which the work is being performed, labor and the re-employment of labor at such places in other industries and without conference and consultation with the War Industries Board which has been constantly in touch with the industries of this country, and with the Department of Labor, which is in intimate touch with the conditions of employment in all parts of the United States.

Overtime, holiday, and Sunday work has been stopped, and as rapidly as possible and as rapidly as the labor can be used in normal day shifts, night shifts will be discontinued.

It is often the case that in a certain locality where labor is working on a war project, this work may be stopped and the same labor utilized on other work in the same locality.

During the war, production has been largely diverted from articles called for in times of peace to war necessities, and civilian needs have been curtailed and non-essentials largely eliminated. With the assistance of the War Industries Board the articles for war necessities are being rapidly curtailed and the industries proportionally freed to work on civilian needs. Industries which have been largely concentrated in certain areas with resultant congestion of transportation, with a great influx of labor in this area, with inadequate facilities for housing, etc., are being taken into consideration in this readjustment.

The two standards which the War Department has set up for itself are that these contract readjustments must be made equitably, in regard to the industry and labor, and promptly, to safeguard the financial elements of the problem.

Of no small interest to the chemical industries is the matter of the future of the large number of women now engaged. Miss Mary Van Kleeck, the director of the Women in Industry Service of the Department of Labor, expresses the following thoughts in this connection:

The question peculiar to women relates to those who have taken men's places. It would seem fair to the returning soldiers that they be reinstated in their old positions, but in justice to the women who have taken their places, sufficient notice should be given to enable them to be transferred to other work. The number of women who have been drawn into gainful employment for patriotic reasons is probably much smaller than is generally supposed. Large numbers of women in the war industries have been transferred from other occupations and the problem of readjustment is to return these workers to their normal occupations.

With the need for production to feed and clothe and shelter other nations besides our own there is no reason to believe that the employment of women in industry will not increase rather than decrease. In view of the responsibility of women for their own support and often for the support of dependents they cannot be asked to withdraw entirely from gainful employment.

That there is an important demand for the continuation of government control in many industries is indicated by the agreements which have been reached at a meeting of the War Industries Board and the copper industry and of the War Industries Board and the steel industry. The copper-producing industry, represented by Daniel Guggenheim, C. F. Kelley, Daniel C. Jackling, and R. L. Aggassiz, made a hard-and-fast agreement with the War Industries Board, in which the principal points are:

(a) The present rate of production is to be maintained in the mines, smelters and refineries, continuous employment being thus insured during the first period of the transition from a war to a peace basis.

(b) The present level of prices of the metal and the existing wage scale of labor are to be preserved.

(c) The War Industries Board or such other governmental agency as may be designated, is to continue regulation of prices and allocation of the material.

The agreement is subject to renewal or revision January 1.

Following the meeting, Bernard M. Baruch, the chairman of the War Industries Board, commented significantly on the copper situation. Practically the same situation exists with regard to many chemical products. The remarks of Mr. Baruch are substantially as follows:

One of the allied governments within the last twenty-four hours has requested information on delivery of 200,000 tons of copper. This is accepted as a sign that the European demand will not only be large but immediate. Prospective requirements for civilian consumption due to the curtailment of the productivity of many American industries for the last eighteen months because of the needs of the war program, have created a demand that is expected to prove a factor in stabilizing conditions generally.

The civilian demands in Europe and elsewhere, held in check for more than four years, will work to the same end.

The demand for copper will be heavy, and most of it must be met by the United States, as between 75 and 85 per cent of the copper production is in the hands of American industry. With the refining facilities included it is probable that the proportions controlled by American producers is nearly 90 per cent.

After the conference with the heads of the steel industry, the War Industries Board made a formal announcement of which the following is a paragraph:

The Iron and Steel Institute Committee, in the course of its suggestions, placed emphasis upon the point that a continuation of governmental supervision of industry for the present was highly desirable. It was agreed that many changes in operating conditions of the steel mills will be necessary in the transition from a war to a peace basis. Some cancellations and adjustments in war contracts will follow, but owing to the removal of many restrictions imposed on non-war industries and the immediate demands of such industries and a probable resumption of Federal, State, and Municipal improvements which had been temporarily suspended, and the demands from abroad for foreign construction which are already taking definite shape, it is believed that the transition can be accomplished in an orderly and systematic way.

An announcement from the President with regard to use which will be made of the powers conferred upon him by the War Minerals Act is expected soon. He already has authorized the use of $100,000 of the appropriation carried by the Act, for the stimulation of the production of potash, arsenic, and zirconium. This work already is under headway. It is being directed by J. E. Spurr, in charge of the War Minerals Section of the Bureau of Mines.

In addition, however, it has been suggested to the President that a comprehensive effort be made looking to the development of the potash industry to the point where the United States will be independent of outside sources. It is contended that the War Minerals Act gives a rare opportunity to get this industry on its feet. Many are of the opinion that the German product can be undersold in addition to reducing the price of cement and pig iron, which would be possible when the potash by-product is recovered.

The Department of Agriculture is interested equally with the Bureau of Mines in the development of a domestic potash industry. Wallace W. Mein, the assistant secretary of agriculture, is giving the matter a considerable portion of his personal attention. Potash hunger has manifested itself in crops from Maine to Florida. This demonstrates, he believes, that potash is a necessary ingredient of fertilizers. He regards as very dangerous the propaganda which has been conducted by certain fertilizer interests to the effect that potash is not necessary to proper fertilization of soil. On the other hand, he regards it as essential to discount the preaching of the German potash industry which urged the use of excessive amounts of potash and fertilizer. By finding the middle ground between these extremes, the best interests of American agriculture will be met, Mr. Mein says. He deprecates the policy which has allowed large quantities of domestic potash to go unused during the war.

Disbanding of the Chemical Warfare Service of the Army began with the signing of the armistice. Whether the skeleton of the organization will be retained is a matter of question. Some contend that chemical warfare is a development of the times and may be retained. Such a view is strengthened by reference to the loud protest which went up when the British army first made use of shrapnel. It was characterized as inhuman and barbaric. Any continuance of the use of gas in warfare is condemned by the men who directed the service in the American army. Should the international situation not be adjusted stably, and should nations continue to compete in armament, it is admitted that the Chemical Warfare Service probably would become a permanent branch of the Army. As no such outcome is anticipated, present preparations are being made largely on a basis of complete disbanding.

At the date of this writing the entire staff of the Chemical Warfare Service is continuing with the work. Maj S. W. Avery is an exception. His resignation was given preference that he might return to especially urgent work at the University of Nebraska. Many other resignations, however, have been submitted and prompt action on them is expected. The per-

sonnel of the service is being released in compliance with the War Department's general policy of not returning men from the Army faster than they can be absorbed in the industries. This does not affect chemists as importantly as men in other industries. Most of the chemists who have been working with the Chemical Warfare Service have positions awaiting them. There is to be no uncertainty in this particular, however, as Major Allen Rogers, the chief of the Industrial Relations Branch of the Chemical Warfare Service, has sent to each man a series of questions which will establish his status with regard to his employment in civil life.

Major Rogers is of the opinion that the demand for chemists will be very much greater as a result of the many practical demonstrations during the war of their worth in many industries The presence of Army chemists in so many plants has taught manufacturers many lessons in the handling of their business.

The manufacture of toxic substances already has been stopped. This portion of the chemical service had attained large proportions with the end of the war. The manufacturing capacity of the United States of these substances was greater at that time than those of England and France combined. Large supplies of materials entering into gases are on hand. As they cannot be stored for any great length of time, their disposition is offering a problem.

It is not claimed at the offices of the Chemical Warfare Service that gases superior to those in use by the Germans were produced. That the best German efforts were equalled is a claim which it is practically certain will be established. In the development of the gas mask, however, there is no question that the best efforts of the enemy or of the Allies were outdone. Important announcements along these lines may be expected after the conclusion of peace.

Over 13,000 replies have been received to the questionnaire which was sent to chemists in September by the Chemical Warfare Service. The number of questionnaires originally sent was 18,000. Classification of the replies received has been completed. There are more than 100 classes into which the chemists are separated.

Chemists in Washington expect to see material improvement when the chemical departments of schools and colleges are reorganized. The war has resulted in the disorganization, it is said, of the chemical departments at most of the institutions for higher education. The remarkable advance made by the chemical industries during the war, as well as the practical experience which has been attained by so many of the chemical instructors and pupils will result in a very material improvement, it is believed.

In this connection it may be stated that a frequent criticism heard in Washington of the Chemical Warfare Service, is that the college professors had too much to say regarding its management. Their inability in certain cases to apply practical methods is said to have delayed the program to some extent. Had industrial chemists had a greater voice, some believe progress would have been more rapid. At any rate, all admit that those connected with the Service have had some very valuable practical training.

At the close of hostilities there were 1500 chemists on active duty with the Chemical Warfare Service. This is in addition to 3000 other men with chemical training, who also were on active duty.

With reference to America's war system of economic control, Chairman Baruch, of the War Industries Board, has called attention to an editorial published in the *Frankfurter Zeitung*, not long before Germany laid down her arms, lamenting the fact that Germany had not adopted the far-sighted methods of the United States to check abnormal rises in the prices for raw materials needed in the war program. Opposed at first to the price-fixing regulations of the Government, observed Mr. Baruch, the industrial leaders of America have themselves come around to appreciate the wisdom of the President in insisting upon a check on the prices for the basic materials where scarcity stimulated the tendency towards extraordinarily high levels. Had a different policy been pursued, said Mr. Baruch, the steel and iron industry, for example, would be facing a return to peace conditions with the price for pig iron boosted up to $150 a ton or more, and other items of their production similarly scaled. It is in appreciation of the value of a restraining influence, he said, that the steel industry and others are asking that government control be extended over the period of transition from a war to a peace basis.

PERSONAL NOTES

First Lieutenant Elbert C. Baker, son of Mr. and Mrs. J. T. Baker, of Easton, Pa., was killed in action in France on September 30. Lieutenant Baker graduated from Cornell University in 1915 and then took an extra year of special work in chemistry, receiving the degree of Bachelor of Chemistry. After leaving Cornell he was associated with his father at the J. T. Baker Chemical Works in Phillipsburg, N. J.

Professor William Main, scientist and engineer, and formerly professor of chemistry in the University of South Carolina, died recently at his home in Piermont, N. Y. Professor Main was one of the pioneers of the copper and lead mining industries of this country. He was the inventor of the lead-zinc storage battery, and the first to apply the storage battery to the propulsion of street cars.

Mr. William E. Garrigue, a member of the Chicago Section of the American Chemical Society and for many years prominently identified with the chemical industry of this country, died at Toronto, Canada, on October 2, 1918.

Mr. H. M. Barkesdale, vice president of E. I. du Pont de Nemours & Co., Inc., died of influenza at Wilmington, Del., on October 18, 1918.

Mr. Roy O. Fitch, of the Bureau of Standards, died on October 13, 1918. His work with the Bureau of Standards was chiefly on bituminous materials of construction.

Mr. Thomas Bartlett Ford, associate physicist of the Bureau of Standards, died on October 1, 1918. He had been for several years in charge of the low-temperature laboratory of the Bureau, including the liquid air and liquid hydrogen apparatus and had devoted considerable attention to the separation of rare gases

Mr. Milton Birch, vice-president and treasurer of the Westmoreland Chemical and Color Company died in October after a brief illness.

Miss Elizabeth S. Weirick, for the past eight years instructor in chemistry at Pratt Institute, Brooklyn, N. Y., has resigned her position there to take up the work, on January 1, of textile chemist in the chemical laboratories of Sears Roebuck and Company, Chicago.

At the request of the Board of Regents of the University of Nebraska, the War Department has permitted Major Samuel Avery, chief of the University Relations Branch, Chemical Warfare Service, to resign his commission, in order to resume his duties as Chancellor of the University, on December 1. Major Victor Lenher, in addition to his other duties in the Relations Section, now takes charge of the work relinquished by Major Avery.

At the meeting of the New York Section of the Société de Chimie Industrielle on November 19, addresses were made by George Maoussa, Docteur des Sciences, Member of the French High Commission, and C. O. Mailloux, E.E., M.S., D.Sc., Past President of the American Institute of Electrical Engineers, Member of the American Industrial Committee to France.

Dr. W. M. Burton was recently elected president of the Standard Oil Co. of Indiana, to succeed the late Lauren J. Drake. Dr. Burton has been connected with the company for many years, having been chief chemist, superintendent, general manager, and vice president.

Mr. G. D. Cain, chief chemist of the fertilizer control laboratory at the Louisiana Agricultural Station, has been appointed assistant director of the North Louisiana Station at Calhoun.

Mr. I. S. Jones has resigned as director and chemist of the Idaho Agricultural Experiment Station and professor of agricultural chemistry in the University of Idaho, and has assumed charge of the laboratory of one of the government nitrate plants under the Ordnance Division of the War Department

Captain W. G. Gribbel, of the First Gas Regiment, has returned from active service in France to act as instructor in gas offense.

Dr. Robert P. Fischelis, director of the control department of the H. K. Mulford Co., has entered the Chemical Warfare Service and is now stationed at the control laboratory of the Gas Defense Plant, Long Island City, N. Y.

Dr. A. D. Hirschfelder, of the University of Minnesota, is now with the Research Division of the Chemical Warfare Section and is stationed in Baltimore.

Mr. G. W. Gray, of the Midland Refining Company, El Dorado, Kansas, has been appointed a director of the Bureau of Refining, Oil Division, U. S. Fuel Administration.

Mr. Charles D. Test, formerly chemist for the Western Potash Works of Antioch, Nebraska, has accepted a position on the staff of the United States Tariff Commission.

Mr. Otto Kress, formerly in charge of the research work in pulp and paper at the U. S. Forest Products Laboratory, Madison, Wis., is now director of the new technical dyestuffs laboratory in the dyestuffs sales department of the E. I. du Pont de Nemours & Co., Wilmington, Del.

Major Henry S. Spackman, of the Spackman Engineering Co., Philadelphia, has been promoted to the rank of Lieutenant Colonel in the Engineers Corps, U. S. A.

Mr. John E. Schott, formerly an Industrial Fellow at Mellon Institute, has accepted a position with the Experimental Division of the Hercules Powder Co., Kenvil, N. J.

Mr. Phillip Wealey has been appointed manager in charge of the oxyhydrogen plant and sales office of the International Oxygen Co., Pittsburgh, Pa.

Professor E. C. Franklin, of Stanford University, California, is on leave of absence and is engaged in research work for the Nitrate Division, Ordnance Department of the Army. This Division has taken over the experimental ammonia plant and laboratory which has been conducted near Washington by the Department of Agriculture. The work is in charge of R. O. E. Davis and L. H. Greathouse.

Mr. George Quelch, one of the staff engineers of the International Oxygen Co., New York, sailed recently for England to supervise the installation of a 460 cell plant of the I. O. C. Unit Oxyhydrogen Generators for the British Admiralty.

Dr. Alfred J. Larson, assistant professor of chemistry, Carleton College, Northfield, Minn., has been in the chemical service of the Government for a year and was recently commissioned Captain.

Mr. F. K. Bezzenberger, of Harvard University, has been commissioned Captain, and is stationed at Cleveland as gas chemist in the Chemical Warfare Service.

INDUSTRIAL NOTES

The editorial office of *Paper* and the office of the Secretary of the Technical Association of the Pulp and Paper Industry have moved to 131 East 23rd St., New York City.

The Director of Munitions, Washington, has stopped the construction work at the government air nitrate plant at Ancor, near Cincinnati. Col. Joyes, who was in charge of the work, states that a study is being made to determine the best way to utilize these plants to meet the changed needs of the country.

A contact sulfuric acid plant will be located at Grand Rapids, Mich. The plant is to be situated upon a tract of land which is the property of the United States Government and upon which a picric acid plant is now being erected. When in operation this plant will produce approximately 75,000 net tons per year.

Arrangements have been made by the Subsistence Division of the Quartermaster's Corps whereby the laboratories of the Bureau of Chemistry, Department of Agriculture, throughout the United States are to be more fully utilized by the Army.

The *British Board of Trade Journal* announces that as potash salts form an essential ingredient in glass making, the very great development which has taken place in the production of British glass would not have been possible had not a parallel development in potash production also taken place.

In view of the need of a permanent exposition of textile and allied industries, a site at San Gines, in the suburbs of Barcelona, Spain, near Catalonia, the center of the textile industries, has been chosen for an imposing edifice for the exposition. The scope of the exposition as planned is both practical and theoretical.

Work has recently been commenced at the salt mines at Buurse, Holland, which is near the German frontier. Previously all the salt for household and industrial needs in the Netherlands was imported from Germany and when these importations stopped there was a great shortage of the commodity.

At a conference on the American potash situation, held October 15 in the office of William Wallace Mein, assistant to the Secretary of Agriculture, in charge of fertilizer control, it was stated that the view of the Department of Agriculture is that the Government should do all that is possible to encourage the production of potash from the cheapest sources in this country in order to enable the farmers to obtain it at a low price, because foreign supplies are now unavailable.

Predictions made a year ago that the deposits of tungsten ore or wolframite in South China would prove to be one of the most important additions to the world's supply of this ore, have been amply fulfilled in the development of the industry. Shipments of the ore from Hongkong alone have totaled $1,831,590 gold in value so far for the current year

Arrangements have been made by the Conservation and Reclamation Division of the Quartermaster's Corps to take over the disposition and reclamation of waste materials at ordnance depots and arsenals which were heretofore handled by the Ordnance Department. An order has been issued by the Chief of Ordnance directing that all waste products at ordnance stations be turned over to the Conservation and Reclamation officers. Equipment will be installed at the Picatinney Arsenal for the reclamation of empty cast iron and steel shells.

A very fine deposit of kaolin, the fusion point of which is about 3500° F., has been discovered in northeastern Oklahoma by W. T. Croslin, president and chief engineer of the Southwestern Light and Power Transport Co., Miami, Okla.

The first concrete ship built in China, a small ferro-concrete vessel named Concrete, was taken out on trial recently and proved very satisfactory in every way, especially as it was found to be easy to handle.

Due to the difficulties in the shipping situation, England is now utilizing domestic waste material such as fen grass, reed, lumber trimmings, and straw in the manufacture of paper.

Dr. Charles S. Venable, formerly gas chemist at the American University, Washington, is now a captain in the Development Division of the Chemical Warfare Service doing gas offense work in Cleveland.

The largest plant in the world for the manufacture of ammonium nitrate with which to fill high explosive shells is located at Perryville, Md. This government plant which is of concrete construction has all been built since March 4, 1918, and began operations on July 26. It consists of two distinct operating units with a capacity of 300 tons of ammonium nitrate daily. A special commission spent a month studying ammonium nitrate production in England and planned a plant closely resembling the British works.

Proctor & Gamble, soap manufacturers of Cincinnati, have offered to run the New York City garbage plant on Staten Island in order to obtain the 1,000,000 lbs. of glycerin which can be produced there.

Artificial rubber has been made in an experimental way for many years, but it is now reported that the great dye and color works at Elberfeld, Germany, are erecting a large factory for the production of synthetic methyl rubber on a large scale.

Secretary Lane of the Department of the Interior says: "The United States does not need German potash. Germany has thought that she had a whip-hand over America because of her supply of this material, but America can in two years become entirely independent of Germany by the development of her own deposits and the use of the process devised by Dr. Cottrell of this department."

GOVERNMENT PUBLICATIONS

By R. S. McBride, Bureau of Standards, Washington

NOTICE—Publications for which price is indicated can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. Other publications can usually be supplied from the Bureau or Department from which they originate. Commerce Reports are received by all large libraries and may be consulted there, or single numbers can be secured by application to the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington. The regular subscription rate for these Commerce Reports mailed daily is $2.50 per year, payable in advance, to the Superintendent of Documents.

COUNCIL OF NATIONAL DEFENSE

X-Ray Apparatus and Supplies, Part IV. Revised edition of the War Industries Board's list of staple medical and surgical supplies selected to meet war conditions by Committee on Standardization. 20 pp. Issued September 1918.

PUBLIC HEALTH SERVICE

An Experimental Investigation of the Toxicity of Certain Organic Arsenic Compounds. G. B. Roth. Hygienic Laboratory Bulletin 113. Issued July 1918.

On the Toxicity of Emetine Hydrochloride, With Special Reference to the Comparative Toxicity of Various Market Preparations. G. C. Lake. Hygienic Laboratory Bulletin 113, Part II. Issued July 1918.

BUREAU OF CENSUS

Textiles. Report from the Census of Manufacturers, 1914. 165 pp. Paper, 30 cents. This includes a report on production and other data relative to wool manufactures, cotton goods, hosiery, knit goods, silk, textiles, and miscellaneous materials.

COMMERCE REPORTS—SEPTEMBER 1918

Owing to increased demands for **vegetable oils** in the United States, this industry has increased greatly in Japan. The principal oils produced there are soy bean, coconut, rapeseed, cottonseed, and peanut. Of the twenty-five largest plants, all but three use the pressure system; these three use the benzene extraction method. (P. 867)

Efforts are being made to develop the extraction of **rubber seed oil** in the Malay states. It may be used as a substitute for linseed oil in paint and varnish, and in soft soap. (P. 887)

Manufacture of **calcium carbide** has been started in South Africa. (P. 915)

The British **Scientific Products Exhibition,** recently opened, includes exhibits of chemical products and processes, glass, quartz, refractories and porcelain, photographic materials, paper and textiles, and substitutes for petroleum products. Among the chemical products are dyes, laboratory reagents, thymol, aspirin, atropin, and other drugs. (Pp. 936–8)

Among the substitutes for **fuel oils** and **lubricating oils** being developed in Sweden are wood-tar oil, sulfite spirits, coal-tar distillates, shale oils, peat-tar oil, etc. (P. 970)

A new **fertilizer** in use in Italy, known as "tetraogisogate" is made from low grade phosphate rock by heating the powdered rock to 600° to 800° C. with 6 per cent of a mixture of calcium, sodium and magnesium carbonate and a small amount of sodium sulfate. After heating, the product is treated with phosphorous acid, and mixed with sand or dry earth. (P. 1026)

Large **phosphate** deposits have been discovered on islands near New Zealand. They have been formed by the impregnation of coral deposits by guano from rookeries of sea birds. The phosphate is said to be 85 per cent available. These islands formerly belonged to Germany, but have recently been taken over by Great Britain. (P. 1139)

Large deposits of high grade **chromite** have been discovered in South Africa, and are being developed. (P. 1141)

Great efforts are being made in Germany to develop **cellulose yarn,** made from wood fiber. The product when woven into fabric is strong when dry, but it becomes very weak when wet. (P. 1142)

COMMERCE REPORTS—OCTOBER 1918

The manufacture and use of **industrial alcohol** is increasing in South Africa. Alcohol to be used for motor fuel is to be denatured with 2 per cent by volume of "wood naphtha" and 0.5 per cent of pyridine bases. (P. 59)

A large number of women are now **studying chemistry** at the German technical schools. (P. 63)

Abandoned mines of Bohemia are now yielding large quantities of **tungsten ore.** (P. 63)

The **petroleum** industry of Mexico is described in detail, giving the location of the fields, and the properties of the fuel oil and other products. (Pp. 84–89)

Steps are being taken to develop **nickel** deposits in Santo Domingo. (P. 99)

The **rubber** industry of Ceylon is increasing and areas formerly devoted to cinnamon, rice, tea and citronella are being planted in rubber. (P. 102)

Efforts are being made in Germany to increase the price of **potash.** The domestic consumption has increased and made up in some degree for loss of foreign trade. A large number of prisoners of war and women are employed in the potash mines. (P. 118)

A pure white fiber, obtained from nettles, is being used extensively for **textiles** in Germany and Denmark. Cloth is being made from peat, with 25 per cent of wool waste. (P. 121)

The British **paper industry** is now in a serious condition owing to the dependence on foreign sources for raw material. Supplies of rags and esparto have been practically cut off and wood pulp is greatly reduced. Local supplies of straw, grass, and reeds have been utilized. Restrictions to save paper are more drastic than in the United States. Thus, for example, envelopes for official correspondence are used repeatedly by the use of a detachable gummed label for the address. (Pp. 122–5)

Two plants are to be erected in Norway for extracting **salt** from sea water by electricity (presumably by electrical heating). (P. 165)

It is pointed out in Dutch journals that the German **potash** industry will, after the war, face severe competition from Cataloma (Spain), Holland, and the United States. (P. 186)

Extensive deposits of **iron and nickel** ore have been discovered and are being developed in Celebes, Dutch East Indies. It is estimated that there are 350,000,000 tons of lateritic iron ore containing considerable chromium and nickel, and a large amount of ore containing 25 per cent of nickel. (P. 196)

It is expected that deposits of **tungsten ore** in Sweden will supply all Sweden's needs for 20 years. (P. 196)

A survey of the **potash situation** in Great Britain shows that the following sources of supply are actually meeting the demands: blast furnace dust, kelp, wool grease, and cement. It is estimated that 50,000 tons of potash can be obtained annually from the blast furnaces, with almost no additional cost, except for the small amount of sodium chloride added to the charge. The British Potash Company is one half controlled by the government and one half by the public. All blast furnace dust is under government control. (Pp. 198–200)

The manufacture of **lithopone** has been started in Italy. (P. 202)

Large amounts of tungsten ore are being exported from Hongkong. (P. 216)

A marked increase is noted in the imports of American dyestuffs into Japan. (P. 247)

It is reported that synthetic rubber is being manufactured successfully at Elberfeld, Germany. (P. 265)

By a new "cold" process paper pulp is being made in England from straw yielding 65 per cent of pulp instead of 40 per cent by the soda process. The new pulp will not bleach white, but it may be used up to 10 per cent in newsprint paper, of which it actually increases the strength. (P. 280)

A new explosive known as "sengite" is made in South Africa by the addition of sodium nitrate to guncotton. Considerable water may be left in the pressed mixture without decreasing its blasting power, but increasing its stability on handling. (P. 282)

The cellulose industry of Sweden shows a marked increase, especially of sulfite pulp. (P. 326)

Manganese ores are now being produced in Chihuahua, Mexico, in large quantities, and exported to the United States. The manganese content is from 40 to 48 per cent. (P. 356)

Paper yarn for textiles is now being used extensively in Germany where 88,000,000 lbs. per year are produced. Thread is being made which is suitable for coarse sacks, etc., but no fine threads. (P. 358)

EXPORTS TO THE UNITED STATES

SAMOA—Sup. 62a
Copra
Hides
Rubber

JAPAN—Sup. 55b
Graphite
Bean oil
Potato starch
Vegetable wax

HONDURAS—Sup. 31b
Balsam
Liquid amber
Copra
Hides
Indigo
Antimony ore
Gold
Silver
Sarsaparilla

FRANCE—Sup. 54
Aluminum
Borax
Carbon
Saffron
Casein
Glass
Hides
Essential oils
Olive oil
Peanut oil
Paper stock
Platinum
Zinc ore

NICARAGUA—Sup. 34a
Balsam
Copper
Fustic
Gold
Hides
Rubber
Silver
Sugar

CEYLON—P. 213)
Citronella oil
Croton seeds
Papain
Graphite
Rubber
Vanilla

DUTCH EAST INDIES—Sup. 53a
Copra
Damar
Gambier
Hides
Kapok
Coconut oil
Quinine
Rubber
Tin
Platinum
Paraffin
Indigo

BOOK REVIEWS

Organic Compounds of Arsenic and Antimony. By GILBERT T. MORGAN, D.Sc., Professor of Applied Chemistry, City and Guilds Technical College, Finsbury. 8vo., 376 pp. Longmans, Green & Company, London, England, 1918. Price, $4.80 net.

In this monograph Dr. Morgan presents in a well systematized manner the chemistry of the organic compounds of arsenic and antimony. The work as a whole discusses the development of this most complicated, but most interesting field of organic chemistry from the earliest discoveries to the most modern, including an account of all researches up to the end of 1917.

In the introduction the author gives a brief review of the more important discoveries, in their historical order, which have brought the chemistry of the arsenicals into its present important position in relation to medical science and the theory of chemistry.

In Chapter IV the author, starting with the classic work of Bechamp, develops the chemistry involved in the preparation of atoxyl and its closely allied derivatives; in Chapters V, VI, and VII he describes the developments which led to the discovery and use of salvarsan and neosalvarsan, and the more modern arsenicals, luargol, gallyl, etc. The detail of their preparation, as well as the chemistry involved, and the discussion of their use in the medical field are given.

In the later chapters the author treats of the preparation and properties of the more important organic compounds of antimony. In the appendix a discussion of the analytical methods for the determination of arsenic and antimony in their organic combinations is given, also a complete and accurate bibliography of the publications on the organic arsenicals and antimonials arranged in chronological order. The use of graphic formulas throughout the work to illustrate the constitution of these compounds and their relation one to another does a great deal towards helping the reader to a clear understanding of the subject.

The appearance of this book, the only complete and modern treatise on this subject in the English language, should be most welcome.

J. B. CHURCHILL

The Chemical Engineering Catalog—1918 Edition. 836 pp. Illustrated. Price, $5.00, or obtained by special arrangement with the Publishers, The Chemical Catalog Co., Inc., New York City.

One of the features of the Fourth National Exposition of Chemical Industries was a booth piled high with the volumes of the 1918 edition of the Chemical Engineering Catalog, ready for distribution, as a loan without cost, "to any Chemical Engineer, Chief Chemist, Industrial Plant Superintendent, Works Manager, Buyer, or Head of a Chemical Department in a University or College." The piles rapidly disappeared. Congratulations to the publishers upon the prompt appearance of this veritable Exposition in itself, in type and cut!

That the Chemical Catalog has proved its usefulness to the industry is attested by the following figures:

Year	Catalog Pages	Directory Pages	No. of Firms Using Space	Maximum No. Pps to One Firm	No. of Copies Printed
1916.....	205	74	132	8	8500
1917.....	347	154	247	18	8500
1918.....	578	210	439	20	10200

As in previous years, the volume is published under the supervision of a committee appointed by the American Institute of Chemical Engineers, the American Chemical Society, and the Society of Chemical Industry. This committee for the 1918 volume consisted of Messrs. Charles F. McKenna, *Chairman*, L. H. Baekeland, M. C. Whitaker, Raymond F. Bacon, William M. Grosvenor, Gustave W. Thompson, and William H. Nichols.

The present volume shows a large increase in the Chemicals and Materials Section, and a similar growth in the Equipment Section, including "pumps, packing, valves, and fittings of all kinds for the handling of steam, air, and liquids; belting, power transmission equipment, conveying, hoisting, and transporting machinery, etc."

For the first time a technical book department has been included, and a book purchasing service is offered the users of the Catalog.

The editors, with every reason to be proud of their achievement, waste no space in idle boasting, but frankly recognize the possibilities of error in so comprehensive a publication, and ask for friendly criticism and corrections.

The Catalog is an exemplification of the growth of the chemical industry and will be constantly consulted by those who bear the responsibility for further development of that industry.

CHAS. H. HERTY

NEW PUBLICATIONS

By CLARA M. GUPPY, Librarian, Mellon Institute of Industrial Research, Pittsburgh

Butter: Book of Butter; A Text on the Nature, Manufacture and Marketing of the Product. E. S. GUTHRIE. 12mo. 270 pp. Price, $1.75. The Macmillan Co., New York.

Chemical Directory: Annual Chemical Directory of the United States. B. F. LOVELACE AND C. C. THOMAS. 2nd Ed. 8vo. 534 pp. Price, $5.00. Williams and Wilkins, Baltimore.

Chemistry: Calculations of Inorganic Chemistry and Qualitative Analysis. ALEXANDER SMITH AND W. C. MOORE. 12mo. 106 pp. Price, $1.00. The Century Co., New York.

Chemistry: Future of Pure and Applied Chemistry; Presidential Address Delivered at the Annual General Meeting of the Chemical Society, March 21, 1918. W. J. POPE. 8vo. 12 pp. Chemical Society, London.

Chemistry: Outlines of Theoretical Chemistry. F. H. GETMAN. 2nd Ed. Revised and enlarged. 8vo. 539 pp. Price, $3.50. John Wiley and Sons, Inc., New York.

Chemistry: Précis de Chimie Industrielle. PIERRE CARRÉ. 976 pp. Price, 16 fr 50. Baillière et Fils, Paris.

Chemistry: Problems in Inorganic Chemistry. L. M. DENNIS. 8vo. 41 pp. Price, $0.25. W. F. Humphrey, Geneva, N. Y.

Chemistry: Treatise on Applied Analytical Chemistry. Volume 2. Translated by T. H. POPE, VITTORIO VILLAVECCHIA AND OTHERS. 8vo. Price, $6.00. P. Blakiston's Son & Co., Philadelphia.

Chemistry for Beginners. C. T. KINGZETT. 3rd Ed. 8vo. Price, 2s 6d Baillière et Fils, Paris.

Coal and Its Scientific Uses. W. A. BONE. 8vo. 491 pp. Price, $7.00. Longmans, Green & Co., New York.

Dyke's Automobile and Gasoline Engine Encyclopedia. The Standard Work on Motor Mechanism. 7th Ed. 8vo. Price, 21s. American Book Supply Co.

Electric Welding. D. T. HAMILTON AND E. V OBERG 8vo. 294 pp. Price, $2.50. Industrial Press, New York.

Fuel Economy in Boiler Rooms. A. R. MAUER AND C. H. BROMLEY. 2nd Ed. 8vo. 308 pp. Price, $2.50. McGraw-Hill Co., New York.

Handbook of Mechanical and Electrical Cost Data. H. P. GILLETTE AND R. T. DANA. 12mo. 1734 pp. Price, $6.00. McGraw-Hill Co., New York.

Metallurgy of Lead. H. O. HOFMAN. 8vo 664 pp. Price, $6.00. McGraw-Hill Co., New York.

Steam Wagon: Manual of the Steam Wagon. Maintenance, Overhauling, Garage, and Running Repairs. 8vo. 104 pp. Temple Press.

Temperature: Methods of Measuring Temperature. D. GRIFFITHS. 8vo. 176 pp. Price, $2.75. J. B. Lippincott Co., Philadelphia.

RECENT JOURNAL ARTICLES

Alcohol: A Simple and Rapid Method for the Estimation of Alcohol in Spirituous Liquors. NAGENDRA CHANDRA NAG AND PANNA LAL. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 18, p. 290t

Alloys of Silicon and Copper and Their High Electrical Conductivity. JAMES SCOTT *The Metal Industry*, Vol. 16 (1918), No. 10, pp. 464–465.

Automatic Engine Stops: Characteristics of Automatic Engine Stops. Why Speed Regulators Fail and Why Substitutes Should be Provided for Emergencies. WALTER GREENWOOD *The Blast Furnace and Steel Plant*, Vol. 6 (1918), No. 10, pp 405–407

Automobile Springs: Heat Treatment of Automobile Springs. M. E. HENDRICKSON. *The American Drop Forger*, Vol. 4 (1918), No. 10, pp. 407–410

Bleaching of Pulp and Paper. JAMES BEVERIDGE. *Paper*, Vol. 23 (1918), No. 8, pp. 11–15

Chemical Control of Water Softeners; A Discussion of the Reactions Involved in the Lime-Soda Ash Process and the Derivation of a Practical and Simple Field Routine Analysis. L. F. CLARK *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 9, pp. 674–677.

Chloramine-T: The Manufacture of Chloramine-T. J. K. H. INGLIS *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 18, pp. 288t–290t

Chlorine: Commercial Uses of Chlorine. V. R. KOKATNUR *Chemical and Metallurgical Engineering*, Vol. 19 (1918) No. 9, pp. 667–671

Chromic Oxide: Determination of Chromic Oxide in Chromite. W. C. RIDDELL AND ESTHER KITTREDGE *Mining and Scientific Press*, Vol. 117 (1918), No. 17, pp. 558–559.

Cleaning Foundry Air Electrically. H. D. EGGLEST *Iron Trade Review*, Vol. 63 (1918) No. 17, pp. 956–959

Colloids in Flotation. J. A. PEARCE. *Mining and Scientific Press*, Vol. 117 (1918), No. 15, pp. 491–492.

Color Tests of Chestnut Bark. T. C. CHESTERS. *Journal of the American Leather Chemists Association*, Vol. 13 (1918), No. 10, pp. 467–469.

Copper-Leaching by Salt Water and Sulfurous Gases. C. S. VADNER *Mining and Scientific Press*, Vol. 117 (1918), No. 14, pp. 457–458.

Crystalloluminescence. H. B. WEISER. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 7, pp. 480–509

Dust Abatement in Mines. W. O. BORCHERDT. *Engineering and Mining Journal*, Vol. 106 (1918), No. 18, pp. 783–786.

Dyeing: Application of Dyestuffs in Cotton Dyeing. J. M. MATTHEWS. *Color Trade Journal*, Vol. 3 (1918), No. 4, pp. 347–349. (See THIS JOURNAL, 10 (1918), 794.)

Dyeing: Use of Organic Dyestuffs for Lake Manufacture; Natural Dyes of Animal Origin. BARRINGTON DE PUYSTER. *Color Trade Journal*, Vol. 3 (1918), No. 4, pp. 339–342.

Electric Arc Welding, A New Industry. H. A. HORNER. *The American Drop Forger*, Vol. 4 (1918), No. 10, pp. 396–401.

Electrodes for Electric Furnaces; Their Manufacture, Properties, and Utilization. JEAN ESCARD. *General Electric Review*, Vol. 21 (1918), No. 10, pp. 664–671.

Ferro-Alloys. J. W. RICHARDS. *Engineering and Mining Journal*, Vol. 106 (1918), No. 18, pp. 787–790 (See THIS JOURNAL, 10 (1918), 851.)

Fertilizer: Manufacture of Fertilizers in Relation to Selling. J. E. BRECKENRIDGE. *The American Fertilizer*, Vol. 49 (1918), No. 9, pp. 25–28.

Foundryman's Iron Problem. C. J. STARK. *The Iron Trade Review*, Vol 63 (1918), No. 16, pp. 895–898.

Gold: Review of the Gold Problem. H. N. LAWRIE. *Mining and Scientific Press*, Vol. 117 (1918), No. 17, pp. 561–566.

Iron: La Guerre Pour le Minerai de Fer. H. LOUIS. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No. 17, pp. 333r–334r.

Iron: Malleable Reports for Examination. Engineering Properties of Malleable Iron Recommend It for Many Construction Uses; The Characteristics are Scientifically Presented and Its Uniformity is Established. H. A. SCHWARTZ. *The Iron Trade Review*, Vol. 63 (1918), No. 16, pp. 899–904

Lead Refining at the Bunker Hill Plant. C. T. RICE. *Engineering and Mining Journal*, Vol. 106 (1918), No. 18, pp. 771–777.

Lubrication: Problems of Steam Cylinder Lubrication. W. F. OSBORNE. *The Blast Furnace and St el Plant*, Vol. 6 (1918), No. 10, pp. 414–416.

Manganese: Pure Carbon-Free Manganese and Manganese Copper. A. F. BRAID. *The Metal Industry*, Vol. 16 (1918), No. 10, pp 457–458.

Microörganisms: Use of Microörganisms in Chemical Industry; Yeasts, Moulds, and Bacteria, Important Organic Chemicals Widely Used in Industry. E. G. GENOUD. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No. 8, pp. 616–617

Molybdenum: Recent Developments in Molybdenum L. F. S. HOLLAND. *Mining and Scientific Press*, Vol. 117 (1918), No. 16, pp. 529–531.

Nitrates: Determination of Nitrates in Caliche and Its Products. J. E. CLENNELL. *Engineering and Mining Journal*, Vol. 106 (1918), No. 15, pp. 660–663.

Osmotic Action of Solutions of Cane Sugar, Silver Nitrate, and Lithium Chloride in Pyridine, when Separated from Pyridine by a Rubber Membrane. A. E KOENIG. *Journal of Physical Chemistry*, Vol. 22 (1918), No. 7, pp. 461–479.

Oxidation of Ammonia. J. R. PARTINGTON. *Journal of the Society of Chemical Industry*, Vol. 37 (1918), No 17, pp. 337r–338r.

Platinum: Process for Recovering Platinum. V. J. ZACHERT. *Mining and Scientific Press*, Vol. 117 (1918), No. 15, pp. 489–490.

Potash as a By-Product in Iron and Cement Production. J. S. GRASTY *Manufacturers Record*, Vol. 74 (1918), No. 14, pp. 82–83.

Refractory Metals: Standardized Tests for Refractories; Determination of After-Contraction, Tests under Load, Thermal Expansion, and Crushing Strength of Refractory Metals Given. COSMO JOHNS. *The American Drop Forger*, Vol. 4 (1918), No. 10, pp. 410–413.

Reinforced Concrete versus Salt, Brine, and Sea Water; An Account Citing Many Examples of Failures in Reinforced Concrete and Showing the Cause to be Due to Electrolytic Corrosion of Reinforcements. H J. M. CREIGHTON. *Chemical and Metallurgical Engineering*, Vol. 19 (1918), No, 8, pp. 618–623.

Separating Barium from Strontium. JOHN WADDELL *Mining and Scientific Press*, Vol 117 (1918), No. 15, pp. 495–496.

Silica Brick: Making and Testing Silica Brick. R. J. MONTGOMERY *The Iron Trade Review*, Vol. 63 (1918), No. 18, pp. 1014–1016

Silicic Acid Gels. H. N. HOLMES. *Journal of Physical Chemistry*, Vol 22 (1918), No. 7, pp. 510–519

Sodium Sulfide in Cyanidation. F. WARTENWEILER *Mining and Scientific Press*, Vol 117 (1918), No. 18, pp. 594–595

Sugar in Chestnut Extract. C. T. GALEY AND OSCAR RIETHOF *Journal of the American Leather Chemists Association*, Vol 13 (1918), No. 10, pp. 470–476

Terry Differential Flotation Process. J. T. TERRY *Mining and Scientific Press*, Vol 117 (1918), No. 16, pp. 533–534

MARKET REPORT—NOVEMBER, 1918

WHOLESALE PRICES PREVAILING IN THE NEW YORK MARKET ON NOVEMBER 16, 1918

INORGANIC CHEMICALS

Acetate of Lime	100 Lbs.	nominal	
Alum, ammonia, lump	100 Lbs.	7.00	
Aluminum Sulfate, (iron free)	Lb.	4.50 @	4.75
Ammonium Carbonate, domestic	Lb.	nominal	
Ammonium Chloride, white	Lb.	19 @	20
Aqua Ammonia, 26°, drums	Lb.	nominal	
Arsenic, white	Lb.	9¼ @	17
Barium Chloride	Ton	70.00 @	80.00
Barium Nitrate	Lb.	12 @	14
Barytes, prime white, foreign	Ton	30.00 @	35.00
Bleaching Powder, 35 per cent	Lb.	4½ @	5
Blue Vitriol	Lb.	9½ @	9¼
Borax, crystals, in bags	Lb.	7¼ @	10¼
Boric Acid, powdered crystals	Lb.	7¾ @	8¾
Brimstone, crude, domestic	Long Ton	nominal	
Bromine, technical, bulk	Lb.	75 @	
Calcium Chloride, lump, 70 to 75% fused	Ton	20.00 @	22.00
Caustic Soda, 76 per cent	100 Lbs.	3.90 @	4.10
Chalk, light precipitated	Lb.	4¾ @	5
China Clay, imported	Ton	20.00 @	30.00
Feldspar	Ton	8.00 @	15.00
Fuller's Earth, foreign, powdered	Ton	nominal	
Fuller's Earth, domestic	Ton	20.00 @	30.00
Glauber's Salt, in bbls	100 Lbs.	2.10 @	3.00
Green Vitriol, bulk	100 Lbs.	2.00 @	2.25
Hydrochloric Acid, commercial, C. P.	Lb.	nominal	
Iodine, resublimed	Lb.	4.25 @	4.30
Lead Acetate, white crystals	Lb.	17 @	18
Lead Nitrate, C. P.	Lb.	85	
Litharge, American	Lb.	14 @	15
Lithium Carbonate	Lb.	1.50	
Magnesium Carbonate, U. S. P.	Lb.	20 @	30
Magnesite, "Calcined"	Ton	60.00 @	65.00
Nitric Acid, 40°	Lb.	7¾	
Nitric Acid, 42°	Lb.	8½	
Phosphoric Acid, 48/50%	Lb.	7½ @	9
Phosphorus, yellow	Lb.	1.10 @	1.15
Plaster of Paris	Bbl.	2.00 @	2.50
Potassium Bichromate	Lb.	44 @	46
Potassium Bromide, granular	Lb.	1.25 @	1.30
Potassium Carbonate, calcined, 80 @ 85%	Lb.	35 @	
Potassium Chlorate, crystals, spot	Lb.	40 @	41
Potassium Cyanide, bulk, 98–99 per cent	Lb.	nominal	
Potassium Hydroxide, 88 @ 92%	Lb.	60 @	70
Potassium Iodide, bulk	Lb.	3.75 @	4.00
Potassium Nitrate	Lb.	27 @	30
Potassium Permanganate, bulk, U. S. P.	Lb.	1.75 @	1.95
Quicksilver, flask	75 Lbs.	125.00 @	130.00
Red Lead, American, dry	100 Lbs.	11.25 @	11.50
Salt Cake, glass makers'	Ton	17.50 @	22.00
Silver Nitrate	Oz.	63½ @	65
Soapstone, in bags	Ton	10.00 @	12.50
Soda Ash, 58%, in bags	100 Lbs.	2.60 @	2.70
Sodium Acetate, broken lump	Lb.	20 @	21
Sodium Bicarbonate, domestic	100 Lbs.	4.10 @	4.25
Sodium Bichromate	Lb.	20 @	22½
Sodium Chlorate	Lb.	25 @	25½
Sodium Cyanide	Lb.	32 @	35
Sodium Fluoride, commercial	Lb.	17 @	18
Sodium Hyposulfite	100 Lbs.	2.60 @	3.60
Sodium Nitrate, 95 per cent, spot	100 Lbs.	4.42½ @	5.00
Sodium Silicate, liquid, 40° Bé		3¼ @	3½
Sodium Sulfide, 60%, fused in bbls	Lb.	11 @	12
Sodium Bisulfite, powdered		12 @	14
Strontium Nitrate	Lb.	25 @	30
Sulfur	100 Lbs.	2.25 @	4.60
Sulfuric Acid, chamber 66° Bé	Ton	18.00	
Sulfuric Acid, oleum (fuming)	Ton	32.00	
Talc, American white	Ton	15.00	
Terra Alba, American, No. 1	100 Lbs.	1.17½	
Tin Bichloride, 50°	Lb.	28 @	30
Tin Oxide	Lb.	90 @	1.00
White Lead, American, dry	Lb.	10 @	10¼
Zinc Carbonate	Lb.	18 @	20
Zinc Chloride, commercial	Lb.	15 @	15½

ORGANIC CHEMICALS

Acetanilid, C. P., in bbls	Lb.	65 @	70
Acetic Acid, 56 per cent, in bbls	100 Lbs.	9.30 @	9.55
Acetic Acid, glacial, 99½%	100 Lbs.	19.50 @	19.70
Acetone, drums	Lb.	25½ @	
Alcohol, denatured, 180 proof	Gal.	68 @	69
Alcohol, sugar cane, 188 proof	Gal.	4.90 @	4.95
Alcohol, wood, 95 per cent, refined	Gal.	91½ @	92
Amyl Acetate	Gal.	4.20 @	4.50
Aniline Oil, drums extra	Lb.	30 @	32
Benzoic Acid, ex-toluol	Lb.	3.00 @	3.25
Benzene, pure	Gal.	22 @	22½
Camphor, refined in bulk, bbls	Lb.	1.24½ @	1.25
Carbolic Acid, U. S. P., crystals, drums	Lb.	42 @	45
Carbon Bisulfide	Lb.	9 @	10
Carbon Tetrachloride, drums, 100 gals	Lb.	nominal	
Chloroform	Lb.	63 @	70
Citric Acid, domestic, crystals	Lb.	1.12 @	1.20
Creosote, beechwood	Lb.	2.00 @	2.10
Cresol, U. S. P.	Lb.	19 @	20
Dextrine, corn (carloads, bags)	Lb.	8 @	9
Dextrine, imported potato	Lb.	nominal	
Ether, U. S. P. 1900	Lb.	27 @	30
Formaldehyde, 40 per cent	Lb.	16¼	Gov't price
Glycerine, dynamite, drums extra	Lb.	60 @	62
Oxalic Acid, in casks	Lb.	41 @	43
Pyrogallic Acid, resublimed, bulk	Lb.	3.25 @	3.50
Salicylic Acid, U. S. P.	Lb.	85 @	95
Starch, corn (carloads, bags) pearl	100 Lbs.	6.00 @	7.00
Starch, potato, Japanese	Lb.	13 @	14
Starch, rice	Lb.	12½ @	13
Starch, sago flour	Lb.	9¾ @	10¾
Starch, wheat	Lb.	nominal	
Tannic Acid, commercial	Lb.	65 @	80
Tartaric Acid, crystals	Lb.	85 @	87

OILS, WAXES, ETC.

Beeswax, pure, white	Lb.	63 @	65
Black Mineral Oil, 29 gravity	Gal.	24 @	25
Castor Oil, No. 3	Lb.	35	
Ceresin, yellow	Lb.	17 @	18
Corn Oil, crude	100 Lbs.	16.75 @	17.75
Cottonseed Oil, crude, f. o. b. mill	Lb.	17½ @	—
Cottonseed Oil, p. s. y.	100 Lbs.	21.00 @	22.00
Menhaden Oil, crude (southern)	Gal.	1.15 @	1.25
Neat's-foot Oil, 20°	Gal.	3.45 @	3.55
Paraffin, crude, 118 to 120 m. p.	Lb.	9¾ @	10
Paraffin Oil, high viscosity	Gal.	40 @	41
Rosin, "F" Grade, 280 lbs	Bbl.	15.10 @	15.20
Rosin Oil, first run	Gal.	75 @	76
Shellac, T. N.	Lb.	68 @	70
Spermaceti, cake	Lb.	31 @	33
Sperm Oil, bleached winter, 38°	Gal.	2.23 @	2.25
Spindle Oil, No. 200	Gal.	38 @	40
Stearic Acid, double-pressed	Lb.	24 @	25
Tallow, acidless	Gal.	1.58 @	1.60
Tar Oil, distilled	Gal.	36 @	38
Turpentine, spirits of	Gal.	65 @	66½

METALS

Aluminum, No. 1, ingots	Lb.	33 @	34
Antimony, ordinary	Lb.	13¾ @	14
Bismuth, N. Y.	Lb.	3.50 @	3.65
Copper, electrolytic	Lb.	26 @	
Copper, lake	Lb.	26 @	
Lead, N. Y.	Lb.	8.05	
Nickel, electrolytic	Lb.	55 @	56
Platinum, refined, soft	Oz.	nominal	
Silver	Oz.	1.01½	
Tin, Straits	Lb.	nominal	
Tungsten (WO_3)	Per Unit	20.00 @	24.00
Zinc, N. Y.		9.40 @	9.60

FERTILIZER MATERIALS

Ammonium Sulfate	100 Lbs.	4.75 @	—
Blood, dried, f. o. b. New York	Unit	7.40 @	7.50
Bone, 3 and 50, ground, raw	Ton	37.00 @	37.50
Calcium Cyanamide	Unit of Ammonia	nominal	
Calcium Nitrate, Norwegian	100 Lbs.	—	
Castor Meal	Unit	—	
Fish Scrap, domestic, dried, f. o. b. works	Unit	7.25 and	20c
Phosphate, acid, 16 per cent	Ton	17.50 @	18.00
Phosphate rock, f. o. b. mine:	Ton	nominal	
Florida land pebble, 68 per cent	Ton	5.00 @	6.00
Tennessee, 78–80 per cent	Ton	7.00 @	8.00
Potassium "muriate," basis 80 per cent	Ton	300.00 @	310.00
Pyrites, furnace size, imported	Unit	nominal	
Tankage, high-grade, f. o. b. Chicago	Unit	6.75 @	6.80

AUTHOR INDEX

THE JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY
VOLUME X—1918

ABEL, J. J. A National Institute of Therapeutics and Pharmacology 969
ADAMS, E. Q. AND L. E. WISE. Photographic Sensitizing Dyes. Their Synthesis and Absorption Spectra. Dyestuff Symposium, Cleveland Meeting, A. C. S. 801
ALEXANDER, J. An Introduction to Theoretical and Applied Colloid Chemistry, by W. Ostwald. *Translated* by M. H. Fischer. (Book Review) 249
Introductory Address. Perkin Medal Award 148
The Chemistry of Colloids, by R. Zsigmondy. *Translated* by E. B. Spear. (Book Review) 250
ALSBERG, C. L. Drug Research and the Bureau of Chemistry 971
ANDERSON, E. AND R. J. NESTELL. Effect of Coal Ash on the Nature of Cement Mill Potash, 1030; *See* Potter and Cheesman 109
ANDERSON, R. P. Reagents for Use in Gas Analysis VII—The Determination of Benzene Vapor 25
AND M. H. KATZ. Reagents for Use in Gas Analysis VI The Absorption of Hydrogen by Sodium Oleate 23
ANDREWS, C. E. Para Cymene. 1 Nitration. Mononitrocymene, 1-CH_3, 2-NO_2, 4-$CH(CH_3)_2$ 453
ARNY, H. V. Annual Report of the Chemical Laboratory of the American Medical Association Vol. 10. Compiled by the American Medical Association. (Book Review) 668
AULD, S. J. M. Methods of Gas Warfare. Address 297

BACHMANN, F. M. The Use of Microorganisms to Determine the Preservative Value of Different Brands of Spices 121
BACON, R. F. French Section American Chemical Society. Note 1023
BAILEY, H. S. AND J. M. JOHNSON. The Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon 999
BAKER, H. A. The Canning Industry—Some Accomplishments and Opportunities along Technical Lines 69
BAKER, J. T. Reagents and Reactions, by E. Tognoli. (Book Review) 667
BAKER, N. D. Transfer of the Experiment Station at American University to the War Department, 654; *See* Wilson 654
BAKER, R. T. Platinum Wanted by the Government. Note 867
BAMMAN, F. C. Correspondence with C. L. Parsons on "Saving Fats from Garbage." 320
BANCROFT, W. D. Chemical Warfare Research. Address, Cleveland Meeting, A. C. S. 785
BARKER, H. H. The Bisulfate Method of Determining Radium 525
BASKERVILLE, C. Sir Wm. Ramsay as a Scientist and Man, by T. C. Chaudhuri. (Book Review) 962
BECKMAN, J. W. Chemistry for Soldiers in Training Camps. Note 869
BELL, J. M. A Manual of Chemical Nomography, by H. G. Deming. (Book Review) 668
BENSON, H. K. Chemistry of Materials, by R. B. Leighou. (Book Review) 666
BERGEIM, O. AND J. O. HALVERSON. The Preparation of *N*/100 Permanganate Solutions 119
BIESTERFELD, C. H. AND O. L. EVENSON. A Study of the Estimation of Fat in Condensed Milk and Milk Powders Correction 159
BLAKE, A. F. An Alinement Chart for the Evaluation of Coal, 627; Correction 948
BLAKELEY, A. G. AND H. GEIST. Some Results of Analysis of Airs from Mine Fire 552
BLASDALE, W. C. Equilibria in Solutions Containing Mixtures of Salts I—The System Water and the Sulfates and Chlorides of Sodium and Potassium 344
The Separation of the Chlorides and Sulfates of Sodium and Potassium by Fractional Crystallization 347
BLEININGER, A. V. Recent Developments in Ceramics. Address, Chemical Exposition 844
BOGERT, M. T. Collar Insignia for Chemical Warfare Service 655
Cooperation of American Chemical Society with the Chemical Service Section 581
Message, Wm. H. Nichols Medal Award 312
Special Chemicals and Apparatus Available through the Chemistry Committee of the National Research Council. Note 158
BOGGS, C. R. Vulcanization of Rubber by Selenium 117
BOYLES, F. M. The Determination of Essential Oils in Non-Alcoholic Flavoring Extracts 537
BRADLEY, L. Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation Address, Chemical Exposition 834
BRAND, C. J. The Bureau of Markets in its Relation to the Conservation of Foods 66
BRECKENRIDGE, J. E. The American Fertilizer Handbook for 1918. (Book Review) 962
BREITHUT, F. E. Census of Chemists, 946; *See* Chemical Warfare Service 683
BREWSTER, J. F. Method of Enzyme Action, by J. Beatty (Book Review) 504
BROOKS, B. T. D. F. SMITH AND H. ESSEX. The Manufacture of Amyl Acetate and Similar Solvents from Petroleum Pentane 511
BROTHER, G. H. Suggestions on Some Common Precipitations 129
BROWN, R. P. The Automatic Control and Measurement of High Temperatures 133
BROWNE, C. A. The Deterioration of Raw Cane Sugar A Problem in Food Conservation 178
The Polariscope Situation and the Need of an International Saccharimetric Scale 916
BURTON, W. M. Chemistry in the Petroleum Industry. Medal Address. Willard Gibbs Medal Award 484
BUSHNELL, L. D. The Influence of Cold Shock in the Sterilization of Canned Foods 432

CAIN, J. R. AND L. C. MAXWELL. Rapid Determination of Carbon in Steel by the Barium Carbonate Titration Method 520
CAMPBELL, E. DEM. II—On the Influence of the Temperature of Burning on the Rate of Hydration of Magnesium Oxide 595
CAPPS, J. H. AND G. B. TAYLOR. Effect of Acetylene on Oxidation of Ammonia to Nitric Acid 457
AND A. S. COOLIDGE. The Production of Nitric Acid from Nitrogen Oxides 270
CAROTHERS, J. N. Electric Furnace Smelting of Phosphate Rock and Use of the Cottrell Precipitator in Collecting the Volatilized Phosphoric Acid, 35; Correction 239
CHAMOT, E. M. Chemical Microscopy. Address 60
AND H. I. COLE. The Use of Textile Fibers in Microscopic Qualitative Chemical Analysis 48
CHANDLER, C. F. Arthur Henry Elliott. Obituary 498
Dr. Nichols—Leader in Chemical Industry 92
CHAPIN, E. S. Natural Dyestuffs—An Important Factor in the Dyestuff Situation. Dyestuff Symposium, Cleveland Meeting, A. C. S. 795
CHAPIN, R. M. The Preparation and Testing of Pure Arsenious Oxide 522
CHAPIN, W. H. A Rapid Pressure Method for the Determination of Carbon Dioxide in Carbonates 527
CHARLTON, H. W. Recovery of Potash from Greensand 6
CHEESMAN, R. D. AND N. S. POTTER, JR. Effect of Coal Ash on the Liberation and Nature of Cement Mill Potash, 109; *See* Letters. 1030
CHURCH, S. R. A Manufacturer's Experience with Graduate Chemical Engineers 1019
CHURCHILL, J. B. Organic Compounds of Arsenic and Antimony, by Morgan. (Book Review) 1038
CLARK, A. N. A Quick Method for Lime Cake Analysis 51
CLARK, A. W. AND L. DUBOIS. Jelly Value of Gelatin and Glue 707
CLARKE, H. T. Examination of Organic Developing Agents 891
CLASSEN, C. H. An Automatic Hydrogen Sulfide Stopcock 131
CLOUKEY, H. AND R. C. PALMER. The Influence of Moisture on the Yield of Products in the Destructive Distillation of Hardwood 262
COLE, H. I. AND E. M. CHAMOT. The Use of Textile Fibers in Microscopic Qualitative Chemical Analysis 48
COLE, W. H. Conversion of Formulas 555
COLLINS, W. D. Arsenic in Sulfured Food Products 360
CONNER, S. D. Determination of the Value of Agricultural Lime 996
COOK, A. A. AND A. G. WOODMAN. The Detection of Vegetable Gums in Food Products 530
COOKE, R. D. Chemistry for the Public. Note 752
COOLIDGE, A. S., G. B. TAYLOR AND J. H. CAPPS. The Production of Nitric Acid from Nitrogen Oxides 270
CORNELISON, R. W. On Reproducing Beilstein's *Handbuch der Organischen Chemie*. Note, 867. *See* Editorial, Turn About is Fair Play 672
CRANE, E. J. Chemical Research in the Various Countries before the War and in 1917. Note 236
The Indexes to *Chemical Abstracts*. Note 237
CUSHMAN, A. S. Antimony Sulfide as a Constituent in Military and Sporting Arms Primers 376

DAUGHTERS, M. R. The Loganberry and the Acid Content of its Juice 30; Correction 159
The Seeds of the *Echinocystis Oregana* 126
DAVIDSON, J. G. The Formation of Aromatic Hydrocarbons from Natural Gas Condensate 901
DAVIS, A. B. The Distillation of Resins, by V. Schweizer. *Translated* by H. B. Stocks (Book Review) 249
DAVIS, H. S. AND M. D. DAVIS. A New Method for the Quantitative Estimation of Vapors in Gases A Differential Pressure Method. Studies on the Absorption of Light Oils from Gases 709, 718
AND D. G. MACGREGOR The Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases 712
DAVIS, J. D. AND G. B. TAYLOR Chemical Control of Ammonia Oxidation Note, 159; *See* Fox 155
DAVIS, M. D. AND H. S. DAVIS. A New Method for the Quantitative Examination of Vapors in Gases A Differential Pressure Method Studies on the Absorption of Light Oils from Gases 709, 718
AND D. G. MACGREGOR The Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases 712
DAVISSON, B. S. Ammonia and Nitric Nitrogen Determination in Soil Extracts and Physiological Solutions 600
DEAN, E. W. A Convenient Electric Heater for Use in the Analytical Distillation of Gasoline 823
DELANEY, C. R. The Manufacture, Use, and Newer Developments of the Natural Dyestuffs. Dyestuff Symposium, Cleveland Meeting, A. C. S. 798
DEMARTIN, F. New Publications 89, 169, 251, 333, 415, 505, 587, 669, 765
DE ROOF, A. JR. Potash from Searles Lake Address, Chemical Exposition 839
DODGE, C. A. AND E. L. KNOBELER Recovery of Solvents from Air Vapor Mixtures 593

DODGE, F. D. On Constituents of Oil of Cassia. II ... 1005
DORSEY, C. A. An American Emblem for American Chemists ... 653
DOWELL, C. T. AND W. G. FRIEDEMAN. The Use of Sodium Sulfate in the Kjeldahl-Gunning Method ... 599
DOWNS, C. R. AND J. M. WEISS. Notes on "Free Carbon" of Tar ... 400
AND C. G. STUPP. The Determination of Phthalic Anhydride in Crude Phthalic Acid ... 596
DUBOIS, L. AND A. W. CLARK. Jelly Value of Gelatin and Glue ... 707
DUKELOW, H. AND R. STEVENSON. Research on the Detection of Added Water in Milk ... 26
DUSCHAK, L. H. Address. Dedication of Gilman Hall, University of California ... 393

EARLE, R. B. Report of Committee on Organic Accelerators, Rubber Section, A. C. S., 865. *See* Council Meeting, Cleveland Meeting, A. C. S. ... 772
EDSON, H. A. Effect of Frost and Decay upon the Starch in Potatoes ... 725
EGGE, W. A. AND E. P. HARDING. A Proximate Analysis of the Seed of the Common Pigweed, *Amaranthus Retroflexus* L. ... 529
EGLOFF, G. Toluol by Cracking Solvent Naphtha in Presence of Blue Gas ... 8
ELDRED, F. R. An Institute of Therapo Chemical Research ... 973
ELLIOTT, F. A. AND S. E. SHEPPARD. The Reticulation of Gelatin ... 727
EMERY, W. O. AND G. C. SPENCER. Studies in Synthetic Drug Analysis. V—Estimation of Theobromine ... 605
AND C. D. WRIGHT. Studies in Synthetic Drug Analysis. VI—Evaluation of Hexamethylenetetramine Tablets ... 606
ENGEL, R. French Section, American Chemical Society ... 575
ERDAHL, B. F. The Concentration of Potash from Raw Materials Containing Only a Trace of this Element by Means of the Electric Precipitation of Flue Dust and Fume Cement Kilns ... 356
ESSELEN, G. J., JR. Airplane Dopes ... 135
ESSEX, H. R. T. BROOKS AND D. F. SMITH. The Manufacture of Amyl Acetate and Similar Solvents from Petroleum Pentane ... 511
EVANS, W. L. Library for Edgewood Arsenal Laboratory. *See* Letters ... 868
EVENSON, O. L. AND C. H. BIESTERFELD. A Study of the Estimation of Fat in Condensed Milk and Milk Powders. Correction ... 159

FALCONER, J. British Progress in Dyestuff Manufacture ... 145
FIELD, A. J. The Determination of Acetone ... 552
FIELDNER, A. C. The Storage of Bituminous Coal, by H. H. Stoek. (Book Review) ... 668
FISHER, H. L. A Special Valve for Dropping Liquids Arranged for Equalizing the Pressures above and below the Outlet in the Stopcock ... 1014
FITZGERALD, F. A. Mr. A. J. Rossi and His Work. Address. Perkin Medal Award ... 138
FOLLETT, H. L. G. FORMANEK, C. T. LINCOLN AND G. W. KNIGHT. Estimation of Phenol in the Presence of the Three Cresols. 9; Correction ... 239
FOOTE, H. W. A Summary of the Literature on the Solubility of Systems Related to Niter Cake ... 896
FORMANEK, G. C. T. LINCOLN, G. W. KNIGHT AND H. L. FOLLETT. Estimation of Phenol in the Presence of the Three Cresols, 9; Correction ... 239
FOX, P. J. Chemical Control of Ammonia Oxidation. Note, 155. *See* Taylor and Davis ... 156
FREAR, W. James Henry Shepard. Obituary ... 499
FREELAND, E. C. AND F. W. ZERBAN. On the Preparation of an Active Decolorizing Carbon from Kelp ... 812
FRERICHS, F. W. Relation between Efficiency of Refrigerating Plants and the Purity of their Ammonia Charge ... 202
FREY, R. W. AND J. S. ROGERS. A Volumenometer ... 554
FRIEDEMAN, W. G. AND C. T. DOWELL. The Use of Sodium Sulfate in the Kjeldahl Gunning Method ... 599
FULLER, A. V. An Improved Automatic Pipette-Washing Device ... 297

GEIST, H. H. AND A. G. BLAKELEY. Some Results of Analysis of Airs from a Mine Fire ... 552
GEORGE, J. Platinum Resolution by the State Council of Defense for California ... 656
GIBBS, H. D. The Color Laboratory of the Bureau of Chemistry, Dyestuff Symposium, Cleveland Meeting, A. C. S. ... 802
GILL, A. H. Aids in the Commercial Analysis of Oils Fats and their Commercial Products. A Laboratory Handbook, by G. P. Pickering. (Book Review) ... 666
American Lubricants, by L. B. Lockhart. (Book Review) ... 504
Lubricating Engineer's Handbook, by J. R. Battle. (Book Review) ... 168
The Occurrence of Carotin in Oils and Vegetables ... 612
GILLETT, H. W. AND A. E. RHOADS. A Rocking Electric Brass Furnace ... 459
GOLDTHWAIT, C. F. The Journals of the American Chemical Society. Note ... 1026
GOLER, G. W. The Debt of Preventive Medicine to Chemistry. Address ... 303
GOODWIN, G. J. The Sulfuric Acid Industry ... 751
GRAY, G. T. The Consumption and Cost of Economic Poisons in California in 1916. Address ... 301
GRAY, H. LE B. A Test for Wool ... 633
Reduction in Waste. *See* Letters ... 153
GRAY, J. G. I. KELLEY, M. G. SPENCER AND C. B. ILLINGWORTH. Determination of Manganese in Steel in Presence of Chromium and Vanadium by Electrometric Titration ... 19
GREAVES, J. E. AND C. T. HIRST. The Composition of the Water of the Intermountain Region ... 1001
GRIGNARD, V. The Collaboration of Science and Industry. Address. Translation ... 137
GUPPY, C. M. New Publications ... 875, 963, 1039

HAIGH, L. D. Variation in the Ether Extract of Silage ... 127
HALE, W. J. Resolution Concerning Organic Nomenclature. Note ... 944
HALL, W. T. Standard Methods of Chemical Analysis. *Edited* by W. W. Scott. Book Review ... 250
HALLAND, A. H. On the Quantitative Analysis of Dyestuffs. Dyestuff Symposium, Cleveland Meeting, A. C. S. ... 804
HALVERSON, I. O. AND J. BERGLUND. The Preparation of N/100 Permanganate Solutions ... 119
HAMOR, W. A. A Letter from France ... 495
HARDING, E. P. AND H. RINGSTROM. A Comparison of the Proximate and Mineral Analysis of Desiccated Skim Milk with Normal Cows' Milk ... 295
AND W. A. EGGE. A Proximate Analysis of the Seed of the Common Pigweed, *Amaranthus Retroflexus* L. ... 529
HART, E. An Evaporator for Acid Liquids ... 555
The Utilization of Niter Cake. Note ... 238
HART, R. An Improved Distillation Method for the Determination of Water in Soap ... 598
HEALY, J. R. Licenses Required for Explosives and their Ingredients. Note ... 237
HEBDEN, J. C. Dyers of Khaki in the United States. Address ... 640
HEIDENHAIN, H. Critical Elaboration of Quantitative Precipitation Methods Exemplified by a Method for the Determination of Phosphoric Acid ... 426
HENDRICK, E. L. Address. Annual Meeting of Chemists' Club ... 489
HENDRICKSON, N. AND G. C. SWAN. Determination of Loosely Bound Nitrogen as Ammonia in Eggs ... 614
HERRESHOFF, J. B. F. Sulfuric Acid Handbook, by T. J. Sullivan. (Book Review) ... 960
HERTY, C. H. Introductory Address. Wm. H. Nichols Medal Award ... 305
Chemical Engineering Catalog, 1918 Edition. (Book Review) ... 1038
Permanent Chemical Independence. Address. Chemical Exposition ... 826

UNSIGNED EDITORIALS
A Chemists' Club for France ... 2
A Dyestuff Section of the American Chemical Society ... 674
A French Local Section ... 510
A Golden Opportunity ... 967
A Long Step in the Right Direction ... 172. *See* Somebody Please Cut the Tape ... 94
A Patent Abuse ... 173
A Record of Achievement ... 879
A Regrettable Inversion of the Directors ... 4
A Special Meeting of the Council ... 967
A Victory of Arms, Not Yet of Ideals ... 966
America in Safe Hands ... 416
An Appreciation and a Greeting ... 98
An Army without Reserves ... 508
An Embargo on Research Work ... 968
An Experiment in Publicity ... 967
An Inglorious Rout ... 419
An International Courtesy ... 673
Another Idol Shattered ... 880
By Order of the President ... 590
Camp Followers ... 255
Chemistry Insignia ... 95
Commissions for Baseball Players ... 879
Conservation Begins at Home ... 879
Developments in Ceramics ... 878
Facts for the Tariff Commission ... 175
Four Days More ... 336
Important Notice. Licenses Required for Explosives and their Ingredients ... 256
Living from Hand to Mouth ... 591
National Self-Contaimedness ... 966
No Change in Exposition Plans ... 673
On With the Investigation ... 93
Organization within the Dyestuff Industry ... 256
Pernicious Activity ... 880

Platinum:
Platinum at White Heat ... 508
Platinum Oscillations ... 95
Platinum Scraps ... 336
The Great Gamble ... 419
Political but not Politics ... 590
Preparation for after the War ... 878
Progress in Selective Service ... 3
Prophecy and Fulfilment ... 419
Publicity Work to be Continued ... 338
Research and the Tar Baby ... 420d
Secretary Crowell at Cleveland ... 672
Somebody, Please Cut the Tape ... 94
Spruce Turpentine ... 4
Spruce Turpentine to the Fore ... 174
Sugar and Soap ... 175
The Approaching Exposition ... 592
The Bull's Eye ... 674
The Chemical Alliance ... 3
The Chemical Service Section of the National Army ... 2
The Chemistry Rainbow ... 254
The Chemists' Club ... 338
The Cleveland Meeting ... 591
The Custodian in Action ... 673
The Demise of the "Garabed" ... 590
The Great Gamble ... 419
The Missing Five Thousand ... 5
The Modern Miracle ... 508
The Naval Consulting Board ... 175
The Parting of the Ways ... 254
The Return of the Chemists ... 968
Typical German Pronouncements ... 420
Turn About is Fair Play ... 672
War Chemistry in the Alleviation of Suffering ... 673
Washington Notes ... 418
Wasting Waters ... 174
What's in a Name? ... 255
Where are the Leaders? ... 172
Wood Waste ... 256
HESSE, R. C. Our Preparation for After the War. Address, 881; *See* Editorial ... 878
Report on Census of Chemical Imports ... 773
HIGGINS, C. A. Recovery of Potash from Kelp. Address. Chemical Exposition ... 832
Solvents from Kelp. Address. Chemical Exposition ... 858
HILDEBRAND, J. H. The Extraction of Potash and Other Constituents from Sea Water Pattern ... 96
HILL, C. W. College Courses for Industrial Chemists. Address ... 640
HILL, R. A. Importance of Chemists Recognized by Secretary of War ... 880
HILLEBRAND, W. F. Government Control of Platinum. Note ... 336

HILTNER, R. S. AND C. E. PARKER. An Improved Method for Determining Citral. A Modification of the Hiltner Method..... 608
HIRSCH, A. The Pyrophoric Alloy Industry. Address, Chemical Exposition..... 849
HIRST, C. T. AND J. E. GREAVES. The Composition of the Water of the Intermountain Region..... 1001
HIXSON, A. W. AND R. H. MCKEE. Study of the Conditions Essential for the Commercial Manufacture of Carvacrol..... 982
HOPKINS, O. P. Chemical Markets in the Union of South Africa.. 887
Chemical Markets of South America:
Argentina, Brazil, and Uruguay..... 701
Chile, Peru, and Bolivia..... 803
Colombia, Ecuador, the Guianas, Venezuela, and Paraguay..... 977
Effect of the War on American Chemical Trade..... 692
Our Publications and Their Bearing on the Chemical Industry. Symposium: Bureau of Foreign and Domestic Commerce and Its Relations to American Chemical Industry..... 933
HORNE, W. D. Valuation of Raw Sugars..... 809
HORNSBY, J. W. Potash from Desert Lakes and Alunite. Address, Chemical Exposition..... 838
HOWE, H. E. Minutes of Sessions, Division of Industrial Chemists and Chemical Engineers, Cleveland Meeting, A. C. S..... 865
HOWE, J. L. As to Platinum Note..... 159
HUDSON, C. S. American Sources of Supply for the Various Sugars. Address..... 176
AND F. B. LAFORGE. The Preparation of Several Useful Substances from Corn Cobs..... 925
HUFF, W. J. Some Applications of Physical Chemistry in the Coal-Tar Industry..... 1016
HURLEY, E. N. Communication from U. S. Shipping Board, 864; *See* Council Meeting, Cleveland Meeting, A. C. S..... 772

ILLINGWORTH, C. B., G. L. KELLEY, M. G. SPENCER AND T. GRAY. Determination of Manganese in Steel in the Presence of Chromium and Vanadium by Electrometric Titration..... 19

JACOBSEN, J. Pipette Used in Titration of Oils for Acidity..... 633
JAMES, C. C. Reverted Phosphate..... 33
JAMIESON, G. S. The Determination of Arsenic in Insecticides by Potassium Iodate..... 290
JAYNE, D. W. Institute for Research on Synthetic Drugs..... 975
JOHLIN, J. M. An Aspirator..... 632
JOHNSON, J. M. AND H. S. BAILEY. The Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon..... 999
JOHNSON, M. O. Reaction of Hawaiian Soils with Calcium Bicarbonate Solutions, Its Relation to the Determination of Lime Requirements of Soils, and a Rapid Approximate Method for the Determination of Lime Requirements of Soils..... 31
JOHNSON, T. B. Address of Acceptance. Wm. H. Nichols Medal Award..... 306
The Development of Pyrimidine Chemistry. Medal Address. Wm. H. Nichols Medal Award..... 306
JOHNSTON, J. A Summary of the Proposals for the Utilization of Niter Cake..... 468
JONES, G. The Tariff Commission and the Dye Industry. Address..... 232
War Disturbances and Peace Readjustments in the Chemical Industries. Address, Cleveland Meeting, A. C. S..... 783

KATZ, M. H. AND R. P. ANDERSON. Reagents for Use in Gas Analysis. VI—The Absorption of Hydrogen by Sodium Oleate.. 23
KEITT, T. E. AND H. E. SHIVER. A Study of Sources of Error Incident to the Lindo-Gladding Method for Determining Potash.. 994
A Study of the DeKroode Method for the Determination of Potash in Fertilizer Materials..... 219
KELLEY, G. L., M. G. SPENCER, C. B. ILLINGWORTH AND T. GRAY. Determination of Manganese in Steel in the Presence of Chromium and Vanadium by Electrometric Titration..... 19
KERR, R. H. Chemical Tests for the Detection of Rancidity..... 471
KIPLINGER, C. C. A Device to Insure Tight Connections between Glass and Rubber Tubing..... 631
KNECHT, M. The Great Effort of the French Industries. Address 423
KNIGHT, G. W., C. T. LINCOLN, G. FORMANEK AND H. L. FOLLETT. Estimation of Phenol in the Presence of the Three Cresols, 9; Correction..... 239
KNOEDLER, E. L. AND C. A. DODGE. Recovery of Solvents from Air-Vapor Mixtures..... 593
KOBER, P. A. Technical Applications of Ebullioscopy. Address.. 556
KRESS, O. AND C. K. TEXTOR. Some Experiments on the Pulping of Extracted Yellow Pine Chips by the Sulfate Process..... 268
KUNZ, G. F. Platinum Resolutions Note..... 159

LAFORGE, F. B. AND C. S. HUDSON. The Preparation of Several Useful Substances from Corn Cobs..... 925
LAIRD, C. N. The Potteries at Shek Waan, Near Canton, China. Address..... 568
LANGMUIR, A. C. The Chemist's Pocket Manual, by R. K. Meade. (Book Review)..... 960
LEECH, P. N. Examination of American-Made Acetylsalicylic Acid.. 288
LEMAISTRE, F. J. Conditions of the French Chemical Industries during 1916. Address..... 421
LEVENE, P. A. An Institute for Chemotherapy..... 970
LEWIS, H. F. The Quantitative Estimation of Anthraquinone.... 428
LINDBERGER, S. C. Carborundum Refractories. Address. Chemical Exposition..... 847
LINCOLN, C. T., G. W. KNIGHT, G. FORMANEK AND H. L. FOLLETT. Estimation of Phenol in the Presence of the Three Cresols, 9; Correction..... 239
LITTLE, A. D. Cellulose—An Outline of Chemistry of Structural Elements of Plants, by Cross and Bevan. (Book Review)..... 960
LORENTHAL, A. S. Institute for Research in Synthetic Organic Chemistry..... 971
LUBS, H. A. Detection of Added Color in Butter or Oleomargarine 156

MACDOWELL, C. H. The Work of the Chemical Section of the War Industries Board. Address, Cleveland Meeting, A. C. S..... 780
MACGREGOR, D. G., H. S. DAVIS AND C. D. DAVIS. The Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light-Oil Content of Gases..... 712
MAINS, G. H. AND H. E. PATTEN. Corrosion Studies. II. The Carbonation of Distilled Water..... 279
MARSHALL, A. E. Avoidable Waste in the Production of Sulfuric Acid by the Chamber Process Note..... 156
MASON, W. P. Chemical Engineering in our Universities. 753; *See* Zoller..... 645
MATOS, L. J. America's Progress in Dyestuffs Manufacturing. Dyestuff Symposium, Cleveland Meeting, A. C. S..... 790
MATTHEWS, J. M. Application of Dyestuffs in Cotton Dyeing. Dyestuff Symposium, Cleveland Meeting, A. C. S..... 794
MAXWELL, L. C. AND J. R. CAIN. Rapid Determination of Carbon in Steel by the Barium Carbonate Titration Method..... 520
MCBRIDE, R. S. Government Publications:
84, 165, 245, 331, 408, 503, 586, 662, 758, 873, 954, 1037
Toluol Recovery and Standards for Gas Quality..... 111
MCDOWELL, A. H. Some Methods of Analysis for Nebraska Potash Salts and Brines..... 128
MCELROY, K. P. Chemical Patents and Allied Patent Problems, by E. Thomas. (Book Review)..... 167
Product Patents..... 257
MCGRATH, S. J. On Reproducing Beilstein's Handbuch der Organischen Chemie. Note, 867; *See* Editorial, Turn About is Fair Play..... 672
MCHARGUE, J. S. Uniform Nitrogen Determination in Cottonseed Meal..... 533
MCKAY, G. P. AND G. G. NASMITH. The Fertilizing Value of Activated Sludge, 339; *See* Rudnick..... 400
MCKEE, R. H. Laboratory Guide of Industrial Chemistry, by A. Rogers. (Book Review)..... 250
AND A. W. HIXSON. Study of the Conditions Essential for the Commercial Manufacture of Carvacrol..... 982
MCMILLAN, A. Current Industrial News Items:
73, 150, 228, 312, 394, 487, 572, 648, 744, 861, 937, 1020
Van Nostrand's Chemical Annual, *Edited* by J. C. Olsen and M. P. Matthias. (Book Review)..... 962
MEES, C. E. K. Chemicals for Research Work. Note..... 1027
Organic Reagents for Research and Industry..... 656
Planning a Research Laboratory for an Industry. Address..... 476
MERRILL, C. W. The Ammonia Program for 1918..... 480
MERZ, A. R. Direct Heat Treatment of Cement Mill Dust to Increase Its Water-Soluble Potash Content..... 106
Russia's Production of Platinum..... 920
METZGER, F. J. The Chemists' Club. Communication and Questionnaire..... 338
MORSE, F. W. Effect of Fertilizers on Hydrogen-Ion Concentration in Soils..... 125
MOUNT, G. The Association of British Chemical Manufacturers.... 495
MUNN, W. F. Determination of Acetic Acid by Distillation with Phosphoric Acid..... 550
New Portable Hydrogen Sulfide Generator..... 130
MUNROE, C. E. Explosives, by A. Marshall. (Book Review)..... 167
MYERS, C. A., JR. A New Timing Device for Simplifying the Thermometric Reading of Calorimetric Determinations..... 1015

NASMITH, G. G. AND G. P. MCKAY. The Fertilizing Value of Activated Sludge, 339; *See* Rudnick..... 400
NESTELL, R. J. AND E. ANDERSON. Effect of Coal Ash on Nature of Cement Mill Potash, 1030; *See* Potter and Cheesman..... 109
NICHOLS, B. G. AND W. D. TURNER. An Inexpensive Ash Leaching Plant..... 374
NICHOLS, W. H. A Retrospect and an Application. President's Address, Cleveland Meeting, A. C. S..... 768
Platinum Resolution by the Argentine Chemical Society. Note, 323; *See* Schaefer..... 323
Presentation Address. Perkin Medal Award..... 140
Presentation Address, Wm. H. Nichols Medal Award..... 305
Ramsay Memorial Fund. Note..... 236
NORTHRUP, Z. An Anaerobic Culture Volumeter..... 624
NOYES, H. A. Comparison of Percentages of Nitrogen in Tops and Roots of Head Lettuce Plants..... 621

OBERFELL, G. G. Testing Natural Gas for Gasoline..... 211
OESPER, R. E. Cooperation between Manufacturers and Universities Note..... 1027
OLSEN, J. C. Reports of American Institute of Chemical Engineers Meetings:
10th Annual Meeting, St. Louis, December 5 to 8, 1917..... 77
10th Semi-Annual Meeting, Gorham and Berlin, N. H., June 19 to 22, 1918..... 651
O'NEILL, E. Dedication of Gilman Hall, University of California. Introductory Address..... 391

PALKIN, S. The Identification and Determination of Potassium Guaiacol Sulfonate..... 610
PALMER, A. M. Cooperation Requested by Alien Property Custodian. Note..... 947
PALMER, R. C. The Effect of Catalyzers on the Yield of Products in the Destructive Distillation of Hardwoods..... 264
The Effect of Incomplete Distillation on the Yield of Products in the Destructive Distillation of Birch..... 260
AND H. CLOCKEY. The Influence of Moisture on the Yield of Products in the Destructive Distillation of Hardwood..... 262
PARKER, C. E. AND R. S. HULTNER. An Improved Method for Determining Citral. A Modification of the Hiltner Method..... 608
PARKHURST, J. P. The Effect of Annealing on the Electrical Resistance of Hardened Carbon Steels..... 515
PARR, S. W. Methods for the Commercial Sampling and Analysis of Coal, Coke, and By-Products. Compiled by the Chemical Sub-Committee of the United States Steel Corporation under the Direction of J. M. Camp. Book Reviews..... 666
PATTERSON, H. S. American Chemical Society Pin..... 80
An Opportunity to Help the French. Note..... 1024
Cleveland Meeting, A. C. S. Note..... 651
Letter Concerning Chemists in War Service (With No Revised Statement by W. H. Walker..... 321
Spring Meeting of the American Chemical Society. Note..... 236
The American Chemist in Wartime. Address, Cleveland Meeting, A. C. S..... 776
PATTEN, H. E. AND G. H. MAINS. Corrosion Studies. II. The Carbonation of Distilled Water..... 279
PATTERSON, A. M. Chemical Frenchi, by M. L. Dolt. (Book Review)..... 961

PEARL, R. Statistics of Garbage Collection and Garbage Grease Recovery in American Cities ... 927
PERRY, R. P. Coal Gas Residuals, by F. H. Wagner. Book Review ... 667
PETERKIN, A. G., JR. Synthetic Phenol ... 738
PETIT, R. New After-War Preparations in the Chemical Industry of Germany. *Translation* ... 1025
PICKRELL, F. R. The Method of Preparation of the Census of Chemical Imports. Symposium Bureau of Foreign and Domestic Commerce and its Relations to American Chemical Industry ... 936
PIERCE, E. W. Problems in Testing Dyes and Intermediates. Dyestuff Symposium, Cleveland Meeting, A. C. S. ... 803
PORTER, J. J. AND E. O. RHODES. Effect of Coal Ash on Nature of Cement Mill Potash, 1031. *See* Potter and Cheesman ... 109
POTTER, N. S., JR. AND R. D. CHEESMAN. Effect of Coal Ash on the Liberation and Nature of Cement Mill Potash, 109. *See* Letters ... 1030
PRANKE, E. J. Development in Nitric Acid Manufacture in the U. S. since 1914. Address, Chemical Exposition ... 830
PULSIFER, H. B. A Standard Apparatus for the Determination of Sulfur in Iron and Steel by the Evolution Method ... 545

RABAK, F. Influence of Time of Harvest, Drying and Freezing of Spearmint upon the Yield and Odorous Constituents of the Oil ... 275
RANDALL, M. Gilman Hall. The Research Unit of the Chemistry Group at the University of California. Address ... 634
RANDALL, W. W. Charles Caspari, Jr. Obituary ... 240
Note on the Use of the Dipping Refractometer ... 629
RATHER, J. B. An Accurate Loss-on-Ignition Method for the Determination of Organic Matter in Soils ... 439
REED, E. O. A Method for Determining the Absorbency of Paper ... 44
AND F. P. VEITCH. A Constant Temperature and Humidity Room for the Testing of Paper, Textiles, Etc ... 38
F. P. VEITCH AND C. F. SAMMET. Blue and Brown Print Paper: Characteristics, Tests, and Specifications ... 222
RHOADS, A. E. AND GILLETT, H. W. A Rocking Electric Brass Furnace ... 459
RHODES, E. O. AND J. J. PORTER. Effect of Coal Ash on Nature of Cement Mill Potash, 1031; *See* Potter and Cheesman ... 109
RHUE, S. N. Improved Methods for the Estimation of Sodium and Potassium ... 429
RICE, F. E. A Simple and Entirely Adjustable Rack for Kjeldahl Digestion Flasks ... 631
RICHARDS, J. W. Milwaukee Meeting American Institute of Mining Engineers. Note ... 945
The Ferro-Alloys. Address, Chemical Exposition ... 851
Report, 34th Meeting American Electrochemical Society. Note ... 944
RICHARDSON, W. T. Tentative Standard Methods for the Sampling and Analysis of Commercial Fats and Oils ... 315
RINGSTROM, H. AND E. P. HARDING. A Comparison of the Proximate and Mineral Analysis of Desiccated Skim Milk with Normal Cows' Milk ... 295
RITTENHOUSE, E. A Safety Valve ... 633
ROBINSON, W. O. A Proximate Quantitative Method for the Determination of Didium and Caesium in Plant Ash ... 50
ROGERS, A. Allen's Commercial Organic Analysis. (Book Review) ... 250
Everyman's Chemistry, by E. Hendrick. (Book Review) ... 168
The Leather Specimen Book, by F. W. LaCroix. (Book Review) ... 88
Treatise on Applied Analytical Chemistry. (Book Review) ... 960
ROGERS, J. S. AND R. W. FREY. A Volumenometer ... 554
ROSENGARTEN, G. D. The Chemical Engineering Catalog—1917 Edition. (Book Review) ... 88
ROSSI, A. J. Address of Acceptance. Perkin Medal Award. (Review) ... 141
ROTH, C. F. Report of Southern Trip of American Electrochemical Society ... 489
RUDNICK, P. Report of Committee on Research and Analytical Methods, Fertilizer Division, A. C. S. ... 946
The Fertilizing Value of Activated Sludge. Note, 400; *See* Nasmith and McKay ... 339

SADTLER, S. P. Advances in Industrial Organic Chemistry since the Beginning of the War. Address, Chemical Exposition ... 854
Joseph Price Remington. Obituary ... 240
SAMMET, C. F. Determining the Comparative Melting Points of Glues as a Measure of Jelly Strength ... 595
Relative Viscosity of Oils at Room Temperature ... 632
F. P. VEITCH AND E. O. REED. Blue and Brown Print Paper. Characteristics, Tests, and Specifications ... 222
SATTLER, L. A Hydrogen Sulfide Generator ... 226
SAXTON, B. The Recrystallization of Niter Cake ... 897
SCHAEFER, G. G. Platinum Resolution by the Argentine Chemical Society. Note, 323; *See* Nicholas ... 323
SCHOELLKOPF, J. F., JR. The Development of the Dyestuff Industry since 1914. Dyestuff Symposium, Cleveland Meeting, A. C. S. ... 792
SCHOLES, S. R. Permanence as an Ideal of Research. Address ... 390
SCHORGER, A. W. Sulfite Turpentine ... 258
SEIDENBERG, A. A Method for the Detection of Foreign Fats in Butter Fat ... 617
SHARWOOD, W. J. Notes on Sodium Cyanide ... 292
SHEPPARD, S. E. The Science and Practice of Photography. (Book Review) ... 961
AND F. A. ELLIOTT. The Reticulation of Gelatin ... 727
SHEPMAN, H. C. Food Chemistry in the Service of Human Nutrition Address ... 383
SHIVER, H. E. AND T. E. KEITT. A Study of Sources of Error Incident to the Lindo-Gladding Method for Determining Potash ... 994
A Study of the DeRoode Method for the Determination of Potash in Fertilizer Materials ... 219
SHOOK, G. A. A Differential Refractometer ... 553
SHREVE, R. N. General Symposium on the Chemistry of Dyestuffs. Note ... 750
Introductory Remarks. Dyestuff Symposium, Cleveland Meeting, A. S. C. ... 789
SILVERMAN, A. A New Illuminator for Microscopes ... 1013
SMITH, D. F., B. T. BROOKS AND H. ESSEX. The Manufacture of Amyl Acetate and Similar Solvents from Petroleum Pentane ... 511
SMITH, E. Fuel for Manufacture of Chemicals. Note ... 159
SNOW, C. D. Government Trade-Building Information. Symposium Bureau of Foreign and Domestic Commerce and Its Relations to American Chemical Industry ... 931
SPENCER, D. Catalysts in Vulcanization ... 115
SPENCER, G. C. AND W. O. EMLEY. Studies in Synthetic Drug Analysis. V.—Estimation of Theobromine ... 605
SPENCER, M. G., G. L. KELLEY, C. B. ILLINGWORTH AND T. GRAY. Determination of Manganese in Steel in the Presence of Chromium and Vanadium by Electrometric Titration ... 19
STEBBINS, J. H., JR. I. Upon the Action of Tetrazodi-o-Tolylmethane Chloride upon Naphthol and Naphthylamine Sulfo Acids ... 445
STEVENSON, R. AND H. DURAND. Research on the Detection of Added Water in Milk ... 26
STIEGLER, H. W. The Structure of Scarlet S.R(B) and Ponceau 3R(B) ... 600
STIEGLITZ, J. Reduction of Waste. Letters. *See* Gray ... 153
STILLMAN, J. M. Dedication of Gilman Hall, University of California. Address ... 392
STOCKETT, A. W. The Potash Situation ... 918
STORM, C. G. Disinfection with Formaldehyde. A Substitute for the Permanganate-Formalin Method ... 123
STUPP, C. G. AND C. R. DOWNS. The Determination of Phthalic Anhydride in Crude Phthalic Acid ... 596
SUYDAM, J. R., JR. AND WHITAKER, M. C. A Comparative Study of the Thermal Decomposition of Coal and of Some of the Products of Its Carbonization ... 431
SWAN, G. C. AND N. HENDRICKSON. Determination of Loosely Bound Nitrogen as Ammonia in Eggs ... 614
SWETT, C. E. Distinguishing Manila from all Other "Hard" Rope Fibers ... 227

TALBOT, H. P. A Short Manual of Analytical Chemistry, Qualitative and Quantitative—Inorganic and Organic, by J. Muter. (Book Review) ... 88
TAYLOR, G. B. AND J. H. CAPPS. Effect of Acetylene on Oxidation of Ammonia to Nitric Acid ... 457
AND A. S. COOLIDGE. The Production of Nitric Acid from Nitrogen Oxides ... 270
AND J. D. DAVIS. Chemical Control of Ammonia Oxidation Note 186; *See* Fox ... 155
TEXTOR, C. K. AND O. KRESS. Some Experiments on the Pulping of Extracted Yellow Pine Chips by the Sulfate Process ... 268
THOMPSON, G. W. The Importance of Practical Chemistry. Address, Chemical Exposition ... 829
THORNTON, W. M., JR. A Simple and Efficient Filtering Tube ... 132
THURAS, A. L. AND E. E. WEIBEL. An Electrical Conductivity Recorder for Salinity Measurements ... 626
TILLISCH, H. Decanting ... 631
TOCH, M. The Pigments of the Tomb of Perneb ... 118
TOLMAN, L. M. Introductory Address. Willard Gibbs Medal Award ... 483
TOMLINSON, G. H. Wood Waste as a Source of Ethyl Alcohol. Address, Chemical Exposition ... 859
TONE, F. J. The Exposition in War and in Peace. Address, Chemical Exposition ... 828
TORRESON, G. The Emblem of the American Chemical Society. Note, 869; *See* Doremus ... 653
TUCKER, S. A. Standard Table of Electrochemical Equivalents and Their Derivatives, by C. Hering and F. H. Getman. (Book Review) ... 88
TURNER, W. D. AND B. G. NICHOLS. An Inexpensive Ash Leaching Plant ... 374

UPTON, H. S. Volumetric Determination of Free Sulfur in Soft Rubber Compounds ... 518

VAN ARSDALE, G. D. Tube Milling, by A. DelMar. (Book Review) ... 168
VEITCH, F. P. AND E. O. REED. A Constant Temperature and Humidity Room for the Testing of Paper, Textiles, Etc ... 38
AND C. F. SAMMET. Blue and Brown Print Paper: Characteristics, Tests, and Specifications ... 222
VERY, F. D. Municipal Contribution to Conservation through Garbage Utilization. Address ... 563

WAGGAMAN, W. H. AND C. R. WAGNER. The Agricultural Availability of Raw Ground Phosphate Rock ... 442
The Use of "Mine Run" Phosphates in the Manufacture of Soluble Phosphoric Acid ... 353
WAGNER, C. R. AND W. H. WAGGAMAN. The Agricultural Availability of Raw Ground Phosphate Rock ... 442
The Use of "Mine Run" Phosphates in the Manufacture of Soluble Phosphoric Acid ... 353
WALKER, H. S. Notes on the Analysis of Molasses ... 198
WALKER, W. H. Library for Edgewood Arsenal Laboratory. *See* Letters ... 868
Revised Statement from the Chemical Service Section, 321; *See* Parsons ... 234
WALLER, C. E. Method of Calculating Comparative Strength and Efficiency of High Explosives from Their Composition and Apparent Densities ... 448
WASHBURN, E. W. The Place of the University in Chemical War Work. Address, Cleveland Meeting, A. C. S. ... 786
WEBRE, A. L. Theory and Practice in the Design of Multiple Evaporators for Sugar Factories ... 191
WEIBEL, E. E. AND A. L. THURAS. An Electrical Conductivity Recorder for Salinity Measurements ... 626
WEIDLEIN, E. R. Remarks Concerning Suggestions for Central Medicinal Research Laboratory ... 976
WELLS, L. S. Y. Conservation of Platinum. Letter ... 494
WEISS, J. M. Safety of TNT as an Explosive. Note ... 1028
Methods of Analysis Used in the Coal-Tar Industry:
I—Crude Tars ... 732
II—Distilled Tars and Pitches ... 817
III—Heavy and Middle Oils ... 911
IV—Benzols and Light Oil ... 1006
AND C. R. DOWNS. Notes on "Free Carbon" of Tar, 400. *See* Monroe and Broderson, THIS JOURNAL **9** (1917), 1100.
WELLS, R. American Garbage Disposal Industry and Its Chemical Relation. Address ... 567
WERTZ, F. A. Notes on the Color Designation of Oil Varnishes ... 475
WESSON, D. Cotton Oil Industry in the War ... 930
Edible Fats and Oils, by C. A. Mitchell. (Book Review) ... 668
Edible Fats, in War and Law ... 71

WHEELER, A. S. Toluol from Spruce Turpentine ... 389
WHITAKER, M. C. AND J. R. SUYDAM, JR. A Comparative Study of the Thermal Decomposition of Coal and of Some of the Products of Its Carbonization ... 431
WHITE, E. C. Chemists and the Draft. Note ... 160
WICHMANN, H. J. The Detection and Determination of Coumarin in Factitious Vanilla Extracts ... 535
WILLARD, F. W. Andrew P. Peterson. Obituary ... 758
WILSON, W. Civil Service Rules Waived for War Gas Investigators. Executive Order ... 753
Licensing of Fertilizer Industry Ordered. Proclamation ... 323
Transfer of the Experiment Station at American University to the War Department, 654; *See* Baker ... 654
WINTER, O. B. A Contribution to the Composition of Lime-Sulfur Solutions ... 889
WISE, L. E. AND E. Q. ADAMS. Photographic Sensitizing Dyes. Their Synthesis and Absorption Spectra. Dyestuff Symposium, Cleveland Meeting, A. C. S. ... 801
WITHERS, W. A. The Chemistry of Farm Practice, by T. E. Keitt (Book Review) ... 249
WOODMAN, A. G. The Examination of Milk for Public Health Purposes, by J. Race. (Book Review) ... 666
AND A. A. COOK. The Detection of Vegetable Gums in Food Products ... 530
WOOTON, P. Washington Letter: 80, 160, 239, 325, 403, 496, 582, 656, 753, 870, 948, 1033
WRIGHT, C. D. AND W. O. EMERY. Studies in Synthetic Drug Analysis. VI—Evaluation of Hexamethylenetetramine Tablets ... 606

ZERBAN, F. W. The Rôle of Oxidase and of Iron in the Color Changes of Sugar Cane Juice ... 814
AND E. C. FREELAND. On the Preparation of an Active Decolorizing Carbon from Kelp ... 812
ZITKOWSKI, H. E. The Seeding Method of Graining Sugar ... 992
ZOLLER, H. F. Some Constituents of the American Grapefruit (*Citrus decumana*) ... 364
The Status of Chemical Engineering in Our Universities and Colleges Immediately Prior to the Declaration of War. Address, 644. *See* Mason ... 753

SUBJECT INDEX

THE JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY

VOLUME X 1918

ABSTRACTORS and Assistant Editors, Directions for 238
Accidents, Metal-Mine, in U. S. during 1916. Fay. Gov. Pub..... 958
Accidents, Quarry, in U. S. during 1916. Fay. Gov. Pub..... 958
Acetic Acid, Determination of, by Distillation with Phosphoric Acid. W. F. Munn..... 550
Acetone, Determination of. A. J. Field..... 552
Acetylene, Effect of, on Oxidation of Ammonia to Nitric Acid. G. B. Taylor and J. H. Capps..... 457
Acetylene, Reactions of. Note..... 488
Acetylsalicylic Acid, American-Made, Examination of. P. N. Leech. 288
Acetylsalicylic Acid. What's in a Name? Editorial..... 255
Acid, Liquids, An Evaporator for. E. Hart..... 555
Acid-Proof Alloys. Note..... 649
Acidity, Pipette Used in Titration of Oils for. J. Jacobsen..... 633
Acids, Fatty, in Butter Fat. Holland and Buckley, Jr. Gov. Pub... 763
ADDRESSES.....60, 133, 297, 383, 476, 556, 634, 918, 1016
Aeronautic Construction, Fabrics for. Whalen. Gov. Pub..... 873
Aeronautic Power Plant Investigations. Dickinson. Gov. Pub.... 873
Aeronautics and Meteorology. Blair. Gov. Pub..... 873
Aeronautics, National Advisory Committee for..... 873
Aeroplane Construction. Note..... 943
Agriculture, Courses in Secondary, for Southern Schools. Barrows. Gov. Pub..... 503
Agriculture, Department of. Gov. Pub.....332, 503, 763, 959
Air Propellers, Experimental Research on. Durand. Gov. Pub.... 873
Air Raid Signals. Note..... 944
Airplane Dopes. G. J. Esselen, Jr. Address..... 135
Air Vapor Mixtures, Recovery of Solvents from. E. L. Knoedler and C. A. Dodge..... 593
Airs from Mine Fire, Some Results of Analysis of. A. G. Blakeley and H. H. Geist..... 552
Alabama, Oil and Gas Possibilities of the Hatchetigbee Anticline. Hopkins. Gov. Pub..... 247
ALABAMA TECHNICAL ASSOCIATION: Joint Meeting with Alabama Section A. C. S., Birmingham, Ala., May 2, 1918. Program..... 493
Alcohol as Used in Medicines, Conservation of. Note..... 495
Alcohol, Industrial-, Chemistry, and Preservatives. Gov. Pub..... 409
Alcohol, New Source of. Notes.....313, 1022
Alcohol Production in Germany. Note..... 649
Alcoholic Medicinal Preparations..... 245
Alcohols and Bases in Vacuum Tar. Note..... 650
Alfalfa Hay, Corn Silage, and Velvet-Bean Meal when Fed Singly and in Combinations, Digestibility of. Ewing and Smith. Gov. Pub.. 764
Alien Property Custodian, Coöperation Requested by the. A. M. Palmer. Note..... 947
Alien Property Custodian: The Custodian in Action. Editorial.... 673
Alinement Chart for Evaluation of Coal. A. F. Blake..... 627
Alloy, A Deoxidizing. Note..... 398
Alloy, New Aluminum. Note..... 650
Alloy, New Magnesium. Note..... 75
Alloys, Acid-Proof. Note..... 649
Alloys, Aluminum, Analysis of. Note..... 747
Aluminum. Hill. Gov. Pub. In 1916, 84; in 1917..... 860
Aluminum. Note..... 862
Aluminum Alloy, New. Note..... 650
Aluminum Alloys, Analysis of. Note..... 747
Aluminum and Copper in Germany. Note..... 649
Aluminum and Its Alloys. Note..... 1020
Aluminum, Annealing. Note..... 1021
Aluminum Goods for Brazil. Note..... 229
Amalgam, Copper, as Metal Cement. Note..... 74
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: 75th Annual Meeting, Pittsburgh, December 28, 1917, to January 2, 1918..... 154
AMERICAN CERAMIC SOCIETY: Northern Ohio Section. Meetings Toledo, April 6, 1918; Cleveland, June 10, 1918.....402, 653
The Journal of. Editorial..... 878
AMERICAN CHEMICAL SOCIETY
A. C. S. Pin. C. L. Parsons..... 80
American Emblem for American Chemists. C. A. Doremus, 653; *See* Torossian..... 869
An Opportunity to Help the French. C. L. Parsons. Note..... 1024
Chemistry for the Public. R. D. Cooke. Note..... 752
Communication from U. S. Shipping Board. E. N. Hurley..... 864
Coöperation with the Chemical Service Section. Note..... 581
Dr. Nichols Leader in Chemical Industry. C. F. Chandler..... 92
Editorials:
A Dyestuff Section of the A. C. S..... 674
A French Local Section..... 510
A Golden Opportunity..... 967
A Regrettable Decision of the Directors..... 4
A Special Meeting of the Council..... 967
America in Safe Hands..... 418
An Experiment in Publicity..... 967
An International Courtesy..... 673
Another Idol Shattered..... 880
Preparation for After the War..... 878
Publicity Work to be Continued..... 338
The Missing Five Thousand..... 8
The Naval Consulting Board..... 175
Fertilizer Division: Report of Committee on Research and Analytical Methods. P. Rudnick..... 946
56th (*Annual*) Meeting, Cleveland, September 10 to 13, 1918:
Announcements, 494, 684, Editorials, 591, 672, Tentative Program, 748, Symposium on Chemistry of Dyestuffs. Note. R. N. Shreve..... 750
President's Address. A Retrospect and an Application. W. H. Nichols..... 768
AMERICAN CHEMICAL SOCIETY (*concluded*)
Council Meeting..... 77
General Meeting..... 774
SYMPOSIUM—*Chemists in Warfare*..... 776
SYMPOSIUM—*Chemistry of Dyestuffs*..... 786
Program of Papers..... 865
Industrial Chemists and Chemical Engineers Division:
Minutes of Business Sessions at Cleveland Meeting. H. E. Howe..... 865
Tentative Standard Methods for the Sampling and Analysis of Commercial Fats and Oils..... 315
Journals. Note..... 1020
Local Sections:
Alabama Section. Joint Meeting with Alabama Technical Association, Birmingham, May 2, 1918. Program of Papers, Etc..... 493
French Section..... 575, 1023
New York Section. Resolutions following suspension of L. P. Brown as Director of Bureau of Food and Drug Inspection of the City of New York..... 493
North Carolina Section. Joint Meeting with North Carolina Academy of Science, Greensboro, N. C., April 26 and 27, 1918. Program of Papers..... 492
Officers for 1918..... 92
Organic Chemistry Division: Resolution Concerning Organic Nomenclature..... 944
Our Preparation for After the War. Address. B. C. Hesse.... 881
Rubber Section: Report of Committee on Organic Accelerators. Cleveland Meeting..... 865
Spring Meeting. Announcement of Its Omission..... 236
American Chemical Trade, Effect of the War on. O. P. Hopkins.... 692
American Chemists Welcomed by the Cercle de la Chimie. *Translation.* President of the Cercle de la Chimie..... 482
AMERICAN DRUG MANUFACTURERS ASSOCIATION: Annual Meeting, New York City, January 29 to 30, 1918..... 233
American Dyestuff Industry and Its Prospects. *Translated from* German..... 1026
AMERICAN ELECTROCHEMICAL SOCIETY:
Resolutions Concerning Alien Enemy Members..... 750
33rd General Meeting, Tour of South, April 28 to May 4, 1918: Announcement, 321; Reports by C. F. Roth..... 489
34th General Meeting, Atlantic City, September 30 to October 2, 1918:
Announcement, 750, 866; Program of Papers..... 866
Report. J. W. Richards..... 944
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS:
10th Annual Meeting, St. Louis, December 5 to 8, 1917..... 77
10th Semi-Annual Meeting, Gorham and Berlin, N. H., June 19 to 22, 1918:
Program of Papers..... 493
Report. J. C. Olsen..... 651
AMERICAN INSTITUTE OF MINING ENGINEERS: 116th Meeting, New York City, February 18 to 21, 1918. Program of Paper..... 320
Report of Milwaukee Meeting, October 7 to 12, 1918. J. W. Richards..... 944
AMERICAN LEATHER CHEMISTS' ASSOCIATION:
Annual Meeting, Atlantic City, N. J., May 16 to 18, 1918: Program of Papers..... 493
AMERICAN METRIC ASSOCIATION: Second Meeting..... 154
AMERICAN PHARMACEUTICAL ASSOCIATION:
Announcement of Annual Convention..... 580
Ammonia and Nitric Nitrogen, Determination in Soils Extracts and Physiological Solutions. B. S. Davisson..... 600
Ammonia Industry, License of. Presidential Proclamation. Gov. Pub..... 408
Ammonia in Eggs, Determination of Loosely Bound Nitrogen as. N. Hendrickson and G. C. Swan..... 614
Ammonia, Latent Heat of Vaporization of. Osborne and Van Dusen. Gov. Pub..... 410
Ammonia, Liquid, Latent Heat of Pressure Variation of. Osborne and Van Dusen. Gov. Pub..... 169
Ammonia, Liquid, Specific Heat of. Osborne and Van Dusen. Gov. Pub..... 411
Ammonia, Oxidation of. Note..... 941
Ammonia Oxidation Process, Analytical Control of. P. J. Fox. Note, 155. *See* Taylor and Davis.
Ammonia Program for 1918. C. W. Merrill..... 480
Ammonia: Relation between Efficiency of Refrigerating Plants and the Purity of their Ammonia Charge. F. W. Frerichs..... 20
Ammonia to Nitric Acid, Effect of Acetylene on Oxidation of. G. B. Taylor and J. H. Capps..... 457
Amyl Acetate and Similar Solvents from Petroleum Pentane, Manufacture of. B. T. Brooks, D. F. Smith and H. Essex..... 511
Anaerobic Culture Volumeter. Z. Northrup..... 624
Andean Sulfur Deposits. Miller and Singewald, Jr. Gov. Pub..... 586
Anthelmintics, Efficacy of Some. Hall and Foster. Gov. Pub..... 504
Anthraquinone, Quantitative Estimation of. H. F. Lewis..... 428
Antimonial Silver-Lead Veins of the Arabia District, Nevada. Knopf. Gov. Pub..... 331
Antimony in 1916. Bastin. Gov. Pub..... 761
Antimony Sulfide as a Constituent in Military and Sporting Arms Primers. A. S. Cushman..... 576
Antipneumococcic Serum, Phenols as Preservatives of. Pharmacological Study. Voegtlin. Gov. Pub..... 875
APPARATUS (*see under name of piece*).
Apparatus and Special Chemicals Available through the Chemistry Committee of the National Research Council. M. T. Bogert. Note..... 588

Argentina, Coal-Mining Machinery for. Note 228
Argentina, Jute Sacks for. Note 74
Argentine Chemical Society, Platinum Resolution by. *See* Letters G. F. Schaefer and W. H. Nichols 322
Army, National, The Chemical Service Section of the. Editorial 2
Army Ordnance, U. S., High-Grade Technical Men and Skilled Operatives Wanted for. Note 495
Army Without Reserves. Editorial, 508; Symposium 685
Aromatic Hydrocarbons from Natural Gas Condensate, The Formation of. J. G. Davidson 901
Arsenates, Calcium. Robinson. Gov. Pub 764
Arsenic. Umpleby. Gov. Pub In 1916, 409; in 1917 761
Arsenic Compounds, An Experimental Investigation of the Toxicity of Certain Organic. Roth. Gov. Pub 1037
Arsenic in Insecticides, Determination of, by Potassium Iodate. G S. Jamieson 390
Arsenic in Sulfured Food Products. W. D. Collins 360
Arsenious Oxide. Pure, Preparation and Testing of. R. M Chapin 522
Arsphenamine and Neo-Arsphenamine, Some Qualitative and Quantitative Tests for. Meyers and DuMez. Gov. Pub 758
Arsphenamine (Salvarsan) and Neo-Arsphenamine (Neo-Salvarsan). Gov. Pub 586
Arsphenamine (Salvarsan): Licenses Ordered and Rules and Standards Prescribed for Its Manufacture. Gov. Pub 245
Asbestos Industry, Russian. Note 397
Ash Leaching Plant, Inexpensive. W. D. Turner and B. G. Nichols 374
Ash: Proximate Quantitative Method for the Determination of Rubidium and Caesium in Plant Ash. W. O. Robinson 50
Asphalt and Coal Deposits. Gov Pub 408
Aspirator. J. M. Johlin 632
Aspirin: Examination of Licensed-Made Acetylsalicylic Acid. P N. Leech, 288; *See* Editorial 255
Assistant Editors and Abstractors, Directions for 238
Association of British Chemical Manufacturers. Note 751
Atlantic Coast, The Menhaden Industry of the. Greer. Gov. Pub. 166
Australia and New Zealand, Railway Materials, Equipment, and Supplies in. Rhea. Gov. Pub 664
Australia, Goods in Demand in. Note 861
Australian Gelatin, Glue and Size. Note 487
Autoclaves and High Pressure Problems. Note 230
Automatic Control and Measurement of High Temperatures. R. P. Brown. Address 133
Azotobacter, Soil Reaction and Growth of. Gainey. Gov. Pub 959

BACTERIA, Effect of Nitrifying, on Solubility of Tricalcium Phosphate. Kelly. Gov. Pub 763
Bacteria, Nitrogen-Assimilating, Influence of Nitrates on. Hills. Gov. Pub 504
Balloon Fabrics, Determination of Permeability of. Edwards. Gov. Pub 762
Bank, National Metal and Chemical. Note 940
Baseball Players, Commissions for. Editorial 879
Bases and Alcohols in Vacuum Tar. Note 650
Batik Dyeing Process. Note 938
Bauxite. Hill. Gov. Pub. In 1916, 84; in 1917 760
Bauxite, Refractory Material from. Note 862
Beilstein's *Handbuch der Organischen Chemie*. Turn About is Fair Play. Editorial, 672; *See* Letters 867
Belting, Laminated. Note 314
Benzene: Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases. H. S. Davis, M. D. Davis, and D. G. MacGregor 712
Benzene Vapor, The Determination of. VII—Reagents for Use in Gas Analysis. R. P. Anderson 25
Benzols: Methods of Analysis Used in the Coal-Tar Industry. IV—Benzols and Light Oils. J. M. Weiss 1006
Bichromate Manufacture in Sweden. Note 1022
Biological Products, Nature of Contaminations of. Bengston. Gov. Pub 873
Biological Products, Studies in Preservatives of. Neill. Gov. Pub.. 873
Birch, The Effect of Incomplete Distillation on the Yield of Products in the Destructive Distillation of. R. C. Palmer 260
Bismuth. Umpleby. Gov. Pub. In 1916, 409; in 1917 873
Bismuth, Industrial Uses of. Note 573
Bismuth, Pure. Notes 573, 229
Bismuthinite, Photoelectric Sensitivity of. Coblentz. Gov. Pub.. 762
Bittern, Sea Water, The Extraction of Potash and Other Constituents from. J. H. Hildebrand 96
Blast-Furnace Breakouts, Explosions, and Slips, and Methods of Prevention. Wilcox. Gov. Pub 412
Blast-Furnace Plants, Occupational Hazards at, and Accident Prevention Based on Records of Accidents at Blast Furnaces in Pennsylvania in 1915. Wilcox. Gov. Pub 412
Blast-Furnace Practice. Note 746
Blast-Furnace Work, Slag Viscosity Tables for Feild and Royster. Gov. Pub 959
Blue and Brown Print Paper: Characteristics, Tests, and Specifications. F. P. Veitch, C. F. Sammet, and E. O. Reed 222
Blue Gas, Toluol by Cracking Solvent Naphtha in the Presence of. G. Egloff 8
Boiler Scale, Graphite for. Note 395
Boiler Scale, Prevention of. Note 151
Bolivia, Ecuador, and Peru, Textile Markets of. Tucker. Gov. Pub 664
Bolivian Wolfram Industry. Note 940
BOOK REVIEWS (*see separate heading below*)
Borax and Boric Acid. Note 73
Borax Production in 1916. Yale and Gale. Gov. Pub 410
Bordeaux Mixtures, Commercial. How to Calculate Their Values. Wallace and Evans. Gov. Pub 959
Boric Acid and Borax. Note 73
Boron. Its Effect on Crops and Its Distribution in Plants and Soil in Different Parts of the U. S. Cook and Wilson. Gov. Pub. 764
Brake, Fan Dynamometer. Note 744
Brass, Bronze, and Copper Products. Gov. Pub 332
Brass, Cadmium in. Note 939
Brass: Thermal Expansion of Alpha and of Beta Brass between 0° and 600° C. in Relation to the Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type. Merica and Schad. Gov. Pub 762
Brass Tubes, Corrosion of. Note 942
Brazil, Aluminum Goods for. Note 229
Brazing Table, Gas-Fired. Note 1022
Brick, Sand-Lime, in 1917. Middleton. Gov. Pub 956
Brines and Potash Salts, Nebraska, Some Methods of Analysis for. A. H. McDowell 128
Briquetting, Fuel, in 1917. Lesher. Gov. Pub 662
British Board of Trade. Notes: 76, 151, 230, 314, 398, 488, 574, 650, 747
British Chemical Manufacturers, Association of. G. Mount 495
British Dye, New. Note 75
British Dyes Limited. Account of Progress. J. Falconer 145
British Empire, Petroleum in. Note 572
British Paper Exports. Note 76
BRITISH PROGRESS IN DYESTUFF MANUFACTURE. J. Falconer 145
British Trade: Register of Overseas Buyers. Note 573
Bromine in 1917. Stone. Gov. Pub 957
Bromine Process Decision. Case of Dow Chemical Co. *vs.* American Bromine Co. and A. E. Schaefer 157
Bronze, Brass, and Copper Products. Gov. Pub 332
Brown and Blue Print Paper: Characteristics, Tests, and Specifications. F. P. Veitch, C. F. Sammet, and E. O. Reed 222
Buckwheat: Comparative Study of Salt Requirements for Young and for Mature Buckwheat Plants in Solution Culture. Shive and Martin. Gov. Pub 959
Bulletin, Official U. S. Note 654
Bureau of Census. Gov. Pub 331, 412, 958, 1037
Bureau of Education. Gov. Pub 412
Bureau of Fisheries. Gov. Pub 166
Bureau of Foreign and Domestic Commerce. Gov. Pub. 664, 764, 874
BUREAU OF FOREIGN AND DOMESTIC COMMERCE: ITS RELATIONS TO CHEMICAL INDUSTRY:
Government Trade-Building Information. C. D. Snow 931
Our Publications and Their Bearing on the Chemical Industry. O. P. Hopkins 933
Method of Preparation of the Census of Chemical Imports. E. R. Pickrell 936
Bureau of Labor Statistics. Gov. Pub 412
Bureau of Markets in Its Relation to the Conservation of Foods. C. J. Brand 66
Bureau of Mines. Director's Annual Report 332
Government Publications 85, 332, 412, 958
Yearbook, 1916 85
Bureau of Ordnance. Gov. Pub 412
BUREAU OF STANDARDS:
Government Publications 85, 166, 412, 503, 762, 959
Recovery of Light Oils and Refining of Toluol 51
Burmese Monazite Sands. Note 1020
Butter and Milk, Enzymes of. Thatcher and Dahlberg. Gov. Pub.. 503
Butter Fat, A Method for the Detection of Foreign Fats in. A. Seidenberg 617
Butter Fat and Income. McDowell. Gov. Pub 763
Butter Fat, Determination of Fatty Acids in. Holland and Buckley, Jr. Gov. Pub 763
Butter or Oleomargarine, Detection of Added Color in. H. A. Lubs. 436
Butter Substitute from Fish Oils. Note 397
Butter Tree, Shea, Gutta-Percha from. Note 76
Buttons, Manufacture of. Gov. Pub 332

Book Reviews 88, 167, 249, 504, 666, 960, 1038
Analytical Chemistry, A Short Manual of, Qualitative and Quantitative—Inorganic and Organic, by Muter. H. P. Talbot 88
Applied Analytical Chemistry, Treatise on, by Villavecchia, *et al Translated* by Pope. A. Rogers 960
Cellulose. An Outline of the Chemistry of the Structural Elements of Plants, by Cross and Bevan. A. D. Little 960
Chemical Analysis, Standard Methods of, *edited* by Scott. W. T. Hall 250
Chemical Annual, Van Nostrand's, *edited* by Olsen and Matthias. R. K. Meade 962
Chemical Engineering, Catalog, issued by The Chemical Catalog Co., Inc., 1917 Edition, G. D. Rosengarten, 88; 1918 Edition, C. H. Herty 1038
Chemical French, by Doit. A. M. Patterson 961
Chemical Laboratory of the American Medical Association, Annual Report of, by American Medical Association. H. V. Arny 668
Chemical Patents and Allied Patent Problems, by Thomas. K. P McElroy 167
Chemistry, Everyman's, by Hendrick. A. Rogers 168
Chemistry of Farm Practice, by Keitt. W. A. Withers 249
Chemistry of Materials of the Machine and Building Industries, by Leighou. H. K. Benson 666
Chemist's Pocket Manual, by Meade. A. C. Langmuir 960
Coal, Bituminous, The Storage of, by H. H. Stock. A. C. Fieldner 668
Coal, Coke, and By-Products, Methods for Commercial Sampling and Analysis, by J. M. Camp. S. W. Parr 666
Coal Gas Residuals, by F. H. Wagner. R. P. Perry 667
Colloid Chemistry, Theoretical and Applied, An Introduction to, by Ostwald. J. Alexander 249
Colloids, The Chemistry of, by Zsigmondy. J. Alexander 250
Commercial Organic Analysis, by Allen. A. Rogers 250
Electrochemical Equivalents and Their Derivatives, Standard Table of, by Hering and Getman. S. A. Tucker 88
Enzyme Action, The Method of, by Beatty. J. F. Brewster 504
Explosives, by Marshall. C. E. Munroe 167
Fats and Oils, Edible, by C. A. Mitchell. D. Wesson 668
Fertilizer Handbook, American, by Ware Bros. Co., *edited* by Toll J. E. Breckenridge 962
Industrial Chemistry, Laboratory Guide of, by Rogers. R. H. McKee 250
Leather Specimen Book, by LaCroix. A. Rogers 88
Lubricants, American, by Lockhart. A. H. Gill 504
Lubricating Engineer's Handbook, by Battle. A. H. Gill 168
Milk, Examination of, for Public Health Purposes, by J. Race. A. G. Woodman 666
Nomography, Chemical, A Manual of, by H. G. Deming. E. M. Bell 668
Oils, Fats and Their Commercial Products, Aids in the Commercial Analysis of. A Laboratory Handbook, by G. F. Pickering. A. H. Gill 504
Organic Compounds of Arsenic and Antimony, by Morgan. J. B. Chatchill 1038
Photographs, The Science and Practice of, by Roebuck. S. E. Sheppard 961
Reagents and Reactions, by Tognoli. J. T. Baker 666
Resins, The Distillation of, by Schweizer. A. H. Davis 249
Sir Wm Ramsay as a Scientist and Man, by Chaudhuri. C. Barker 962
salle

Book Reviews (*concluded*):
Sulfuric Acid Handbook, by Sullivan J. E. F. Herreshoff 960
Tube Milling, by DelMar G. D. Van Arsdale 168

CADMIUM in Brass Note 939
Cadmium in 1917 Siebenthal Gov. Pub 954
Cadmium Vapor, Resonance and Ionization Potentials for Electrons in. Tate and Foote Gov. Pub 762
Caesium and Rubidium in Plant Ash. A Proximate Quantitative Method for the Determination of W. O. Robinson 50
Calcium and Magnesium, Influence of Carbonates of, on Bacteria of Certain Wisconsin Soils Fulmer Gov. Pub 763
Calcium Arsenates Robinson Gov. Pub 764
Calcium Chloride in 1917 Stone Gov. Pub 957
CALENDAR OF MEETINGS 321, 403, 494, 580, 653, 748
California, The Research Unit of the Chemistry Group at the University of, Gilman Hall. M. Randall 634
CALIFORNIA, UNIVERSITY OF, THE DEDICATION OF GILMAN HALL 391
Calorimeter Installation, A Convenient Multiple Unit. Davis and Wallace. Gov. Pub 959
Camphor, Japanese Note 1022
Canada, Mineral Production in Note 74
Canada's Export Trade Note 572
Canadian Lake, Recovery of Magnesia and Potash from Note 151
Canadian Nickel, Recovery of Platinum Metals from Note 76
Cane By-Products in Natal Note 745
Canning and Preserving Gov. Pub 332
Canning Industry. Some Accomplishments and Opportunities Along Technical Lines. Address. H. A. Baker 69
Carbon, Active, Decolorizing, from Kelp. On the Preparation of. F. W. Zerban and E. C. Freeland 812
Carbon Dioxide in Carbonates, A Rapid Pressure Method for Determination of. W. H. Chapin 527
Carbon Dioxide, New Determinations of, in Water of Gulf of Mexico. Wells Gov. Pub 954
Carbon Dioxide, Relation of, to Soil Reaction as Measured by the Hydrogen Electrode. Hoagland and Sharp Gov. Pub 504
Carbon in Steel, Rapid Determination of, by Barium Carbonate Titration Method. J. R. Cain and J. C. Maxwell 520
Carbonation Studies: II—The Carbonation of Distilled Water. H. E. Patten and G. H. Mains 279
Carnotite Ores, Mining and Concentration of. Kithil and Davis Gov. Pub 958
Carotin in Oils and Vegetables, The Occurrence of. A. H. Gill 612
Carvacrol, A Study of Conditions Essential for Commercial Manufacture of. A. W. Hixson and R. H. McKee 982
Casein in Presence of Starch, Effect of Time of Digestion on Hydrolysis of. McHargue. Gov. Pub 504
Casein, Manufacture of, from Buttermilk or Skim Milk. Dahlberg. Gov. Pub 763
Caspari, Charles, Jr., Obituary. W. W. Randall 240
Cassia, Oil of, Constituents of. H. F. D. Dodge 1005
Cast Iron Pipe Gov. Pub 331
Catalyst from Metallic Salts Note 747
Catalysts in Vulcanization. D. Spence 115
Catalytic Processes in Germany Note 939
Catalyzers, Effect of, on Yield of Products in Destructive Distillation of Hardwoods. R. C. Palmer 264
Cell, New Voltaic Note 744
Cellulose Turpentine Note 1...
Cement. Concentration of Potash from Raw Materials Containing only a Trace of this Element by Means of the Electric Precipitation of Flue Dust and Fume. Cement Kilns. B. F. Erdahl 356
Cement, Dramtite and Concrete in Alkali Soils, Durability of. Containing Results of Third Year's Tests. Wig *et al.* Gov. Pub 85
Cement Industry, The Recovery of Potash as a By-Product in the. Ross *et al.* Gov. Pub 332
Cement Metal, Copper Amalgam as Note 74
Cement Mill Dust, Direct Heat Treatment of, to Increase Its Water-Soluble Potash Content. Merz 106
Cement Mill Potash, Effect of Coal Ash on the Liberation and Nature of. N. S. Potter, Jr., and R. D. Cheesman. 109. Sc. Letters 1030
Cement Mortars and Magnesium Note 746
Cement, Portland, Properties of, Having a High Magnesia Content. Bates Gov. Pub 413
Cement, Portland, Standard Specifications and Tests for Gov. Pub 874
Cement Production, 1916. Burchard Gov. Pub 410
Census of Chemists. F. E. Brethut Note 946
Census of Dyes and Coal-Tar Chemicals, 1917. A Record of Achievement. Editorial 859
Ceramics, Developments in. Editorial 878
Cercle de la Chimie, American Chemists Welcomed by the. *Translation.* President of the Cercle de la Chimie 482
Cereal Foods, with Reference to Their Content in Antineuritic Vitamine, The Dietary Deficiency of. Voegtlin, *et al.* Gov. Pub 586
Chalcopyrite-Pyrrhotite Ores of Southern Oregon, Flotation of. Chalcopyrite in. Cochill Gov. Pub 412
Chamber Process, Avoidable Waste in the Production of Sulfuric Acid by the. A. E. Marshall Note 156
Chart Allowance for the Evaporation of Coal. A. F. Blake. 627. Correction 948
Cheese, Ripening, Study of the Streptococci Concerned in. Evans Gov. Pub 763
Cheese, Varieties of, Dorner and Lawson Gov. Pub 763
Chemical Abstracts. Decennial Index Patrons 77
Chemical Abstracts. The Indexes to. E. J. Crane Note 237
Chemical Alliance, The. Editorial Announcement 231
Chemical and Allied Industries Gov. Pub 958
Chemical and Dye Industry, Italian. Note 745
Chemical Bank, National Metal and Note 940
Chemical Engineering in Our Universities and Colleges, Immediately Prior to the Declaration of War the Status of. H. F. Zoller. 644. See Note by W. P. Mason 733
Chemical Engineers, A Manufacturer's Experience with Graduate. S. R. Church 1019
Chemical Glassware, Comparative Tests of. Walker and Smither Gov. Pub 762
CHEMICAL INDUSTRIES, FOURTH NATIONAL EXPOSITION OF, New York City, September 3 to 8, 1918. Editorials, 892, 672, 674. Notes, 681, 826. Program and List of Exhibitors, 749; Addresses 826
Chemical Industries, Fraudulent Promoters of, Camp Followers. Editorial 255
Chemical Industries, French, During 1916. F. J. LeMaistre 421
Chemical Industries of England, Women in the Note 1028
Chemical Industries, U. S. Tariff Commission Inquiry in Regard to 158
CHEMICAL INDUSTRY, AMERICAN, AND THE BUREAU OF FOREIGN AND DOMESTIC COMMERCE:
Government Trade Building Information. C. D. Snow 931
Our Publications and Their Bearing on the Chemical Industry. O. P. Hopkins 933
Method of Preparation of the Census of Chemical Imports. E. R. Pickrell 936
Chemical Industry in China Note 649
Chemical Industry in the Netherlands. Note 947
Chemical Industry of Germany, New After-War Preparations. *Translated from French* 1025
Chemical Manufacturers, Association of British. G. Mount, 495; *See* Note 751
CHEMICAL MARKETS IN THE UNION OF SOUTH AFRICA. O. P. Hopkins 887
CHEMICAL MARKETS OF SOUTH AMERICA. O. P. Hopkins
Chemical Trade of Argentine, Brazil and Uruguay 701
Chemical Trade of Chile, Peru, and Bolivia 805
Chemical Markets of Colombia, Ecuador, the Guianas, Venezuela, and Paraguay 977
Chemical Microscopy. E. M. Chamot. Address 60
Chemical Research in the Various Countries Before the War and in 1917. E. J. Crane. Note 236
Chemical Service Section of the National Army. Editorial 2. Note C. L. Parsons, 234; Revised Statement, W. H. Walker 321
Chemical Society, Meeting in New York City, Program for 1918-1919 Season 748
Chemical Society for Women. Iota Sigma Pi. Note 1023
Chemical Society (London). An International Courtesy. Editorial. 673
Chemical Tests for Detection of Rancidity. R. H. Kerr 471
CHEMICAL TRADE, AMERICAN, EFFECT OF THE WAR ON. O. P. Hopkins 692
CHEMICAL WARFARE SERVICE:
Editorial Note, 675; General Orders, No. 62 675
Organization Plan of Chemical Warfare Service 677
Commissioned Personnel, 680; Correction 948
Census of Chemists 683
Chemists in Camp 684
Chemical Warfare Service, Collar Insignia for. Note 655
Chemical Warfare Service Commission for Baseball Players. Editorial 879
Chemicals and Explosives Divisions, War Industries Board. Note 654
Chemicals Division of National War Savings Committee Organized. Note 402
Chemicals, Explosive Note 745
Chemicals for Research Work. C. E. K. Mees. Notes 656, 1027
Chemicals, Fuel from, Manufacture of. E. Smith. Note 159
Chemicals, Special, and Apparatus Available Through the Chemistry Committee of the National Research Council. Note. M. T. Bogert 158
Chemistry for Soldiers in Training Camps. J. W. Beckman 869
Chemistry for the Public. Note. R. D. Cooke 752
Chemistry, Industrial Alcohol and Preservatives. Gov. Pub 499
Chemistry of Cotton Plant, with Special Reference to Upland Cotton. Viethoever *et al.* Gov. Pub 764
CHEMISTRY OF DYESTUFFS, SYMPOSIUM ON, Cleveland Meeting, A. C. S.:
Introductory Remarks. R. N. Shreve 780
Americas Progress in Dyestuffs Manufacturing. L. J. Matos 790
The Development of the Dyestuff Industry Since 1914. J. F. Schoellkopf, Jr. 792
Application of Dyestuffs in Cotton Dyeing. J. M. Matthews 794
Natural Dyestuffs. An Important Factor in the Dyestuff Situation. E. S. Chapin 795
The Manufacture, Use, and Newer Developments of the Natural Dyestuffs. C. R. Delaney 798
Photographic Sensitizing Dyes. Their Synthesis and Absorption Spectra. L. E. Sese and E. Q. Adams 801
The Color Laboratory of the Bureau of Chemistry. H. D. Gibbs 802
Problems in Testing Dyes and Intermediates. E. W. Pierce 805
On the Quantitative Analysis of Dyestuffs. A. H. Halland 804
Chemistry, Physical, in Coal-Tar Industry. W. J. Huff 1016
Chemistry, The Debt of Preventive Medicine to. G. W. Gale 305
Chemists, American. An American Emblem for. C. A. Doremus. Note 653
Chemists, American, Welcomed by the Cercle de la Chimie. *Translation.* President of the Cercle de la Chimie 482
Chemists and Enemy Owned Chemical Works 673
The Custodian in Action. Editorial 673
Chemists and the Draft. E. C. White. Note 160. See Editorials 2, 3 489
Chemists Club, Annual Meeting. Editorial 538
Portrait of C. M. Hall. Note 947
The Parting of the Ways. Editorial 284
Chemists' Club for France. Editorial 2
Chemists, Deferred Classification and Furloughs for Government and State Chemists. Note 947
CHEMISTS IN WARFARE, SYMPOSIUM ON, Cleveland Meeting, A. C. S.:
The American Chemist in Warfare. C. L. Parsons 776
The Work of the Chemical Section of the War Industries Board. C. H. MacDowell 780
War Disturbance and Peace Readjustments in the Chemical Industries. G. Jones 785
Chemical Warfare Research. W. D. Bancroft 788
The Place of the University in Chemical War Work. E. W. Washburn 786
CHEMISTS IN WAR SERVICE. A Letter from France. W. A. Hamor 498
A Long Step in the Right Direction. Editorial 172
America Is in Safe Hands. Editorial 418
An Army Without Reserves. Editorial 808. Symposium by Order of the President. Editorial 890. See Note 654
Chemistry Insignia. Editorial 97
Cooperation of American Chemical Society with the Chemical Service Section. Note 581
Government Recognizes the Importance of Chemistry in the War. C. L. Parsons, 234; Revised Statement. W. H. Walker 321
Importance of Chemists Recognized by Secretary of War. Note 580
Political but not Politics. Editorial 321
Preparedness Congress. Note 419
Prophecy and Fulfilment. Editorial 94
Somebody Please Cut the Tape. Editorial 284
The Chemistry Rainbow. Editorial 283
The Return of the Chemists 968

CHEMISTS IN WAR SERVICE (*concluded*):
Transfer of the Experiment Station at American University to the War Department. W. Wilson, N. D. Baker. Note, 654; *See* Editorial ... 590
War Risk Insurance for Chemists in Military Service. Note ... 236
Washington Notes. Editorial ... 418
Where are the Leaders? Editorial ... 172
Chemists, Industrial, College Courses for. C. W. Hill ... 646
Chemists, The Census of. F. E. Breithut Note ... 946
Chile, Potash Salts in. Note ... 937
China, Chemical Industry in. Note ... 649
China, Jute Production in. Note ... 861
China, Potteries at Shek Waan, Near Canton. C. N. Laird ... 569
Chinese Pencil Factory. Note ... 942
Chinese Perfume Plant. Note ... 1022
Chlorides and Sulfates of Sodium and Potassium, Separation of, by Fractional Crystallization. W. C. Blasdale ... 347
Chlorides: Equilibria in Solutions Containing Mixtures of Salts. I—The System Water and the Sulfates and Chlorides of Sodium and Potassium. W. C. Blasdale ... 344
Chlorine, Tar-Still Corrosion by. Note ... 574
Chrome Ore and Magnesite, Transvaal Deposits of. Note ... 313
Chrome Tanning. Note ... 746
Chromite Diller Gov. Pub. In 1916, 84; in 1917 ... 956
Citral, An Improved Method for Determining. A Modification of the Hiltner Method. C. E. Parker and R. S. Hiltner ... 608
Civil Service Rules Waived for War Gas Investigators. W. Wilson ... 753
Clay-Working Industries and Building Operations in the Larger Cities in 1916. Middleton. Gov. Pub ... 759
Clays, Louisiana, Including Results of Tests Made in the Laboratory of the Bureau of Standards at Pittsburgh. Matson. Gov. Pub ... 331
Cloves, Oil of. Note ... 648
Coal. A Comparative Study of Thermal Decomposition of Coal and Some of the Products of Its Carbonization. M. C. Whitaker and J. R. Suydam, Jr. ... 431
Coal, An Alinement Chart for the Evaluation of. A. F. Blake, 627; Correction ... 948
Coal: Analyses of Mine and Car Samples of Coal Collected in Fiscal Years 1913–1916. Fisher, *et al.* Gov. Pub ... 959
Coal and Asphalt Deposits. Gov. Pub ... 408
Coal and Rock-Dust Mixtures in Mines, The Quick Determination of Incombustible Matter in. Fieldner, *et al.* Gov. Pub ... 958
Coal Ash, Effect of, on the Liberation and Nature of Cement Mill Potash. N. S. Potter, Jr. and R. D. Cheesman, 109; *See* Letters ... 1030
Coal, Cannel, in the U. S. Ashley. Gov. Pub ... 586
Coal, Combustion of. Note ... 938
Coal, Combustion of, and Design of Furnaces. Kreisinger, *et al.* Gov. Pub ... 412
Coal, Effect of Low Temperature Oxidation on the Hydrogen in, and the Change in Weight of Coal on Drying. Katz and Porter. Gov. Pub ... 85
Coal for Shipment or Delivery, Directions for Sampling. Pope. Gov. Pub ... 332
Coal Mines of Illinois, Use of Permissible Explosives in. Fleming and Koster. Gov. Pub ... 958
Coal-Mining Machinery for Argentina. Note ... 228
Coal, New Views of the Combustion of the Volatile Matter in. Katz. Gov. Pub ... 412
Coal Products, an Object Lesson in Resource Administration. Mineral Industries of the U. S. Gilbert. Gov. Pub ... 245
Coal, Resource and its Full Utilization: Mineral Industries of the United States. Gilbert and Pogue. Gov. Pub ... 409
Coal Saving. Note ... 488
Coal, Stored, Effects of Moisture on Spontaneous Heating of. Katz and Foster. Gov. Pub ... 959
Coal, Stored, The Diffusion of Oxygen through. Katz. Gov. Pub ... 959
Coal Tar and Creosote in Longleaf Pine. Tests of Absorption and Penetration of. Teesdale and McLean. Gov. Pub ... 959
Coal-Tar Industry, Methods of Analysis Used in the. J. M. Weiss. I—Crude Tars, 732; II—Distilled Tars and Pitches, 817; III—Heavy and Middle Oils, 911; IV—Benzols and Light Oils ... 1006
Coal-Tar Industry, Some Applications of Physical Chemistry in the. W. J. Huff ... 1016
Coal Tar, Oils from. Note ... 1021
Coal Tar Products for 1917. Note ... 582
Coal: The Santo Tomas Cannel Coal, Webb Co., Texas. Ashley. Gov. Pub ... 955
Coals, Firing, Bituminous in Large House Heating Boilers. Flagg. Gov. Pub ... 412
Coals, Weights of Various. Flagg. Gov. Pub ... 959
Cobalt Arc, Wave Lengths in Red and Infra-Red Spectra of. Meggers and Kiess. Gov. Pub ... 959
Cod Liver Oil, Newfoundland. Note ... 939
Coke, Determination of Moisture in. Fieldner and Selvig. Gov. Pub ... 85
Cold Shock, the Influence of, in the Sterilization of Canned Foods. L. D. Bushnell ... 432
Colombia, Construction Materials and Machinery in. Ewing. Gov. Pub ... 664
Colombia, Vegetable Wax from. Note ... 230
Color Blindness. Collins. Gov. Pub ... 789
Color Designation of Oil Varnishes, Notes on. F. A. Wentz ... 178
Color Photographic Screens. Note ... 649
COMMERCE REPORTS. October 1917, 86; November 8th, December 16th, January 1918, 248, February, March, 411, April, 664, May, 665, June, 764, July, 874, August, 989, September, October ... 1037
Commissions for Baseball Players. Editorial ... 829
Concentration Experiments with the Siboney Red Hematite of the Birmingham District, Alabama. Sawtelle. Gov. Pub ... 442
Concrete and Cement Dynamite, Durability of, in Moist Soils; Containing Results of Third Year's Tests. Wells. Gov. Pub ... 85
Concrete and Concrete Roads, The Expansion and Contraction of. Goldbeck and Jackson. Gov. Pub ... 432
Concrete, Mixer, New. Note ... 938
Concrete Slab Subjected to Eccentric Compressive Loads, Tests of. Large Sized Reinforced. Goldbeck and Lyon. Gov. Pub ... 408
Congressional Committees. Gov. Pub ... 1
Conservation Through Garbage Utilization. Municipal Contribution to. E. D. Very ... 867
Controller, Automatic, for Electrical Heating Apparatus. Note ... 699
Conversion Tables, Hydraulic and Conversion Equivalents. Anonymous. Gov. Pub ... 176
Copper. Gov. Pub ... 67
Copper Amalgam as Metal Cement. Note ... 74
Copper and Aluminum in Germany. Note ... 649
Copper Area, A New. Note ... 487
Copper Carbonate Ores, Zinc Carbonate and Related, at Ophir, Utah. Loughlin. Gov. Pub ... 331
Copper in Eastern States in 1917. Gov. Pub ... 956
Copper in Idaho and Washington in 1916. Gerry. Gov. Pub ... 586
Copper in the Central States. Dunlop and Butler. Gov. Pub. In 1916 ... 84
Copper in 1916. Butler. Gov. Pub ... 759
Copper Production (1916). Gov. Pub.: Alaska, by Brooks, 246; New Mexico, Texas, South Dakota, and Wyoming, by Henderson, 246; California and Oregon, by Yale, 246; Arizona and Montana, by Heikes, 246; Eastern States, by Hill, 246; Colorado, by Henderson, 409; Utah and Nevada, by Heikes ... 409
Copper Products, Brass and Bronze. Gov. Pub ... 332
Copper: Swedish Industrial Developments. Note ... 76
Copper: Zinc Carbonate and Related Copper Carbonate Ores at Ophir, Utah. Loughlin. Gov. Pub ... 331
Corn and Sorghums, Comparative Transpiration of. Millet and Coffman. Gov. Pub ... 764
Corn and Wheat Products, Phosphorus as an Indicator of the Vitamine Content of. Voegtlin and Myers. Gov. Pub ... 759
Corn and Wheat, The Growth-Promoting Properties of Foods Derived from. Voegtlin and Myers. Gov. Pub ... 758
Corn Cobs, Preparation of Several Useful Substances from. F. B. LaForge and C. S. Hudson ... 925
Corn Silage, Velvet-Bean Meal, and Alfalfa Hay when Fed Singly and in Combinations, Digestibility of. Ewing and Smith. Gov. Pub ... 764
Corrosion, Tar-Still, by Chlorine. Note ... 574
Cotton Linters, Batting, and Waste, Foreign Markets for. Gov. Pub ... 764
Cotton Oil Industry in the War. D. Wesson ... 930
Cotton Plant, Chemistry of the. Vierhoever, *et al.* Gov. Pub ... 764
Cotton-Sampling Machine. Note ... 574
Cotton Standards for Grade, Manufacturing Tests of the Official. Dean and Taylor. Gov. Pub ... 503
Cottonseed: Gossypol, the Toxic Substance in Cottonseed. Withers and Carruth. Gov. Pub ... 504
Cottonseed Meal for Feeding Beef Cattle. Ward. Gov. Pub ... 763
Cottonseed Meal, Uniform Nitrogen Determination in. J. S. McHargue ... 533
Cottrell Precipitator: Electric Furnace Smelting of Phosphate Rock and Use of the Cottrell Precipitator in Collecting the Volatilized Phosphoric Acid. J. N. Carothers ... 35
Coumarin in Factitious Vanilla Extracts, The Detection and Determination of. H. Eichmann ... 535
Council of National Defense. Gov. Pub ... 586, 1037
Cranes and Transporters. Note ... 861
Creosote and Coal Tar in Longleaf Pine, Tests of Absorption and Penetration of. Teesdale and McLean. Gov. Pub ... 959
Creosote or Phenol Preservative in Serums, A Colorimetric Method for the Estimation of. Elvove. Gov. Pub ... 245
Cresols, The Three, The Estimation of Phenol in the Presence of. G. W. Knight, C. T. Lincoln, G. Formanek and H. L. Follett, @; Correction ... 239
Creosote, Relative Resistance of Various Hardwoods to Injection with. Teesdale and MacLean. Gov. Pub ... 763
Cryolite and Fluorspar in 1916. Burchard. Gov. Pub ... 246
Cucumber, Wild, *Echinocystis Oregana*, Seeds of. M. R. Daughters ... 126
CURRENT INDUSTRIAL REPORTS. A. McHugh ... 73, 150, 228, 312, 394, 487, 572, 648, 744, 861, 937, 1020
Cyanamide, Pure. Note ... 487
Cyanide, Sodium, Notes on. W. J. Sharwood ... 292
Cycle Components, Tubular. Note ... 150

DAMASCENE Steel. Note ... 942
Decanting. H. Tillisch ... 631
DEDICATION OF GILMAN HALL, UNIVERSITY OF CALIFORNIA
Introductory Address. E. O'Neill ... 391
Addresses. J. M. Stillman, 392; I. H. Duschak ... 393
DeRoode Method for the Determination of Potash in Fertilizer Materials, A Study of. T. E. Keitt and H. E. Shiver ... 219
Developing Agents, Organic, Examination of. H. T. Clarke ... 891
Device to Insure Tight Connections between Glass and Rubber Tubing. C. C. Kiplinger ... 631
Diamonds, South African. Note ... 395
Dieyanin, Application of, to Photography of Stellar Spectra. Merrill. Gov. Pub ... 762
Disease, Pulmonary, among Miners in Joplin District, Missouri, Siliceous Dust in Relation to. Higgins, *et al.* Gov. Pub ... 958
Diesel Engine Blast Pressure Control. Note ... 228
Disinfectant Testing Machine, New. L. Stimson and Neill. Gov. Pub ... 586
Disinfectants, Some Common. Dorset. Gov. Pub ... 764
Disinfectants, South African Requirements. Note ... 649
Disinfectants, Their Use and Application in Prevention of Communicable Diseases. Mechanic, 929; Ivy McCoy, *et al.* Gov. Pub ... 409
Dopes, Airplane. C. J. Esselen, Jr. ... 135
Draft Chemists and the. E. C. White. Note, 160. *See* Editorials ... 3
Drug Analysis, Studies in Synthetic
V. Estimation of Phenolphthalein. W. O. Emery and G. C. Spencer ... 605
VI. Evaluation of Hexamethylenetetramine Tablets. W. O. Emery and C. D. Wright ... 606
Drug Plant Crops, Production of, in U. S. Stockberger. Gov. Pub ... 763
DRUG RESEARCH, INSTITUTE FOR COÖPERATIVE RESEARCH AS AN AID TO THE AMERICAN DRUG INDUSTRY. Addresses by I. J. Abel, 969, P. A. Levene, 970, C. J. Alsberg, 971, A. S. Loevenhart, 974, E. R. Eldred, 974, D. W. Jayne, 975, E. R. Wendlum ... 976
Drying, Steam, Effect of Insulation on. Note ... 873
Du Pont Fellowships. Note ... 581
Dye and Chemical Industry, Britain. Note ... 748
Dye from Maple Leaves. Note ... 988
Dye from Sulfite. Note ... 142
Dye Industry and the Tariff Commission. C. Jones. Address ... 237
Dye, New Black. Note ... 74
Dyeing Process, Batik. Note ... 948
Dyes, Lessons of Khaki in the United States. J. C. Hebden ... 640
Dyes, The Treatment of the Tombs of Priests. M. Tech ... 118
Dyes, The Structure of Methyl OR, Butyl and Ponceau 3R By. H. Wauchope ... 600
Dyestuff Convention Proceedings on, 731. The Tariff Commission and the Dye Industry. C. Jones. Address ... 237
Dyestuff Industry, American and Its Prospects. Translation from German ... 1076
Dyestuff Industry, An Inglorious Rout. Editorial ... 419

Dyestuff Industry Organization within the. Editorial ... 786
Dyestuff Manufacture, British Progress in. J. Falconer ... 145
Dyestuff Manufacturers' Association, American. Note ... 402
Dyestuff, Request for Definition of Term. A Record of Achievement. Editorial ... 879
Dyestuff Situation in Textile Industries. Gov. Pub. ... 504
Dyestuffs Association. Note ... 324
DYESTUFFS, SYMPOSIUM ON CHEMISTRY OF (Cleveland Meeting, A. C. S.):
Announcement. R. N. Shreve, 750; Introductory Remarks. R. H. Shreve ... 789
America's Progress in Dyestuffs Manufacturing. L. J. Matos ... 790
The Development of the Dyestuff Industry since 1914. J. F. Schoellkopf, Jr. ... 792
Application of Dyestuffs in Cotton Dyeing. J. M. Matthews ... 794
Natural Dyestuff—An Important Factor in the Dyestuff Situation. E. S. Chapin ... 795
The Manufacture, Use, and Newer Developments of the Natural Dyestuffs. C. R. Delaney ... 798
Photographic Sensitizing Dyes: Their Synthesis and Absorption Spectra. L. E. Wise and E. Q. Adams ... 801
The Color Laboratory of the Bureau of Chemistry. H. D. Gibbs ... 802
Problems in Testing Dyes and Intermediates. E. W. Pierce ... 803
On the Quantitative Analysis of Dyestuffs. A. H. Halland ... 804
Dyestuffs: The Modern Miracle. Editorial ... 508

EARTH: Its Figure, Dimensions, and Constitution of Its Interior. Chamberlin, *et al.* Gov. Pub. ... 245
Ecuador, Peru, and Bolivia, Textile Markets in. Tucker. Gov. Pub. ... 664
Edgewood Arsenal Laboratory, Library for. W. L. Evans ... 868
EDITORIALS: 2, 93, 172, 254, 336, 418, 508, 590, 672, 876, 966. (*See* HERTY, C. H., in AUTHOR'S INDEX for Complete List of Titles; Actual Subjects treated are to be found in place in this index.)
Eggs, Determination of Loosely Bound Nitrogen as Ammonia in. N. Hendrickson and G. C. Swan ... 614
Ekenberg Peat Process. Note ... 312
Electric Arc Welding. Note ... 152
Electric Heater for Use in Analytical Distillation of Gasoline. E. W. Dean ... 823
Electric Lamp Industry in France. Note ... 1021
Electrical Appliances, Shortage of. Note ... 396
Electrical Conductivity Recorder for Salinity Measurements. E. E. Weibel and A. L. Thuras ... 626
Electrical Energy from the Volterra "Sofioni." Note ... 487
Electrical Heating Apparatus, Automatic Controller for. Note ... 229
Electrical Machinery. Note ... 746
Electricity in Silk Industry. Note ... 862
Electrochemical Industries, Swiss. Note ... 398
Electrodes, Manufacture of. Note ... 151
Electrolytic Process. Note ... 746
Electrometric Titration, The Determination of Manganese in Steel in the Presence of Chromium and Vanadium by. G. L. Kelley, M. G. Spencer, C. B. Illingworth and T. Gray ... 19
Electrons in Cadmium Vapor, Resonance and Ionization Potentials for. Tate and Foote. Gov. Pub. ... 762
Electro-Steel Works in Germany. Note ... 75
Electro-Technical Industry in Japan. Note ... 228
Elliott, Arthur Henry. Obituary. C. F. Chandler ... 498
Emetine Hydrochloride, On the Toxicity of, Special Reference to the Comparative Toxicity of Various Market Preparations. Lake. Gov. Pub. ... 1037
Engineering, Chemical, in our Universities and Colleges Immediately Prior to the Declaration of War, The Status of. H. F. Zoller ... 644
Engines, Detachable, for Ships. Note ... 314
Engines, Gas and Petrol. Note ... 940
Engines, Various Classes of. Note ... 573
England, Women in the Chemical Industries of. Note ... 1028
English Pottery Industry. Note ... 395
Enzymes of Milk and Butter. Thatcher and Dahlberg. Gov. Pub. ... 503
Equilibria in Solutions Containing Mixtures of Salts. I—The System Water and the Sulfates and Chlorides of Sodium and Potassium. W. C. Blasdale ... 344
Equivalents, Table of, Millimeters to Inches. Gov. Pub. ... 413
Ether, Effect of, on Tetanus Spores and on Certain Other Micro-organisms. Corbitt. Gov. Pub. ... 873
Ether Extract of Silage, Variation in. L. D. Haigh ... 127
Evaporator for Acid Liquids. E. Hart ... 555
Evaporators, Multiple, for Sugar Factories, Theory and Practice in the Design of. A. H. Webb ... 191
Evolution, Present Problem of. Caullery. Gov. Pub. ... 245
Experiment Station at American University, Transfer of, to the War Department. W. Wilson, N. D. Baker. Note, 654; *See* Editorial ... 590
Explosive Chemicals. Note ... 745
Explosive, New Mining. Note ... 747
Explosive, Safety of TNT as an. J. M. Weiss. Note ... 1028
Explosives. Gov. Pub. ... 409
Explosives and Chemical Divisions, War Industries Board. Note ... 654
Explosives and Their Ingredients, Licenses Required for. J. R. Healy. Note, 237. *See* Editorial, Important Notice ... 256
Explosives, High, Initial Priming Substances for. Taylor and Cope. Gov. Pub. ... 958
Explosives Manufacture, School of, Ordnance Department, Columbia University. Note ... 868
Explosives, Method of Calculating Comparative Strength and Efficiency of High Explosives from Their Composition and Apparent Densities. C. E. Waller ... 448
Explosives, Modern. Note ... 650
Explosives, Use of, Permissible, in Coal Mines of Illinois. Fleming and Kosler. Gov. Pub. ... 958
EXPOSITION OF CHEMICAL INDUSTRIES, FOURTH NATIONAL, New York City, September 23 to 28, 1918. Editorials 592, 672, 674; Notes, 681, 826, Program and Lists of Exhibitors ... 749
ADDRESSES: Permanent Chemical Independence. C. H. Herty ... 826
The Exposition in War and in Peace. F. J. Tone ... 828
The Importance of Practical Chemistry. G. W. Thompson ... 829
SYMPOSIUMS: *Acids and Chemicals*
Development in Nitric Acid Manufacture in the U. S. since 1914. E. J. Pranke ... 830
Potash
Recovery of Potash from Kelp. C. A. Higgins ... 832
Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation. L. Bradley ... 834
Potash from Desert Lakes and Alunite. J. W. Hornsey ... 838
Potash from Searles Lake. A. de Ropp, Jr. ... 836
Ceramics
Recent Developments in Ceramics. A. V. Bleininger ... 844
Carborundum Refractories. S. C. Linbarger ... 847
Metal Industries
The Pyrophoric Alloy Industry. A. Hirsch ... 849
The Ferro-Alloys. J. W. Richards ... 851
Industrial Organic Chemistry
Advances in Industrial Organic Chemistry since the Beginning of the War. S. P. Sadtler ... 854
Solvents from Kelp. C. A. Higgins ... 858
Wood Waste as a Source of Ethyl Alcohol. C. H. Tomlinson ... 859
Extracts, Non-Alcoholic Flavoring, The Determination of Essential Oils in. F. M. Boyles ... 537

FABRICS, Balloon, Determination of Permeability of. Edwards. Gov. Pub. ... 702
Fabrics for Aeronautic Construction. Whalen. Gov. Pub. ... 878
Fabrics, Water-Proof and Dust-Proof. Note ... 75
Fat in Condensed Milk and Milk Powders, A Study of the Estimation of. C. H. Biesterfeld and O. L. Evenson. Correction ... 156
Fatigue Products, The Present Status of Our Knowledge of. Scott. Gov. Pub. ... 586
Fats and Oils, Commercial, Tentative Standard Methods for the Sampling and Analysis of. W. D. Richardson ... 315
Fats and Oils in Germany. Note ... 942
Fats and Oils, Saponification of. Note ... 75
Fats, Edible, In War and Law. Address. D. Wesson ... 71
Fats, Foreign in Butter Fat, A Method for the Detection of. A. Seidenberg ... 61
Fats, Saving, from Garbage. F. C. Bamman. Notes ... 320
Federal Trade Commission. Gov. Pub. ... 409
Feed Residues: Study of the Physical Changes in Feed Residues which Take Place in Cattle During Digestion. Ewing and Wright. Gov. Pub. ... 764
Feeds: Mineral Content of Southern Poultry Feeds and Mineral Requirements of Growing Fowls. Kaupp. Gov. Pub. ... 959
Feldspar in 1917. Katz. Gov. Pub. ... 959
Fellowship, Du Pont ... 581
Fellowship, Research, State College of Washington. Note ... 753
Fellowship System, Industrial, The Growth of. Mellon Institute. Note ... 401
Ferro-Concrete Shipbuilding. Note ... 395
Ferromanganese Manufacture in Spain. Note ... 1021
Ferrosilicon, Acid-Resisting. Note ... 939
Fertilizer: Decomposition of Green and Stable Manures in Soil. Potter and Snyder. Gov. Pub. ... 504
Fertilizer Industry, Licensing of, Ordered. President Wilson. Proclamation ... 328
Fertilizer Materials, A Study of the DeRoode Method for the Determination of Potash in. T. E. Keitt and H. E. Shiver ... 219
Fertilizer Materials from Minor Sources, Conservation of. Fletcher. Gov. Pub. ... 763
Fertilizer: Phosphate Rock, Our Greatest Fertilizer Asset. Waggaman. Gov. Pub. ... 763
Fertilizer: Reverted Phosphate. C. C. James ... 33
Fertilizer Situation in the United States, Interpretation of. Mineral Industries of the United States. Pogue. Gov. Pub. ... 84
Fertilizer: The Agricultural Availability of Raw Ground Phosphate Rock. W. H. Waggaman and C. R. Wagner ... 442
Fertilizers, Commercial Bordeaux Mixtures: How to Calculate their Values. Wallace and Evans. Gov. Pub. ... 959
Fertilizers: Commercial Stocks of Fertilizers and Fertilizer Materials in U. S. as Reported for October 1, 1917. Gov. Pub. ... 763
Fertilizers: Comparison of Percentages of Nitrogen in Tops and Roots of Head Lettuce Plants. H. A. Noyes ... 621
Fertilizers, Effect of, on Hydrogen-Ion Concentration in Soils. F. W. Morse ... 125
Fertilizers from Industrial Wastes. Ross. Gov. Pub. ... 763
Fertilizers, Sources of our Nitrogenous. Brown. Gov. Pub. ... 763
Fertilizers: The Fertilizing Value of Activated Sludge. G. G. Nasmith and G. F. McKay, 339. *See* Rudnick ... 400
Fibers, "Hard" Rope, Distinguishing Manila from all other. C. E. Swett ... 227
Filter, Ultra-. Note ... 747
Filtering Tube, Simple and Efficient. W. M. Thornton, Jr. ... 132
Fire-Clay Bodies, Effect of Size of Grog in. Kirkpatrick. Gov. Pub. ... 762
Fish, Commercial Freezing and Storing of. Clark and Almy. Gov. Pub. ... 763
Fish, Experiments on Digestibility of. Holmes. Gov. Pub. ... 763
Fish Oil, Utilization of. Note ... 487
Flours: Hydration Capacity of Gluten from "Strong" and "Weak" Flours. Gortner and Doherty. Gov. Pub. ... 764
Fluorspar and Cryolite in 1916. Burchard. Gov. Pub. ... 240
Fluxes. Note ... 15
Food: Chemical Tests for Detection of Rancidity. R. H. Kerr ... 47
Food Chemistry in the Service of Human Nutrition. Address. H. C. Sherman ... 383
Food Conservation, A Problem in. The Deterioration of Raw Cane Sugar. C. A. Browne ... 178
Food: Determination of Loosely Bound Nitrogen as Ammonia in Eggs. N. Hendrickson and G. C. Swan ... 614
Food: Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon. H. S. Bailey and J. M. Johnson ... 999
Food: Effect of Different Oxygen Pressures on Carbohydrate Metabolism of Sweet Potato. Hasselbring. Gov. Pub. ... 959
Food: Enzymes of Milk and Butter. Thatcher and Dahlberg. Gov. Pub. ... 503
Food: Influence of Age of Cow on Composition and Properties of Milk and Milk Fat. Eckles and Palmer. Gov. Pub. ... 503
Food In War Time. Note ... 328
Food: Method for the Detection of Foreign Fats in Butter Fat. A. Seidenberg ... 61
Food: Occurrence of Carotin in Oils and Vegetables. A. H. Gill ... 612
Food Products, Detection of Vegetable Gums in. A. A. Cook and A. G. Woodman ... 530
Food Products, Sulfured, Arsenic in. W. D. Collins ... 360
Food: Study of the Streptococci Concerned in Cheese Ripening. Evans. Gov. Pub. ... 763
Foods, Canned, The Influence of Cold Shock in Sterilization of. L. D. Bushnell ... 432

Foods Derived from Corn and Wheat, The Growth-Promoting Properties of. Voegtlin and Meyers. Gov. Pub. 758
Foods, The Bureau of Markets in Its Relation to the Conservation of. C. J. Brand. 66
Formaldehyde, Disinfection with, A Substitute for the Permanganate-Formalin Method. C. C. Storm. 123
Formulas, Conversion of. W. H. Cole. 555
France, A Chemists' Club for. Editorial. 2
France, A Letter from. W. A. Hamor. 495
France, Electric Lamp Industry in. Note. 1021
France, Machinery for. Note. 394
Frasch, Herman, Unveiling of Portrait of. 326
Freezing-Point Method as an Index of Variations in the Soil Solution Due to Season and Crop Growth. Hoagland. Gov. Pub. 504
French Chemical Industries during 1916. F. J. LeMaistre. 421
French Industries, The Great Effort of the. M. Knecht. 423
French Orphans, A Golden Opportunity Editorial. 967
Fruits: Some Constituents of the American Grapefruit (*Citrus decumana*). H. F. Zoller. 364
Fruits: The Composition of Loganberry Juice and Pulp. M. R. Daughters. Correction. 189
Fruits: The Loganberry and the Acid Content of its Juice. M. R. Daughters. 30
Fuel. Gov. Pub. 409
Fuel Briquetting in 1917. Lesher. 662
Fuel for Manufacture of Chemicals. E. Smith. Note. 159
Fuel in the U. S. Gov. Pub. 408
Fungi, Wood-Rotting, Pure Culture of, on Artificial Media. Long and Harsch. Gov. Pub. 504
Furnace, A Rocking Electric Brass. H. W. Gillett and A. E. Rhoads. 459
Furnace, Blast, Practice. Note. 746
Furnace, Electric Zinc. Note. 487
Furnaces, Design of, and Combustion of Coal. Kreisinger, *et al.* Gov. Pub. 412

"GARABED," The Demise of the. Editorial 590
Garbage Collection and Garbage Grease Recovery in American Cities, Statistics on. R. Pail. 927
Garbage Disposal Industry, American, and Its Chemical Relation R. Wells. 567
Garbage, Saving Fats from. F. C. Bamman. Notes 320
Garbage, Utilization, Municipal Contribution to Conservation through. E. D. Very. 563
Gas. Gov. Pub. 409
Gas Analysis, Reagent Use in.
VI—The Absorption of Hydrogen by Sodium Oleate. R. P. Anderson and M. H. Katz. 23
VII—The Determination of Benzene Vapor R P. Anderson 25
Gas Analysis, Use of the Interferometer in. Siebert and Harpster. Gov. Pub. 959
Gas and Oil Possibilities of the Hatchetigbee Anticline, Alabama. Hopkins. Gov. Pub. 247
Gas and Petrol Engines. Note. 940
Gas Condensate, Natural, Formation of Aromatic Hydrocarbons from. J. G. Davidson. 901
Gas Exhausters, Water Lubrication of. Note. 488
Gas-Fired Brazing Table. Note. 1022
Gas: Geologic Structure in the Crushing Oil and Gas Field, Oklahoma, and Its Relation to the Oil, Gas, and Water. Beal. Gov. Pub. 331
Gas in Glass Industry. Note. 940
Gas Interferometer Calibration. Edwards. Gov. Pub. 413
Gas-Mantle Lighting Conditions in Ten Large Cities in the U. S. McBride and Reinicker. Gov. Pub. 85
Gas, Natural, and Its Constituents, Compressibility of, with Analyses of Natural Gas from 31 Cities in the U. S. Burrell and Robertson. Gov. Pub. 332
Gas, Natural, in 1916. Northrop. Gov. Pub. 662
Gas, Natural, Testing for Gasoline. G. G. Oberfell 211
Gas: Recovery of Gasoline from Natural Gas by Compression and Refrigeration. Dykema. Gov. Pub. 958
Gas: Report of the Bureau of Standards on the Recovery of Light Oils and Refining of Toluol. 81
Gas: Toluol by Cracking Solvent Naphtha in the Presence of Blue Gas. G. Egloff. 8
Gas: Toluol Recovery and Standards for Gas Quality. R. S. McBride. 111
Gas Warfare, Methods of. Address. S. J. M. Auld. 297
Gas Warfare: Typical German Pronouncements. Editorial. 420c
Gases, A New Method for the Quantitative Estimation of Vapors in. H. S. Davis and M. D. Davis. 709
Gases: Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Gases. H. S. Davis, M. D. Davis, and D. G. MacGregor. 713
Gases, Measuring the Temperature of, in Boiler Settings. Kreisinger and Barkley. Gov. Pub. 959
Gases: Physiological Effect of Different Gases on Man. Burrell. Gov. Pub. 959
Gases, Studies on the Absorption of Light Oils from. H. S. Davis and M. D. Davis. 718
Gasoline. Gov. Pub. 409
Gasoline, A Convenient Electric Heater for Use in Analytical Distillation of. E. W. Dean. 823
Gasoline, Determination of Unsaturated Hydrocarbons in. Dean and Hill. Gov. Pub. 412
Gasoline Engines in Mines, Suggestions for the Safe Operation of. Kudlich and Higgins. Gov. Pub. 412
Gasoline from Natural Gas by Compression and Refrigeration, Recovery of. Dykema. Gov. Pub. 958
Gasoline, Testing Natural Gas for. G. G. Oberfell 211
Gauges, Swedish. Note. 395
Gauges, Wire. Gov. Pub. 413
Gelatin and Glue, Jelly Value of. A. W. Clark and L. DuBois. 707
Gelatin, Australian. Note. 487
Gelatin, The Reticulation of. S. E. Sheppard and P. A. Elliott 727
Gems and Precious Stones. Shaller. Gov. Pub. In 1915, 955; in 1917. 957
Generator: Electric Heat Storage in Boilers. Note. 151
Generator, Hydrogen Sulfide. L. Sattler. 326
Generator, Hydrogen Sulfide, A New Portable. W. F. Munn. 130
Geologic Structure of Northwestern Part of Pawhuska Quadrangle, Oklahoma. Heald. Gov. Pub. 409
Geological Survey; Director's Annual Report 247
Gov. Pub. 84, 165, 246, 331, 409, 586, 662, 759, 873, 954
Geology and Oil Prospects of the Salinas Valley-Parkfield Area, California. English. Gov. Pub. 874
Geology, North American, Bibliography of, for 1916, with Subject Index. Nickles. Gov. Pub. 331
Geology: Structure of Parts of the Central Great Plains. Darton Gov. Pub. 586
German Enterprise in the Ukraine. Note. 1021
German Potash and the War. Note. 655
German Union of Technical and Scientific Societies. 575
Germany, Alcohol Production in. Note. 650
Germany, Catalytic Processes in. Note. 939
Germany, Copper and Aluminum in. Note. 685
Germany, Electro-Steel Works in. Note. 75
Germany, Fats and Oils in. Note. 942
Germany, New After-War Preparations in Chemical Industry of. Translated from the French. 1025
Germany, New Sources of Oil Supply in. Note. 747
Germany, Tanning Material in. Note. 1022
Germany's Commercial Methods. Note. 228
GIBBS MEDAL AWARD:
Editor's Note, 483; Introductory Address. L. M. Tolman. 483
Chemistry in the Petroleum Industry. Medal Address. W. M. Burton. 484
Gilman Hall: The Research Unit of the Chemistry Group at the University of California. M. Randall. 634
GILMAN HALL, UNIVERSITY OF CALIFORNIA, DEDICATION OF. 391
Glass and Quartz, Compression Strength of. Note. 942
Glass and Rubber Tubing, A Device to Insure Tight Connections Between. C. C. Kiplinger. 631
Glass, Demands for. Note. 650
Glass Industry, Gas in. Note. 940
Glassware, Chemical, Comparative Tests. Walker and Smither. Gov. Pub. 762
Glue and Gelatin, Jelly Value of. A. W. Clark and L. DuBois. 707
Glue, Australian. 487
Glues, Determining the Comparative Melting Points of, as a Measure of the Jelly Strength. C. F. Sammet. 595
Glues: Non-Inflammable Plastic Material. Note. 74
Gluten from "Strong" and "Weak" Flours, Hydration Capacity of Gortner and Doherty. Gov. Pub. 764
Glycerin and Soap Manufacture in India. Note. 744
Glycerin as Used in Medicines, Conservation of. Note. 495
Glycerin, Japanese. Note. 75
Gold and Silver in 1916. McCaskey and Dunlop. Gov. Pub. 956
Gold Coast, Exports from. Note. 394
Gold in Eastern States in 1917. Hill. Gov. Pub. 956
Gold in Idaho and Washington in 1916. Gerry. Gov. Pub. 586
Gold Placers and Lode Deposits near the Nenana Coal Field, Alaska. Overbeck and Maddren. Gov. Pub. 331
Gold Placers of the Anvik-Andreafski Region, Alaska. Harrington. Gov. Pub. 331
Gold Placers of the Tolovana District, Alaska. Mertie. Gov. Pub. 331
Gold Production (1916). Gov. Pub. Alaska, by Brooks, 246. New Mexico, Texas, South Dakota, and Wyoming, by Henderson, 246. California and Oregon, by Yale, 246. Arizona and Montana, by Heikes, 246. Eastern States, by Hill, 246. Colorado, by Henderson, 409. Utah and Nevada, by Heikes. 409
Goods in Demand in Australia. Note. 861
Gossypol, the Toxic Substance in Cottonseed. Withers and Carruth. Gov. Pub. 504
GOVERNMENT PUBLICATIONS. R. S. McBride:
84, 165, 245, 331, 408, 503, 586, 662, 758, 873, 954, 1037
Grain Relation of the Density of Cell Sap to Winter Hardiness in Small Grains. Salmon and Fleming. Gov. Pub. 764
Grapefruit, American (*Citrus decumana*), Some Constituents of. H. F. Zoller. 364
Graphite for Boiler Scale. Note. 395
Graphite in 1917. Ferguson Gov. Pub. 957
Gravel and Sand in 1916. Stone Gov. Pub. 247
Gravel Deposits of the Caddo Gap and DeQueen Quadrangles, Arkansas. Miser and Purdue. Gov. Pub. 954
Gravel, Flaxville, and its Relation to Other Terrace Gravels of the Northern Great Plains. Collier and Thom. Gov. Pub. 409
Grease Recovery. 650
Great Britain, Mineral Output of. Note. 573
Great Britain, Preparation for Post-War Conditions in. Note. 399
Greensand, Recovery of Potash from. H. W. Charlton 6
Grog in Fire-Clay Bodies, Effect of Size of. Kirkpatrick. Gov. Pub. 762
Guaiacol Sulfonate, Potassium, The Identification and Determination of. S. Palkin. 610
Gums, Vegetable, The Detection of, in Food Products. A. A. Cook and A. G. Woodman. 530
Gun, Long-Range. Note. 574
Gutta-Percha from the Shea Butter Tree. Note. 76
Gypsum Deposit in a Boiler. Note. 488
Gypsum, Influence of, Upon Solubility of Potash in Soils. McMiller. Gov. Pub. 959
Gypsum in 1916. Stone Gov. Pub. 165
Gypsum Products, Their Preparation and Uses. Stone Gov. Pub. 332

HALL, C. M., Portrait of, for Chemists' Club. Note. 947
Hardwood, The Influence of Moisture on the Yield of Products in the Destructive Distillation of. R. C. Palmer and R. Cloukey. 267
Hardwoods, Relative Resistance of Various, to Injection with Creosote. Teesdale and MacLean. Gov. Pub. 763
Hardwoods, The Effect of Catalyzers on the Yield of Products in the Destructive Distillation of. R. C. Palmer 261
Hawaiian Soils, Reaction of, with Calcium Bicarbonate Solutions, Its Relation to the Determination of Lime Requirements of Soils, and a Rapid Approximate Method for the Determination of Lime Requirements of Soils. M. O. Johnson 91
Health Department, City, Appropriations for. Preble. Gov. Pub. 245
Heat, Electric, Storage in Boilers. Note. 151
Heat Hazard in Industry, Mitigation of the. Watkins. Gov. Pub. 245
Heat Insulator, A New. Note. 861
Hematite Siliceous Red of the Birmingham District, Alabama, Concentration Experiments with. Singewald. Gov. Pub. 41
Hexamethylenetetramine, Tables for Evaluation of, Studies in Synthetic Urine Analyses. VI. W. O. Emery and C. D. Wright 606
Hide and Leather Situation. Gov. Pub. 409
Hides and Skins from Venezuela. Note. 328
Hilmer Method, A Modification of, An Improved Method for Determining Uric Acid. C. F. Parker and R. S. Hilmer 608

Holland Margarine Industry in Note 396
Household Materials for Gov. Pub. 413
Household, Safety for Gov. Pub. 413
Humus in Mulched Basins, Relations of Humus Content to Organic Production and Effect of Mulches on Organic Production Lipman Gov. Pub. 765
Hydraulic Conversion Tables and Convenient Equivalents, Gov. Pub 168
Hydrocarbons Aromatic from Natural Gas Condensate, The Formation of J. G. Davidson 991
Hydrocarbons, Desulfuration of Note 73
Hydrocarbons in Gasoline, Unsaturated, Determination of Dean and Hill, Gov. Pub. 413
Hydrocyanic Acid Gas as Soil Fumigant, de Ong, Gov. Pub. 803
Hydrogen, Absorption of by Sodium Oleate, VI, Reagents for Use in Gas Analysis, R. P. Anderson and M. H. Katz 23
Hydrogen Electrode, Relation of Carbon Dioxide to Soil Reaction as Measured by the, Haseland and Sharp, Gov. Pub. 804
Hydrogen Electrode, Studies in Soil Reaction as Indicated by the, Plummer, Gov. Pub. 804
Hydrogen in Coal and the Change in Weight of Coal on Drying, Effect of Low Temperature Oxidation on, Katz and Porter Gov. Pub. 85
Hydrogen Ion Concentration in Soils, Effect of Fertilizers on, F. W. Morse 125
Hydrogen Sulfide Generator, L. Satrbr 226
Hydrogen Sulfide Generator, A New Portable, W. F. Munn 130
Hydrogen Sulfide Stopcock, An Automatic, C. H. Classen... 131
Hydrosulfites, Note 941

IGNEOUS Rocks, Chemical Analyses of, Washington, Gov. Pub 331
Illuminator, New, for Microscopes, A. Silverman 1013
Incombustible Matter in Coal and Rock Dust Mixtures in Mines, Quick Determination of, Fieldner *et al.*, Gov. Pub. 958
India, Indigo Crop of, Note 488
India Oil Pressing Plant for, Note 807
India, Soap and Glycerin Manufacture in, Note 744
Indian Oilseeds, Note 397
Indian Resin, Note 747
Indigo Crop of India, Note 488
Indigo Industry, Natural, Note 862
Industrial Developments in Japan, Note 397
Industrial Developments, South African, Note..... 230
Industrial Efficiency, Lee, Gov. Pub. 245
Industrial Efficiency, Research as an Aid to 493
INDUSTRIAL NOTES
82, 162, 243, 329, 406, 501, 588, 689, 787, 857, 981, 1036
Industries, Chemical and Allied, Gov. Pub. 988
Industries, Clay Working and Building, Operations in the Larger Cities in 1916, Middleton, Gov. Pub. 759
Industries, French, Great Effort of, M. Knecht 423
Industries, New Norwegian, Note 939
Industries, New South African, Note 943
Industry and Research, Organic Reagents for, C. E. K. Mees, Notes 656, 1027
Industry and Science, The Collaboration of, *Trade Addresses* of Address by V. Grignard 137
Industry, Chemical in China, Note 649
Industry, Chemical in the Netherlands, Note 947
Industry, Cotton Oil in the War, D. Wesson 930
Industry, Electric Lamp in France, Note 1021
Industry, Planning a Research Laboratory for an, C. E. K. Mees 476
Insect Eggs, Toxicity of Volatile Organic Compounds to, Moore and Graham, Gov. Pub. 763
Insecticides, A Contribution to the, Composition of Lime Sulfur Solutions, O. B. Winter 539
Insecticides, Contact, Physical Properties Governing the Efficacy of, Moore and Graham, Gov. Pub. 764
Insecticides, Determination of Arsenic in, by Potassium Iodate, G. S. Jamieson 290
Insecticide Chemistry, Editorial 95
Instrument Collar, for Chemical Warfare Service, Note 685
Instrument, Optical, The Properties and Testing of, Gov. Pub. 959
Insulating Material, Note 814
Insulation on Steam Drums, Effect of, Note 873
Interferometer, Gas Calibration, Edwards, Gov. Pub. 413
Interferometer in Gas Analysis, Use of the, Siebert and Harpster, Gov. Pub. 959
Internal Revenue Commissioner 245
Invention Problems, Note 1028
Iota Sigma Pi, Note 1023
Iron and Oxidases in Color Changes of Sugar Cane Juice, The Role of, F. W. Zerban 814
Iron and Steel, Gov. Pub. 332
Iron and Steel Industry During the War Period, Trend of Accident Frequency Rates in, Chance, Gov. Pub. 412
Iron and Steel Industry in Japan, Note 861
Iron and Steel, Sulfur in, A Standard Apparatus for Determination of by Evolution Method, H. B. Pulsifer 845
Iron and Steel Trade in Aden, Note 943
Iron Arc Wave Lengths in Red and Infra-Red Spectra of, Meggers and Kiess, Gov. Pub. 959
Iron, Determination of Oxygen in, Note 745
Iron Industry, Norwegian, Note 813
Iron Ore Production 1916, Burchard, Gov. Pub. 411
Iron Ore, South African, Note 398
Iron Ores, Manganiferous, Hubbard, Gov. Pub. 1065
Iron Pig Production 1916, Burchard, Gov. Pub. 411
Irrigation Plant, Note 872
Irrigation, Studies on Capacities of Soils for Irrigation Water and on a New Method for Determining Volume Weight, Israelsen Gov. Pub. 763
Isothermal Room, Gas Heated, Note 813
Italian Dye and Chemical Industry, Note 748

JAPAN, Electric Lamp Trade in, Note 74
Japan, Electro-Technical Industry in, Note 228
Japan, Iron and Steel Industry in, Note 861
Japan Peppermint Cultivation, Note 4
Japan Railway Material for, Note 476
Japan, Rubber Industry in, Note 396
Japan, Vegetable Oils in, Note 862
Japan, Zinc Refining in, Note 230
Japanese Camphor, Note 1022
Japanese Calcium Nitrate Enterprise, Note 942
Japanese Glycerin, Note 75
Japanese Industrial Development, Note 397
Jelly Strength, Determining the Comparative Melting Points of Glues as a Measure of the, C. L. Garner 545
Jelly Value of Gelatin and Glue, A. W. Clark and L. DuBois 707
Journal of the American Chemical Society, Change in Editorship, An Appreciation and a Correction, Editorial 95
Journals of the American Chemical Society, C. E. Goldthwait, Note 1026
Jute Production in China, Note 861
Jute Sacks for Arsenites, Note 74

KAFIR Kernel, A Physical and Chemical Study of the, Bidwell, Gov. Pub. 763
Kelp, On the Preparation of an Active Decolorizing Carbon from, F. W. Zerban and L. C. Freeland 812
Khaki Dyeing of, in the United States, J. C. Hebden 649
Kjeldahl Digestion Flasks, A Simple and Entirely Adjustable Rack for, F. E. Rice 631
Kjeldahl Gunning Method, The Use of Sodium Sulfate in the, C. T. Dowell and W. G. Friedman 899
Korea, Machinery for, Note 230

LABORATORY AND PLANT
88, 158, 222, 292, 334, 389, 545, 626, 732, 817, 941, 1066
Laboratory, Research, for an Industry, C. E. K. Mees 476
Laboratory Specimens, Public Health, Their Preparation and Shipment, Hasseltine, Gov. Pub. 245
Laboratory Supplies, Gov. Pub. 586
Laboratory Ware, Porcelain, Comparative Tests of, Waters, Gov. Pub. 803
Lamp Industry, Electric in France, Note 1021
Lamp Test, Note 948
Lampblack Manufacture, Note 75
Lamps, Approved Electric Lamps for Miners, Clark and Ilsley, Gov. Pub. 85
Lamps, Electric Lamp Trade in Japan, Note 74
Lamps, Incandescent, Note 1020
Lamps, Incandescent Electric Tungsten and Carbon, Standard Specifications for, Gov. Pub. 762
Lead in Eastern States in 1917, Hill, Gov. Pub. 986
Lead in Idaho and Washington in 1916, Gerry, Gov. Pub. 889
Lead in the Central States, Dunlap and Butler, Gov. Pub. In 1916 84
Lead Production 1915, Gov. Pub., Alaska by Brooks, 246, New Mexico, Texas, South Dakota and Wyoming by Henderson 246, California and Oregon by Yale 246, Arizona and Montana by Heikes 16, Eastern States, by Hill 246, Colorado by Henderson 409, Utah and Nevada by Heikes 409
Lead Silver, Antimonial Veins of the Arabia District, Nevada, Knopf, Gov. Pub. 331
Leather and Hide Situation, Gov. Pub. 409
Leather Imitation for Switzerland, Note 75
Leather Industry, Gov. Pub. 988
Leather, Utilization of Waste Boots, Note 230
Leaves, Axial Aberrations of, Tillyer and Shultz, Gov. Pub. 86
Lettuce Plants, Head, Comparison of Percentages of Nitrogen in Tops and Roots of, H. A. Noyes 921
Levenstein Limited, Report of Progress 149
Library for Edgewood Arsenal Laboratory, W. L. Evans 868
Light, Atmospheric Scattering of, Fowle, Gov. Pub. 764
Lighting Factory, Note 649
Lime, Agricultural, Determination of Value of, S. D. Conner 926
Lime Cake Analysis, A Quick Method for, A. N. Clark..... 81
Lime, in 1916, Machin, Gov. Pub. 662
Lime, Reaction of Hawaiian Soils with Calcium Bicarbonate Solutions, Its Relation to the Determination of Lime Requirements of Soils, and a Rapid Approximate Method for the Determination of Lime Requirements of Soils, M. O. Johnson 31
Lime Valuation of, for Various Purposes, R. K. Meade 214
Limestone, Helderberg of Central Pennsylvania, Reeside, Gov. Pub. 331
Lime Sulfur Solutions, A Contribution to Composition of, O. B. Winter 539
Limning, Soils, Principles of, Shorey, Gov. Pub. 763
Linseed Oil, Influence on Linseed Oil of Geographical Source and Variety of Flax, Rabak, Gov. Pub. 763
Liquids, Metallic, Note 941
Lode Deposits and Gold Placers near the Nenana Coal Field, Alaska, Overbeck and Maddren, Gov. Pub. 331
Lode Mining in the Fairbanks District, Alaska, Martin, Gov. Pub. 331
Locust Cherry and the Acid Content of its Juice, M. R. Daughters 30
Locust Cherry Juice and Pulp, The Composition of, M. R. Daughters, Correction 159
Lubricating Material, Note 47
Lubricating Oil, Note 75
Lyes, Sulfite, Dye from, Note 1022

MACHINE Cotton Sampling, Note 574
Machine, New, Disinfectant Testing, Stimson and Neff, Gov. Pub. 886
Machinery and Materials, Construction in Colombia, Ewing, Gov. Pub. 664
Machinery, Electrical, Note 746
Machinery for France, Note 394
Machinery for Korea, Note 230
Machinery for Venezuela, Note 398
Machinery in South America, Note 746
Magnesia and Potash from Canadian Lake Recovery of, Note 181
Magnesia Bricks, Refractory Properties of, Note 130
Magnesite, Gov. Pub., In 1916, Yale and Gale 34, in 1917, Yale and Stone 83
Magnesite and Chrome Ore, Transvaal Deposits of, Note 813
Magnesite, Note 488
Magnesium Alloy, New, Note 5
Magnesium and Calcium, Influence of Carbonates of, on Bacteria of Certain Wisconsin Soils, Fulmer, Gov. Pub. 763
Magnesium Chloride and Cement Mortars, Note 46
Magnesium Oxide, On the Influence of the Temperature of Burning, on the Rate of Hydration of, E. DeM. Campbell 898
Magnetic Separations and the Rarer Metals, Note 813

Magneto Ignition. Note . . . 314
Magneto Machines for Pocket Torches Note 150
Magnets, Chromium Steel for. Note. 229
Malay States, Mineral Deposits in Note 397
Malaya, Tungsten in. Note 150
Manganese and Manganiferous Ores in 1916. Hewett Gov Pub 955
Manganese at Butte, Montana. Pardee. Gov. Pub 586
Manganese Deposits in Madison County, Montana. Pardee. Gov. Pub. . . . 954
Manganese in Steel, The Determination of, in the Presence of Chromium and Vanadium by Electrometric Titration. G. L. Kelley, M. G. Spencer, C. B. Illingworth and T. Gray. . . . 19
Manganese Ore, Possibilities for, on Certain Undeveloped Tracts in Shenandoah Valley, Virginia. Hewett, *et al.* Gov. Pub. . . . 409
Manila Rope, Distinguishing from all other "Hard" Rope Fibers C E. Swett . . . 227
Manufactures, Census of, (1914); Petroleum Refining. Gov Pub 412
Manufacturers and Universities, Coöperation Between. R. E. Oesper Note . . . 1027
Manures, Decomposition of Green and Stable, in Soil. Potter and Snyder. Gov. Pub. . . . 504
Manures, Green, Soil Acidity as Influenced by. White. Gov. Pub. . . . 763
Maple Sugar Composition, Methods of Analysis, Effect of Environment Bryan, *et al* Gov Pub . . . 503
Margarine Industry in Holland. Note. . . . 396
Market Report . 90, 170, 252, 334, 416, 506, 588, 670, 766, 876, 964, 1040
Massachusetts Institute of Technology
Four Hundred Thousand Dollar Gift to. Note. . . . 581
Readjustments to meet War Conditions Note . . . 238
Meal, Check, Contest. Note. . . . 656
Medical and Surgical Supplies, Staple, List of. Gov. Pub. . . . 586
Medicinals: War Chemistry in the Alleviation of Suffering. Editorial. . . . 673
Medicine, Prevention of, The Debt of, to Chemistry. G. W. Goler. . . . 303
Medicines and Compounds, Patent and Proprietary, and Druggists' Preparations. Gov. Pub . . . 958
Medicines, Conservation of Alcohol, Glycerin, and Sugar as Used in. Note . . . 495
Mellon Institute. Growth of Industrial Fellowship System. Note. . . . 401
Melting Points, Comparative, of Glues as a Measure of the Jelly Strength C. P. Sammet . . . 595
Menhaden Industry of the Atlantic Coast. Greer. Gov. Pub. . . . 166
Metal-Spray Process, Schoop Notes . . . 939, 1022
Metallurgical Works in the U. S during the Calendar Year 1916, Accidents at Fay. Gov Pub . . . 412
Metals and Other Materials Made in Ordnance Laboratory at Watertown Arsenal, Mass., Fiscal Year 1916. Report of Tests of. Gov. Pub. . . . 245
Metals, Antifriction. Note. . . . 941
Metals, Platinum, from Canadian Nickel, Recovery of. Note. . . . 76
Metals, Rarer, Magnetic Separations and Note . . . 313
Meteorology and Aeronautics. Blair. Gov. Pub . . . 873
Methane Accumulations from Interrupted Ventilation Smith and Hamon Gov. Pub . . . 959
Mica Schaller Gov Pub In 1916, 246, in 1917 . . . 957
Microörganisms, The Use of, to Determine the Preservative Value of Different Brands of Spices. F. M. Bachmann . . . 121
Microscopes, A New Illuminator for. A. Silverman. . . . 1013
Microscopic Qualitative Chemical Analysis The Use of Textile Fibers in. E. M. Chamot and H. J. Cole . . . 48
Microscopy, Chemical. E. M. Chamot Address . . . 60
Milk: A Comparison of the Proximate and Mineral Analysis of Desiccated Skim Milk with Normal Cows' Milk. E. P. Harding and H. Ringstrom. . . . 295
Milk, Added Water in, Research on the Determination of. H. Durand and R. Stevenson . . . 26
Milk and Butter, Enzymes of Thatcher and Dahlberg Gov Pub . . . 503
Milk and Milk Fat, Influence of Age of Cow on Composition and Properties of Eckles and Palmer Gov Pub . . . 503
Milk, Condensed, and Milk Powders, A Study of the Estimation of Fat in C H Biesterfeld and O L. Evenson Correction . . . 159
Milk Manufacture of Casein from Buttermilk or Skim Milk Dahlberg. Gov Pub . . . 763
Milk Ordinance, A Guide for Formulating Gov Pub . . . 332
Milk Powder, Dried Gov Pub . . . 788
Mine Fire Some Results of Analysis of Airs from. A. G Blakeley and H. H Geist . . . 552
Mineral Content of Southern Poultry Feeds and Mineral Requirement of Growing Fowls Kaupp Gov Pub . . . 959
Mineral Deposits in Malay States Note . . . 397
Mineral Industries of the U. S Gov Pub. Coal Products, An Object Lesson in Resource Administration Gilbert 245, Coal, Resource and Its Full Utilization Gilbert and Pogue, 409, Interpretation of Fertilizer Situation in the U. S., Pogue, 84, Sulfur, an Example of Industrial Independence, Pogue . . . 245
Mineral Output of Great Britain Note . . . 873
Mineral Production in Canada Note . . . 24
Mineral Production of Victoria Note . . . 181
Mineral Resources The Lake Clark Central Kuskokwim Region, Alaska Smith. Gov Pub . . . 586
Mineral Springs of Alaska Chemical Character of Some Surface Waters of Alaska Waring, *et al* Gov Pub . . . 24
Mineral Waters in 1916. Ellis Gov Pub . . . 663
Minerals Rare Earth, and Zirconium in 1916. Schaller. Gov. Pub. . . . 24
Miners, Siliceous Dust in Relation to Pulmonary Disease among Miners in Joplin District Missouri Bloomer, *et al* Gov Pub . . . 958
Mines Gov Pub . . . 409
Mines Approved Electric Lamps for Miners Clark and Ilsley . . . 83
Mines Metal-Mine Accidents in the U. S during 1916 Fay Gov Pub . . . 958
Mines Quick Determination of Incombustible Matter in Coal and Rock-Dust Mixtures in Mines Forbes Gov Pub . . . 958
Mines Suggestions for the Safe Operation of Gasoline Engines in Kudlich and Higgins Gov Pub . . . 412
Mining Developments and Water Power Investigations in Southeastern Alaska Chapin Gov Pub . . . 412
Mining District, Dunkleberg, Granite Creek, Montana Gov Pub . . . 166
Mining Industry, Alaskan, in 1916 Gov Pub . . . 166
Mining Industry in the Territory of Alaska during the Calendar Year 1916 Smith Gov Pub . . . 412
Mining in the Lower Copper River Basin and the Prince William Sound Region, Alaska. Moffit and Johnson. Gov Pub . . . 412
Mining, Lode and Placer on Seward Peninsula, Alaska Mertie Gov Pub . . . 409
Mining, Lode, in Fairbanks District, Alaska Mertie Gov Pub . . . 331
Molasses, Notes on the Analysis of. H S Walker . . . 198
Monazite Sand Deposits, Russian. Note. . . . 573
Monazite Sands, Burmese. Note. . . . 1020
Morocco, Soap Demand in. Note . . . 395
Motor, New Steam. Note. . . . 943
Muntz Metal Thermal Expansion of Alpha- and Beta-Brass Between 0° and 600° C in Relation to Mechanical Properties of Heterogeneous Brasses of the Muntz Metal Type. Merica and Schad Gov. Pub. . . . 762
Muntz Metal (60 40 Brass), Typical Case of the Deterioration of, by Selective Corrosion. Rawdon. Gov. Pub. . . . 413

NAPHTHA, Solvent, in the Presence of Blue Gas, Toluol by Cracking, G. Egloff . . . 8
Naphtha, Solvent, Recovery of. Note . . . 572
Naphthol and Naphthylamine Sulfo Acids, Action of Tetrazodi-o-Tolylmethane Chloride upon. J. H. Stebbins. . . . 445
Naphthol Resin—Substitute for Shellac. Note. . . . 862
Naphthylamine Sulfo Acids and Naphthol, Action of Tetrazodi-o-Tolylmethane Chloride upon. J. H. Stebbins. . . . 445
Natal, Cane By-Products in. Note. . . . 745
National Exposition of Chemical Industries, New York, September 23–28, 1918. Editorials, 592, 672, 674; Notes, 651, 826; Program and List of Exhibitors, 749; Addresses. . . . 826
National Fertilizer Association
25th Annual Convention, Atlantic City, July 15 to 18, 1918. Program . . . 493
National Museum. Gov. Pub. . . . 84, 245, 409
National Research Council, Special Chemicals and Apparatus Available through the Chemistry Committee of. M. T. Bogert. Note. . . . 158
National War Savings Committee, Chemical Division of, Organized. Note . . . 402
Natural Gas and Its Constituents, Compressibility of, with Analyses of Natural Gas from 31 Cities in the U. S Burrell and Robertson. Gov. Pub . . . 332
Natural Gas in 1916. Northrop. Gov. Pub. . . . 662
Natural Gas, Recovery of Gasoline from, by Compression and Refrigeration Dykema Gov Pub . . . 958
Naval Consulting Board Editorial . . . 175
Neo-Arsphenamine and Arsphenamine, Some Qualitative and Quantitative Tests for Meyers and Du Mez. Gov Pub . . . 758
Neo-Arsphenamine (Neo-Salvarsan) and Arsphenamine (Salvarsan) Gov Pub . . . 586
Nephelometry, Technical Applications of P. A. Kober . . . 556
Netherlands Beechnut Oil in Note . . . 1022
Netherlands, Chemical Industry in. Note. . . . 947
Newfoundland Cod Liver Oil Notes . . . 397, 939
New Journals . . . 89
New Publications
I DeMatty . . . 89, 169, 251, 333, 415, 505, 587, 669 765
C. M. Guppy . . . 875, 963 1039
New Zealand and Australia, Railway Materials, Equipment, and Supplies in Rhea Gov Pub . . . 664
Niagara Falls Wasting Waters Editorial . . . 174
Nichols Medal Award
Announcement . . . 80
Introductory Address. C H Herty . . . 305
Presentation Address W H Nichols . . . 305
Acceptance of Medal T B Johnson . . . 306
Medal Address. The Development of Pyrimidine Chemistry, T B. Johnson . . . 306
Message M T Bogert . . . 312
Nichols, W H Leader in Chemical Industry C F Chandler . . . 92
Nickel Arc, Wave Lengths in Red and Infra-Red Spectra of Meggers and Kiess Gov Pub . . . 950
Nickel Canadian Recovery of Platinum Metals from Note . . . 76
Nickel Colloidal. Note . . . 396
Niter Cake Note . . . 572
Niter Cake, A Summary of the Literature on the Solubility of Systems Related to H W Foote . . . 896
Niter Cake A Summary of the Proposals for Utilization of J. Johnston . . . 468
Niter Cake, The Recrystallization of B. Saxton . . . 897
Niter Cake, The Utilization of E. Hart. Note . . . 238
Niter Cake, Utilization of Note . . . 228
Nitrate Enterprise, Japanese Chilean Note . . . 942
Nitrates on Nitrogen Assimilating Bacteria, Influence of Hills Gov Pub . . . 450
Nitric Acid Effect of Acetylene on Oxidation of Ammonia to G B Taylor and J. Capps . . . 457
Nitric Acid from Nitrogen Oxides The Production of G B Taylor, J H Capps, and A S Coolidge . . . 270
Nitrogen Comparison of Percentages of, in Tops and Roots of Head Lettuce Plants H A Noyes . . . 621
Nitrogen Loosely Bound as Ammonia in Eggs Determination of N Hendrickson and C. Swan . . . 614
Nitrogen Nitric and Ammonia Determinations in Soil Extracts and Physiological Solutions B. S Davisson . . . 600
Nitrogen Uniform Determination of, in Cottonseed Meal J S McHargue . . . 336
Nomenclature Organic Resolution Concerning W J Hale Note . . . 944
North Carolina Academy of Science
17th Annual Meeting Greensboro N C April 26 and 1918 Program of Papers . . . 492
Norwegian Industries New Note . . . 939
Norwegian Iron Industry Note . . . 413
Notes and Correspondence . . . 236, 311, 499, 494, 580, 683, 781, 866, 946 1034
Nutrition Human Food Chemistry in the Service of H C Sherman Address . . . 486
Nuts and Oils from Gold Coast Note . . . 924
Nuts Oil Note . . . 813

OBITUARIES . . . 240, 498 . . .
Organic Chemicals Note . . . 654
Oil and Gas Possibilities of the Hatchetigbee Anticline Alabama Hopkins Gov Pub . . . 247
Oil Anticline in the Southern Part of the Big Horn Basin Wyoming A Preliminary Report on the Occurrence of Oil Howell and Lupton Gov Pub . . . 247
Oil Application of the Differential Pressure Method to the Estimation of the Benzene and the Total Light Oil Content of Coals H. S. Davis, M. D. Davis and D. G. MacGregor . . . 247

Oil, Beechnut, in the Netherlands. Note 1022
Oil Break Switchgear. Note 398
Oil Clarifier. Note 552
Oil, Cod Liver, Newfoundland. Notes 939
Oil: Cotton Oil Industry in the War. D. Wesson 930
Oil: Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon. H. S. Bailey and J. M. Johnson 699
Oil Field, The Salt Creek, Wyoming. Wegmann. Gov. Pub 486
Oil, Fuel, Fuel Economy of. Note 487
Oil, Geologic Structure in the Cushing Oil and Gas Field, Oklahoma, and Its Relation to the Oil, Gas, and Water. Beal. Gov. Pub 331
Oil, Influence of Time of Harvest, Drying, and Freezing of Specimens upon the Yield and Odorous Constituents of the Oil. F. Rabak 275
Oil, Influence on Linseed Oil of Geographical Source and Variety of Flax. Rabak. Gov. Pub 763
Oil in Paint, Substitute for. Note 152
Oil, Lubricating. Note 937
Oil: Methods of Analysis Used in the Coal-Tar Industry. IV-Benzols and Light Oil. J. M. Weiss 1006
Oil, Nesson Anticline, Williams County, North Dakota. Collier. Gov. Pub 955
Oil Nuts, New. Note 313
Oil of Cassia, Its Constituents of. II. F. D. Dodge 1005
Oil of Cloves. Note 648
Oil, Olive, Stability of. Holland, *et al.* Gov. Pub 764
Oil-Pressing Plant for India. Note 397
Oil Producers, Cost Accounting for. Smith. Gov. Pub 412
Oil Prospects of the Salinas Valley-Parkfield Area, California. English. Gov. Pub 874
Oil, Rubber-Seed. Note 938
Oil Sands, Methods for Increasing the Recovery from. Lewis. Gov. Pub 332
Oil Shale of the Uinta Basin, Northeastern Utah, and Results of Dry Distillation of Miscellaneous Shale Samples. Winchester. Gov. Pub 874
Oil Shales, Phosphatic, near Dell and Dillon, Beaver Head County, Montana. Bowen. Gov. Pub 409
Oil Storage Tanks and Reservoirs. Bowie. Gov. Pub 958
Oil Supply in Germany, New Sources of. Note 747
Oil: The Menhaden Industry of the Atlantic Coast. Greer. Gov. Pub 166
Oil Varnishes, Notes on Color Designation of. F. A. Wertz 475
Oil, Waterproof Varnish from. Note 152
Oils and Fats, Commercial, Tentative Standard Methods for the Sampling and Analysis of. Report of A. C. S. Committee. W. D. Richardson 315
Oils and Fats in Germany. Note 942
Oils and Fats, Saponification of. Note 75
Oils and Nuts from Gold Coast. Note 394
Oils and Vegetables, The Occurrence of Carotin in. A. H. Gill 612
Oils at Room Temperature, Relative Viscosity of. C. F. Sammet 632
Oils, Catalytical Bleaching of. Note 313
Oils: Digestibility of Some Seed Oils. Holmes. Gov. Pub 959
Oils, Essential, in Non-Alcoholic Flavoring Extracts, The Determination of. F. M. Boyles 537
Oils, Fish, Butter Substitute from. Note 397
Oils from Coal Tar. Note 1021
Oils, Light, Recovery of, and Refining of Toluol. Report of the Bureau of Standards 51
Oils: Methods of Analysis Used in Coal-Tar Industry. III—Heavy and Middle Oils. J. M. Weiss 911
Oils, Nut, Studies on Digestibility of. Holmes. Gov. Pub 763
Oils: Pipette Used in Titration of Oils for Acidity. J. Jacobsen 633
Oils: Studies on the Absorption of Light Oils from Gases. H. S. Davis and M. D. Davis 719
Oils: The Palestine Salt Dome, Anderson County, Texas. The Brenham Dome, Washington and Austin Counties, Texas. Hopkins. Gov. Pub 85
Oils, Vegetable, in Japan. Note 862
Oilseed Industry of Rhodesia. Note 744
Oilseeds, Indian. Note 397
Oleomargarine or Butter, Detection of Added Color in. H. A. Lubs 436
Orange Production: Humus in Mulched Basins, Relations of Humus Content to Orange Production, and Effect of Mulches on Orange Production. Jensen. Gov. Pub 763
Ordnance Department, School of Explosives Manufacture, Columbia University 868
Ore Deposits of the Northwestern Part of the Garnet Range, Montana. Pardee. Gov. Pub 409
Ore, Low-Grade, Utilization. Note 76
Ore, Sources of. Note 940
Organic Developing Agents, Examination of. H. T. Clarke 891
Organic Matter, An Accurate Loss-On-Ignition Method for the Determination of, in Soils. J. B. Rather 439
Organic Reagents for Research and Industry. C. E. K. Mees. Notes 656, 1027
ORIGINAL PAPERS...6, 96, 176, 258, 339, 425, 511, 593, 707, 809, 891, 982
Ovens, Drying. Note 943
Oxidases and Iron in Color Changes of Sugar Cane Juice, The Rôle of. P. W. Zerban 814
Oxides, Nitrogen, The Production of Nitric Acid from. G. B. Taylor, J. H. Capps and A. S. Coolidge 270
Oxygen in Iron, Determination of. Note 745
Oxygen through Stored Coal, Diffusion of. Katz. Gov. Pub 959
Ozone, The Application of, to the Purification of Swimming Pools. Manheimer. Gov. Pub 409

PAINT and Varnish. Gov. Pub 413
Paint, Substitute for Oil in. Note 152
Paint, White, Discoloration of. Note 940
Pan American Union. Gov. Pub 586
Paper, A Method for Determining the Absorbency of. E. O. Reed 44
Paper and Sorghum. Note 396
Paper, Blue and Brown Print: Characteristics, Tests and Specifications. F. P. Vetter, C. E. Sammet and E. O. Reed 222
Paper Exports, British. Note 769
Paper: Some Experiments on the Pulping of Extracted Yellow Pine Chips by the Sulfate Process. O. Kress and C. K. Textor 268
Paper, Textiles, etc., A Constant Temperature and Humidity Room for the Testing of. F. P. Vetter and E. O. Reed 38
Para Cymene. 1-Nitration. Mononitrocymene 1 CH_3. 2-NO_2. 4 $CH.CH_3$. C. E. Andrews 453
Patent Abuse. Editorial 173

PATENT APPLICATIONS UNDER TRADING WITH THE ENEMY ACT: 243, 329, 406, 501, 659, 757, 952
Peace Preparations. Note. Skoda Works 748
Peat Fuel. Note 1020
Peat in 1916. Turp. Gov. Pub 165
Peat, Inorganic Composition of a Peat and of the Plant from Which It Was Formed. Miller. Gov. Pub 764
Peat Process, The Ekman. Note 312
Pencil Factory, Chinese. Note 94
Pentane, Petroleum, Manufacture of Amyl Acetate and Similar Solvents from. B. T. Brooks, D. F. Smith and H. Essex 511
Peppermint Cultivation, Japan. Note 74
Perfume Plant, A Chinese. Note 1021
Perfumery for Stim. Note 74
PERKIN MEDAL AWARD. Announcement 86
Introductory Address. J. Alexander 148
Medalist and His Work. F. A. J. FitzGerald 153
Presentation Address. W. H. Nichols 149
Address of Acceptance. A. J. Rossi 14
Permanganate, The Preparation of N/100 Permanganate Solutions. J. O. Halverson and O. Bergeim 11
Permanganate Formalin Method, A Substitute for. Disinfection with Formaldehyde. C. G. Storm 72
PERSONAL NOTES 51, 161, 241, 327, 404, 499, 585, 658, 755, 871, 949, 1035
Peru, Bolivia, Ecuador, Textile Markets in. Tucker. Gov. Pub 664
Peterson, Andrew P. Obituary. F. W. Willard 755
Petrol and Gas Engines. Note 940
Petroleum. Gov. Pub 409
Petroleum and Allied Substances, 1915, Bibliography of. Burroughs. Gov. Pub 488
Petroleum Industry, Chemistry in the. Medal Address. W. M. Burton 484
Petroleum in 1916. Northrup. Gov. Pub 962
Petroleum in the British Empire. Note 870
Petroleum Pentane, Manufacture of Amyl Acetate and Similar Solvents from. B. T. Brooks, D. F. Smith and H. Essex 511
Petroleum Refining, Census of Manufactures, 1914. Gov. Pub 413
Petroleum Resources of the U. S. Arnold. Gov. Pub 241
Petroleum, Roumanian. Note 398
Phenol in the Presence of the Three Cresols, the Estimation of. G. W. Knight, C. T. Lincoln, G. Formanek and H. L. Follett, 9; Correction 240
Phenol or Cresol Preservative in Serums, A Colorimetric Method for the Estimation of. Elvove. Gov. Pub 245
Phenol, Synthetic. A. G. Peterkin, Jr. 748
Phenols as Preservatives of Antipneumococcic Serum, Pharmacological Study. Voegtlin. Gov. Pub 873
Phosphate. A Geologic Reconnaissance of the Uinta Mts. Northern Utah, with Special Reference to Phosphate. Shultz 871
Phosphate, Reverted. J. C. James 14
Phosphate Rock, Electric Furnace Smelting of, and Use of the Cottrell Precipitator in Collecting the Volatilized Phosphoric Acid. J. N. Carothers, 35; Correction 239
Phosphate Rock, Our Greatest Fertilizer Asset. Waggaman. Gov. Pub 960
Phosphate Rock, Raw Ground, The Agricultural Availability of. W. H. Waggaman and C. R. Wagner 1
Phosphate, Tricalcium, Effect of Nitrifying Bacteria on the Solubility of. Kelly. Gov. Pub 414
Phosphates "Mine Run," The Use of, in the Manufacture of Soluble Phosphoric Acid. W. H. Waggaman and C. R. Wagner 353
Phosphoric Acid: Critical Elaboration of Quantitative Precipitation Methods; Exemplified by a Method for Determination of Phosphoric Acid. J. Lehman 4
Phosphoric Acid: Electric Furnace Smelting of Phosphate Rock and Use of the Cottrell Precipitator in Collecting the Volatilized Phosphoric Acid. J. N. Carothers, 35; Correction 239
Phosphoric Acid, Soluble, The Use of "Mine Run" Phosphates in the Manufacture of. W. H. Waggaman and C. R. Wagner 353
Phosphorus as an Indicator of the Vitamine Content of Corn and Wheat Products. Voegtlin and Myers. Gov. Pub 509
Photoelectric Sensitivity of Bismuthinite and Various Other Substances. Coblentz. Gov. Pub 76
Photography, Color, Screens. Note 944
Phthalic Anhydride in Crude Phthalic Acid, The Determination of. C. R. Downs and C. G. Stupp 596
Physiological Effect of Different Gases on Man. Burrell. Gov. Pub 959
Physiological Solutions and Soil Extracts, Ammonia and Nitric Nitrogen Determinations in. B. S. Davisson 600
Pigments of the Tomb of Perneb. M. Toch 118
Pigweed, Common (*Amaranthus Retroflexus* L.), A Proximate Analysis of Seed of. E. P. Harding and W. A. Egge 529
Pine Chips, Yellow, Some Experiments on the Pulping of, by the Sulfate Process. O. Kress and C. K. Textor 268
Pine, Longleaf, Sorption and Penetration of Coal Tar and Creosote in. Teesdale and McLean. Gov. Pub 959
Pipette Used in Titration of Oils for Acidity. J. Jacobsen 633
Pipette-Washing Device, An Improved Automatic. A. V. Fuller 297
Pitches. Methods of Analysis Used in the Coal-Tar Industry. II—Distilled Tars and Pitches. J. M. Weiss 817
Plants and Soils, The Relation of Some of the Rarer Elements in. Robinson, *et al.* Gov. Pub 503
Plastic Compound, A New. Note 943
Plastic Material, Non-Inflammable. Note 74
Platinum and Allied Metals in 1917. Hill. Gov. Pub 954
Platinum, As to. J. L. Howe. Note 156
Platinum at White Heat. Editorial 508
Platinum, Government Control of. W. F. Hillebrand. Note 322
Platinum in Spain. Note 150
Platinum, Living from Hand to Mouth. Editorial 597
Platinum Metals from Canadian Nickel, Recovery of. Note 75
Platinum Oscillations. Editorial 95
Platinum Regulations 866
Platinum Resolution by the Argentine Chemical Society. G. F. Schaefer and W. H. Nichols. Letters 320
Platinum Resolution by the State Council of Defense for California. J. George. Note 697
Platinum Resolutions. C. F. Kunz. Note 156
Platinum, Russia's Production of. A. R. Merz 322
Platinum Scraps. Editorial 943
Platinum Substitute. Note 1027
Platinum, Theft of. Note

Platinum: The Great Gamble. Editorial ... 419
Platinum Wanted by the Government. R. T. Baker ... 867
Platinum: Women's National League for the Conservation of Platinum. Note, including letter from L. S. Y. Weill ... 494
Poisons, Economic, in California in 1916, The Consumption and Cost of. G. P. Gray ... 301
Polariscope Situation and Need for an International Saccharimetric Scale. C. A. Browne ... 916
Ponceau 3R(By) and Scarlet S3R(B), The Structure of. H. W. Stiegler ... 600
Porcelain Laboratory Ware, Comparative Tests of. Waters. Gov. Pub. ... 503
Portland Cement, Standard Specifications and Tests for. Gov. Pub. 874
Potash and Magnesia from Canadian Lake, Recovery of. Note ... 151
Potash and Other Constituents from Sea Water Bittern, The Extraction of. J. H. Hildebrand ... 96
Potash: An Inexpensive Ash Leaching Plant. W. D. Turner and B. G. Nichols ... 374
Potash as a By-Product in the Cement Industry, The Recovery of. Ross, *et al.* Gov. Pub ... 332
Potash: A Study of Sources of Error Incident to the Lindo-Cladding Method for Determining Potash. T. E. Keitt and H. E. Shiver ... 994
Potash, Cement Mill, Effect of Coal Ash on the Liberation and Nature of. N. S. Potter, Jr., and R. D. Cheesman. *See* Letters ... 1030
Potash from Greensand, Recovery of. H. W. Charlton ... 6
Potash from Raw Materials Containing only a Trace of this Element, The Concentration of, by Means of the Electric Precipitation of Flue Dust and Fume Cement Kilns. B. F. Erdahl ... 356
Potash, German, and the War. Note ... 655
Potash in Fertilizer Materials, A Study of the DeRoode Method for the Determination of. T. E. Keitt and H. E. Shiver ... 219
Potash in Soils, Influence of Gypsum upon Solubility of. McMiller. Gov. Pub ... 959
Potash Leasing Act, Regulations under the. Note ... 400
Potash Lye. Note ... 572
Potash Salts and Brines, Nebraska, Some Methods of Analysis for. A. H. McDowell ... 128
Potash Salts in Chile. Note ... 937
Potash: Searles Lake Open to Lease Application. Note ... 494
Potash Situation. A. W. Stockett ... 918
Potash: The Direct Heat Treatment of Cement Mill Dust to Increase Its Water-Soluble Potash Content. A. R. Merz ... 106
Potassium and Sodium, Improved Methods for Estimation of. S. N. Rhue ... 429
Potassium and Sodium, The Separation of Chlorides and Sulfates of, by Fractional Crystallization. W. C. Blasdale ... 347
Potassium: Equilibria in Solutions Containing Mixtures of Salts. I—The System Water and the Sulfates and Chlorides of Sodium and Potassium. W. C. Blasdale ... 344
Potassium Guaiacol Sulfonate, The Identification and Determination of. S. Palkin ... 610
Potassium Permanganate: The Preparation of *N*/100 Permanganate Solutions. J. O. Halverson and O. Bergeim ... 119
Potato: Effect of Different Oxygen Pressures on Carbohydrate Metabolism of Sweet Potato. Hasselbring. Gov. Pub ... 959
Potatoes, Effect of Frost and Decay upon the Starch in. H. A. Edson ... 725
Potteries at Shek Waan, near Canton, China. C. N. Laird ... 568
Pottery Industry, English. Note ... 395
Power from Refuse. Note ... 74
Power: Wasting Waters. Editorial ... 174
Precipitation, Electric: The Concentration of Potash from Raw Materials Containing only a Trace of this Element by Means of the Electric Precipitation of Flue Dust and Fume Cement Kilns. B. F. Erdahl ... 356
Precipitation Methods, Critical Elaboration of Quantitative, Exemplified by a Method for Determination of Phosphoric Acid. H. Heidenhain ... 426
Precipitations Suggestions on Some Common. G. H. Brother ... 129
PREPARATION FOR AFTER THE WAR. Address B. C. Hesse, 881; *See* Editorial ... 878
Preservative Value of Different Brands of Spices, The Use of Microorganisms to Determine. F. M. Bachmann ... 121
Preservatives, Industrial Alcohol, and Chemistry. Gov. Pub ... 409
Preservatives of Biological Products, Studies in. Neill. Gov. Pub ... 873
Preservatives: Toxicity of Certain Preservatives Used in Serums, Viruses, and Vaccines. Leake and Corbitt. Gov. Pub ... 245
Preserving and Canning. Gov. Pub ... 332
Pressure Control, Diesel Engine Blast. Note ... 228
Primers, Military and Sporting Arms, Antimony Sulfide as a Constituent in. A. S. Cushman ... 376
Primus Stoves. Note ... 630
PRODUCT PATENTS. K. P. McElroy ... 257
Propellers, Air, Experimental Research on. Durand. Gov. Pub ... 873
Protactinium, New Radioactive Element. Note ... 938
Public Health Service. Gov. Pub ... 84, 245, 409, 586, 758, 873, 954, 1037
Publicity, An Experiment in. Editorial ... 967
Pulp, Soda and Sulfite. Note ... 1021
Pyrheliometer, Marvin, Some Characteristics of the. Foote. Gov. Pub ... 762
Pyrite Production (1916). Smith. Gov. Pub ... 410
Pyrites, Sulfur, and Sulfuric Acid. Smith. Gov. Pub ... 958

QUARRY Accidents in U. S. during 1916. Fay. Gov. Pub ... 958
Quartz and Glass, Compression Strength of. Note ... 942
Quicksilver Deposits of Phoenix Mountains, Arizona. Schrader. Gov. Pub ... 954

RACK, A Simple and Entirely Adjustable, for Kjeldahl Digestion Flasks. F. E. Rice ... 631
Radio Instruments and Measurements. Gov. Pub ... 762
Radioactive Element, New. Note ... 938
Radiometry, Instruments and Methods Used in. Coblentz. Gov. Pub ... 762
Radium, The Bisulfate Method of Determining. H. H. Barker ... 525
Railway Material for Japan. Note ... 395
Railway Materials, Equipment, and Supplies in Australia and New Zealand. Rhea. Gov. Pub ... 664
Ramsay Memorial Fund, W. H. Nichols. Note ... 236
Rancidity, Chemical Tests for Detection of. R. H. Kerr ... 471
Reagents for Use in Gas Analysis
VI—The Absorption of Hydrogen by Sodium Oleate. R. P. Anderson and H. H. Katz ... 23
VII—The Determination of Benzene Vapor. R. P. Anderson ... 25
Reagents, Organic, for Research and Industry. C. E. K. Mees. Notes ... 656, 1027
RECENT JOURNAL ARTICLES:
I. DeMatty ... 89, 169, 251, 333, 415, 505, 587, 669 765
C. M. Guppy ... 875, 963, 1039
Recorder, Electrical Conductivity, for Salinity Measurements. E. E. Weibel and A. L. Thuras ... 626
Recorder, Riveting. Note ... 943
RECOVERY OF LIGHT OILS AND REFINING OF TOLUOL. Report Prepared by the Bureau of Standards ... 51
Refractometer, A Differential. G. A. Shook ... 553
Refractometer, Dipping, Note on the Use of. E. W. Randall ... 629
Refractory Material from Bauxite. Note ... 862
Refrigerating Plants, Relation between Efficiency of, and the Purity of their Ammonia Charge. F. W. Frerichs ... 202
Remington, Joseph Price. Obituary. S. P. Sadtler ... 240
Rensselaer Polytechnic Institute, Meeting War Conditions at. Note. 328
Research and Industry, Organic Reagents for. C. E. K. Mees. Notes ... 656, 1027
Research and the Tar Baby. Editorial ... 420*d*
Research as an Aid to Industrial Efficiency ... 493
Research, Chemical, in the Various Countries Before the War and in 1917. E. J. Crane. Note ... 236
Research Fellowship, State College of Washington. Note ... 753
Research Information Committee. Note ... 324
Research, Permanence as an Ideal of. Address. S. R. Scholes ... 390
Research Work, An Embargo on. Editorial ... 968
Resin, Indian. Note ... 747
Rheostats, Starting. Note ... 941
Rhodesia, Oilseed Industry in. Note ... 744
Road Materials, Standard Forms for Specification, Tests, Reports, and Methods of Sampling for. Gov. Pub ... 503
Rocks, Igneous, Chemical Analyses of. Washington. Gov. Pub ... 331
Rocks, The Upper Chitina Valley, Alaska. Moffit. Gov. Pub ... 954
Rope Fiber: Distinguishing Manila from all other "Hard" Rope Fibers. C. E. Swett ... 227
Rosin and Turpentine, Increased Yield of, from Double Chipping. Schorger and Pettigrew. Gov. Pub ... 332
Roumanian Petroleum. Note ... 398
Rubber, Catalysis in Vulcanization. D. Spence ... 115
Rubber Industry in Japan. Note ... 396
Rubber-Seed Oil. Note ... 938
Rubber, Soft, Compounds, Volumetric Determination of Free Sulfur in. H. S. Upton ... 518
Rubber, Synthetic. Note ... 941
Rubber Tubing and Glass, A Device to Insure Tight Connections between. C. C. Kiplinger ... 631
Rubber, Vulcanization of, by Selenium. C. R. Boggs ... 117
Rubidium and Caesium in Plant Ash, A Proximate Quantitative Method for the Determination of. W. O. Robinson ... 50
Russian Asbestos Industry. Note ... 397
Russian Monazite Sand Deposits. Note ... 573
Russia's Production of Platinum. A. R. Merz ... 920
Rust Prevention, New. Note ... 313

SACCHARIMETRIC Scale, International, the Need of, and the Polariscope Situation. C. A. Browne ... 916
Salinity Measurements, Electrical Conductivity Recorder for. E. E. Weibel and A. L. Thuras ... 626
Salmon: Determination of the Hexabromide and Iodine Numbers of Salmon Oil as a Means of Identifying the Species of Canned Salmon. H. S. Bailey and J. M. Johnson ... 999
Salt in 1917. Stone. Gov. Pub ... 957
Salt Requirements for Young and for Mature Buckwheat Plants in Solution Cultures, Comparative Study of. Shive and Martin. Gov. Pub ... 959
Salvarsan (Arsphenamine) and Neo-Arsphenamine (Neo-Salvarsan). Gov. Pub ... 586
Salvarsan (Arsphenamine): Licenses Ordered and Rules and Standards Prescribed for Its Manufacture. Gov. Pub ... 245
Sand and Gravel in 1916. Stone. Gov. Pub ... 247
Sand-Lime Brick in 1917. Middleton. Gov. Pub ... 956
Saybolt Universal Viscosimeter, Standardization of the. Herschel. Gov. Pub ... 762
Scale in Boilers, Prevention of. Note ... 151
Scale, International Saccharimetric, The Need of. C. A. Browne ... 916
Scarlet S3R(B) and Ponceau 3R(By), The Structure of. H. W. Stiegler ... 600
Schoop Metal-Spray Process. Notes ... 939, 1022
Science and Industry, The Collaboration of. Address. V. Grignard. 137
Scientific and Technical Societies, The German Union of ... 575
SCIENTIFIC SOCIETIES ... 77, 153, 315, 489, 575, 651, 748, 863, 944, 1023
Screens, Color Photography. Note ... 649
Searles Lake Open to Lease Application. Note ... 494
Seeding Method of Gramin, Sugars. H. E. Zitkowski ... 992
Seeds of the *Echinocystis Oregana* (Wild Cucumber). M. R. Daughters ... 126
Selenium. Umpleby. Gov. Pub. In 1916, 409; in 1917 ... 873
Selenium, Vulcanization of Rubber by. C. R. Boggs ... 117
Separators, Magnetic Separations and the Rarer Metals. Note ... 313
Serum, Human, Observations on the Significance of Anti-Sheep Amboceptor in, with Reference to Complement Fixation Test for Syphilis. Neill. Gov. Pub ... 245
Serums, A Colorimetric Method for the Estimation of the Cresol or Phenol Preservative in. Elvove. Gov. Pub ... 245
Serums, Establishments Licensed for Propagation and Sale of. Gov. Pub ... 758
Serums, Official Control of, Antipneumococcus and Antimeningococcus. Gov. Pub ... 954
Serums, Viruses, and Vaccines, Toxicity of Certain Preservatives Used in. Leake and Corbitt. Gov. Pub ... 245
Sewage Grease Recovery. Note ... 650
Sewage, The Fertilizing Value of Activated Sludge. G. G. Nasmith and G. P. McKay. 349. *See* Rudnick ... 400
Shea Butter Tree, Gutta Percha from. Note ... 76
Shellac Derivatives. Note ... 152
Shellac Substitute. Notes ... 648, 862
Shepard, James Henry. Obituary. W. Frear ... 499
Shipbuilding, Ferro-Concrete. Note ... 395
Shipping Board, United States, Communication to the American Chemical Society ... 864
Siam, Perfumery for. Note ... 74

Signals, Air Raid Note 941
Silica, Variation in the Ether Extract of L. D. Haigh 127
Silicosis Dust in Relation to Pulmonary Disease among Miners in Joplin District, Missouri Higgins *et al.* Gov. Pub 958
Silk Industry Gov. Pub 337
Silk Industry, Electricity in Note 86
Silver and Gold in 1916 McCaskey and Dunlop Gov. Pub 986
Silver in the Central States Dunlop and Butler Gov. Pub. In 1916 84
Silver in the Eastern States in 1917 Hill Gov. Pub 986
Silver Lead Antimonial, Veins of the Arabia District, Nevada Knopf Gov. Pub 331
Silver Production 1916 Gov. Pub. Alaska, by Brooks 946; New Mexico, Texas, South Dakota, and Wyoming, by Hendricks 946; California and Oregon, by Vanderburg 946; Arizona and Montana, by Heikes 946; Eastern States, by Hill 946; Colorado, by Hewett and Rove 109; Utah and Nevada, by Heikes 109; Idaho and Washington, by Gerry 886
Silver Sulfide, Some Electrical Properties of Vinal Gov. Pub 86
Size, Australian Note 487
Skins and Hides from Venezuela Note 228
Skodi Works, Pearce Preparations 748
Slag, Viscosity Tables for Blast Furnace Work Field and Royster Gov. Pub 959
Slate in 1917 Loughlin Gov. Pub 986
Sludge, Activated, Fertilizing Value of G. G. Nasmith and G. P. McKay, 349. See Rudnick
Smithsonian Institution
Administration and Activities of Clark Gov. Pub 345
Annual Report of the Board of Regents of Gov. Pub 408
Government Publications 345, 408, 764
Smithsonian Physical Tables. Gray. Gov. Pub 764
Soap and Glycerin Manufacture in India Note 744
Soap Demand in Morocco Note 595
Soap, Sugar and Editorial 175
Soap, Water in, An Improved Distillation Method for the Determination of R. Hart 598
Soapstone and Talc in 1917 Diller Gov. Pub 955
SOCIÉTÉ DE CHIMIE INDUSTRIELLE
Organization of New York Section 154
First Meeting of New York Section
Conditions of the French Chemical Industries during 1916 F. J. LeMaistre 421
The Great Effort of the French Industries M. Knecht 423
SOCIETY OF CHEMICAL INDUSTRY New York Section, Resolution 1023
SOCIETY OF COTTON PRODUCTS ANALYSTS Check Meal Contest Note 656
Soda and Sulfite Pulp Note 1021
Sodium and Potassium, Improved Methods for Estimation of S. N. Rhue 429
Sodium and Potassium, The Separation of, and Chloride Sulfates of, by Fractional Crystallization W. C. Blasdale 347
Sodium Cyanide Notes on W. J. Sharwood 292
Sodium Equilibria in Solutions Containing Mixtures of Salts I. The System Water and the Sulfates and Chlorides of Sodium and Potassium. W. C. Blasdale 344
Sodium Oleate, The Absorption of Hydrogen by. VI—Reagents for Use in Gas Analysis R. P. Anderson and M. H. Katz 23
Sodium Sulfate, The Use of, in the Kjeldahl-Gunning Method. C. T. Dowell and W. G. Friedeman 599
Soil Aeration and Hydrolytic Ratio in Soils Sporwaz Gov. Pub 503
Soil Aerivity as Influenced by Green Manures White Gov. Pub 763
Soil, Decomposition of Green and Stable Manures in Potter and Snyder Gov. Pub 504
Soil Extract, Effect of Season and Crop Growth in Modifying the Stewart Gov. Pub 504
Soil Extracts and Physiological Solutions, Ammonia and Nitric Nitrogen Determinations in. B. S. Davisson 600
Soil Reaction and Growth of Azotobacter Gainey Gov. Pub 959
Soil Reaction as Indicated by the Hydrogen Electrode, Studies in. Plummer Gov. Pub 504
Soil Reaction as Measured by the Hydrogen Electrode, Relation of Carbon Dioxide to Hoagland and Sharp. Gov. Pub 504
Soil Solution Due to Season and Crop Growth, The Freezing Point Method as an Index of Variations in the. Hoagland. Gov. Pub. 504
Soils, Alkali, Durability of Cement Draintile and Concrete in. (Continuing Results of Third Year's Tests.) Wig, *et al.* Gov. Pub 85
Soils, An Accurate Loss-on-Ignition Method for Determination of Organic Matter in J. B. Rather 439
Soils and Plants, Relation of Some of the Rarer Elements in Robinson, *et al.* Gov. Pub 503
Soils, Effect of Fertilizers on Hydrogen-Ion Concentration in. F. W. Morse 125
Soils, Influence of Carbonates of Magnesium and Calcium on Bacteria of Certain Wisconsin Soils Fulmer Gov. Pub 763
Soils, Influence of Gypsum upon Solubility of Potash in McMiller. Gov. Pub 959
Soils, Movement of Soluble Salts through McCool and Wheeting Gov. Pub 503
Soils, Principles of Liming of Shorey Gov. Pub 763
Soils, Reaction of Magnesium Soils with Calcium Carbonate Solutions, Its Relation to the Determination of Lime Requirements of Soils, and a Rapid Approximate Method for the Determination of Lime Requirements of Soils. M. O. Johnson 31
Soils, Relation between Biological Activities in Presence of Various Salts and Concentration of Soil Solution in Different Classes of Soil. Miller Gov. Pub 763
Soils, Studies on Quantities of, for Irrigation Water, and on a New Method for Determining Volume Weight Israelsen Gov. Pub 763
Soils, Water Extraction of, as Criteria of Their Crop Producing Power Bland Gov. Pub 504
Sodbuster in Training Camps Chemistry for J. W. Beckman 869
Solvent from Air Vapor Mixture, Recovery of F. L. Knoedler and C. A. Bodine 893
Sorghum and Paper. Note 396
Sorghum and Corn, Comparative Transpiration of Miller and Coffman Gov. Pub 764
SOUTH AFRICA, CHEMICAL MATTERS IN THE UNION OF. O. P. Hopkins 88
South African Diamonds Note 595
South African Industrial Development Note 530
South African Industries, New Note 943
South African Iron Ore Note 595
South African Requirements, Note 649
SOUTH AMERICA, CHEMICAL MISSION OF. O. P. Hopkins
Chemical Trade of Argentine, Brazil and Uruguay 701
Chemical Trade of Chile, Peru and Bolivia 805
Chemical Markets of Colombia, Ecuador, the Guianas, Venezuela and Paraguay 957
South American Machinery in Note 746
South American Water Front and Its Note 75
South Bertram Quantities of Concentrate in Note 1021
Spain, Platinum in Note 150
Spearmint, Influence of Time of Harvest, Drying and Freezing of, upon the Yield and Chemical Constituent of the Oil. E. Rabak 275
Spectra, Application of Duvanin to the Photographs of Stellar Merrill Gov. Pub 762
Spectra from 3600 A. to 9000 A., Wave Length Measurements in Meggers Gov. Pub 442
Spices, The Use of Microorganisms to Determine the Preservative Value of Different Grades of Spices F. M. Bachmann 191
Spirits, Distilled Gov. Pub 346
Spruce, Effect of Various Certain Cooking Conditions in Production of Sulfite Pulp from Limak Gov. Pub 763
Spruce, Turpentine to the Pore Editorial 174
Starch, Digestion of, by the Young Calf Hart *et al.* Gov. Pub. 763
Starch, Effect on Time of Digestion on Hydrolysis of Casein in Presence of, Mc Hargue Gov. Pub 504
Starch in Potatoes, Effect of Frost and Decay upon H. A. Edson 725
Statistical Abstract of U. S., 1917 Gov. Pub 874
Steam, Volcanic, Electrical Energy from. Note 487
Steel and Iron Gov. Pub 332
Steel and Iron Industry during the War Period, Trend of Accident Frequency Rates in Gov. Pub 412
Steel and Iron Industry in Japan Note 861
Steel and Iron, Sulfur in, A Standard Apparatus for Determination of, by Evolution Method H. B. Pulsifer 545
Steel and Iron Trade in Aden Note 943
Steel, Carbon, and High Speed, Liquids for Heating, Quenching and Tempering Note 940
Steel Carbon, Hardening Note 374
Steel, Chromium for Magnets Note 229
Steel, Damascus Note 942
Steel, Determination of Manganese in, in the Presence of Chromium and Vanadium by Electrometric Titration G. L. Kelley, M. G. Spencer, C. E. Blumgworth and T. Gray 19
Steel, Electro-, Works in Germany, Note 78
Steel, Microscopic Examination of Gov. Pub 442
Steel, Nickel, Note 1022
Steel Production 1916 Burchard Gov. Pub 411
Steel, Rapid Determination of Carbon in, by Barium Carbonate Titration Method. J. R. Cain and L. C. Maxwell 520
Steels, Hardened Carbon, Effect of Annealing on Electrical Resistance of I. P. Parkhurst 515
Steels, Tool Note 942
Stones of Minnesota, The Structural and Ornamental. Bowles. Gov. Pub 586
Stopcock, Hydrogen Sulfide An Automatic C. H. Classen 131
Stopcock, Special for Dropping Liquids Arranged for Equalizing Pressure above and below the Outlet in the H. L. Fisher 1014
Stoves, Primus Note 680
Stream Pollution. Gov. Pub 409
Streptococci Concerned in Cheese Ripening, Study of Evans Gov. Pub 763
Strontianite Deposits near Barstow, California Knopf. Gov. Pub. 409
Strontium in 1917, Hill Gov. Pub 761
Sudan Grass Hay, Composition and Digestibility of, Gaessler and MacLandish Gov. Pub 959
Sugar and Soap, Editorial 175
Sugar as Used in Medicines, Conservation of Note 495
Sugar Cane Juice, The Role of Oxidases and Iron in Color Changes of F. W. Zerban 814
Sugar Factories, Theory and Practice in the Design of Multiple Evaporators for A. C. Webre 191
Sugar, Maple, Composition, Methods of Analysis, Effect of Environment Bryan, *et al.* Gov. Pub 503
Sugar, The Deterioration of Raw Cane Sugar, A Problem in Food Conservation. C. A. Browne 178
Sugar, The Seeding Method of Graining. H. E. Zitkowski 992
Sugars, Raw, Valuation of W. D. Horne 809
Sugars, Various, American Sources of, Supply for C. S. Hudson Address 176
Sulfate of Ammonia, Production of. Note 745
Sulfate Process, Some Experiments on the Pulping of Extracted Yellow Pine Chips by the O. Kress and C. K. Textor 268
Sulfates and Chlorides of Sodium and Potassium, The Separation of, by Fractional Crystallization W. C. Blasdale 347
Sulfates: Equilibria in Solutions Containing Mixtures of Salts I. The System Water and the Sulfates and Chlorides of Sodium and Potassium W. C. Blasdale 344
Sulfite Lye, Waste Utilization of Note 488
Sulfite Lyes, Uses from Note 187
Sulfite Pulp and Soda Note 1021
Sulfite Pulp from Spruce, Effect of Various Certain Cooking Conditions in Production of Limak Gov. Pub 763
Sulfite Turpentine A. W. Schorger 258
Sulfur, A Contribution to the Composition of Lime-Sulfur Solutions O. B. Winter 539
Sulfur, Andean Deposits Miller and Smeewald Jr. Gov. Pub 886
Sulfur, an Example of Industrial Independence Mineral Industries of the U. S. Louis Gov. Pub 345
Sulfur, Free, Volumetric Determination of, in Soil Rubber Compounds H. S. Paine 518
Sulfur in Iron and Steel, Determination of, by the Evolution Method, A Standard Apparatus for H. B. Pulsifer 545
Sulfur Production, 1916 Smith Gov. Pub 410
Sulfur, Pyrites and, Sulfuric Acid Smith Gov. Pub 955
Sulfured Food Products, Arsenic in W. D. Collins 369
Sulfuric Acid, Avoidable Waste in the Production of, by the Chamber Process A. L. Marshall Note 781
Sulfuric Acid Industry, A. J. Goodwin 1
Sulfuric Acid Production, 1916 Smith Gov. Pub 410
Sulfuric Acid Patents and Sulfur Smith Gov. Pub 955
Superintendent of Documents Gov. Pub 1000
Surgical and Medical Supplies, Staple List of Gov. Pub 886

Sweden, Bichromate Manufacture in. Note 1022
Sweden, Trade Developments in. Note 396
Swedish Gauges. Note 395
Swedish Industrial Developments. Note 76
Swiss Electrochemical Industries. Note 398
Switchgear, Oil-Break. Note 598
Switzerland, Imitation Leather for. Note 75
Synthetic Market. Note 745
Synthetic Materials. Note, 314; Correction 403
Syphilis. Observations on the Significance of Anti-Sheep Amboceptor in Human Serum, with Reference to Complement Fixation Test for Syphilis. Neill Gov. Pub 245

TALC and Soapstone in 1917. Diller Gov. Pub 988
Tannin and Timber. Note 329
Tanning, Chrome. Note 40
Tanning Material in Germany. Note 1022
Tar, Notes on "Free Carbon" of. J. M. Weiss and C. R. Downs 400
Tar-Still Corrosion by Chlorine. Note 74
Tar Vacuum, Alcohols and Bases in. Note 650
Tariff Commission. Gov. Pub 504
Tariff Commission and the Dye Industry. G. Jones. Address 733
Tariff Commission, Facts for the. Editorial 173
Tariff Commission, U. S., Inquiry in Regard to Chemical Industries 158
Tars: Methods of Analysis Used in the Coal-Tar Industry. J. M. Weiss.
I. Tars, 732; II. Distilled Tars and Pitches 817
Technical and Scientific Societies, The German Union of 878
TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY: Annual Meeting, New York City, February 5 to 7, 1918. Note, 154. Third Annual Spring Meeting. Announcement 403
Technical Education in Foreign Countries. Smith and Jesson. Gov. Pub 403
Technical Men and Skilled Operatives Wanted for U. S. Army Ordnance. Note 954
Tellurium. Umpleby. Gov. Pub. In 1916, 409; in 1917 873
Temperature-Viscosity Relations in Ternary System $CaO-Al_2O_3-SiO_2$. Feild and Royster. Gov. Pub 959
Temperatures, High. The Automatic Control and Measurement of. R. P. Brown 133
Ternary System $CaO-Al_2O_3-SiO_2$. Temperature Viscosity Relations in the. Feild and Royster. Gov. Pub 959
Tetanus Antitoxin, Destruction of, by Chemical Agents. Berg and Kelser. Gov. Pub 764
Tetanus Spores, Effect of Ether on. Corbitt. Gov. Pub 873
Tetrachloro-s-Tolylmethane Chloride, Action of, upon Naphthol and Naphthylamine Sulfo Acids. J. H. Stebbins, Jr. 448
Textile Exposition, Sixth National 491
Textile Fibers, The Use of, in Microscopic Qualitative Chemical Analysis. E. M. Chamot and H. L. Cole 48
Textile Industries, The Dyestuff Situation in. Gov. Pub 504
Textile Markets of Bolivia, Ecuador, and Peru. Tucker. Gov. Pub 664
Textiles. Gov. Pub 1037
Textiles, Miscellaneous. Gov. Pub 332
Textiles, Paper, etc., A Constant Temperature and Humidity Room for the Testing of. F. P. Veitch and E. O. Reed 38
Textiles, Water-Proof and Dust-Proof Fabrics. Note 75
Theobromine, Estimation of. Studies in Synthetic Drug Analysis. V. W. O. Emery and G. C. Spencer 605
Thermit Welding. Note 150
Thermite. Modern Explosives. Note 650
Timber and Tannin. Note 229
Timber, Pit, Preservation of. Note 397
Timing Device for Simplifying the Thermometric Reading of Calorimetric Determinations. C. A. Myers, Jr. 1015
Tin, Conservation of. Conservation Begins at Home. Editorial 879
Tin Production. Knopf. Gov. Pub. In 1916 410
Tin, Recovery of. Note 746
Tin Resources of the Kings Mountain District, North Carolina and South Carolina. Keith and Sterrett. Gov. Pub 331
TNT as an Explosive, Safety of. J. M. Weiss. Note 1038
Tobacco: Effects of Various Salts, Acids, Germicides, etc., Upon the Infectivity of the Virus Causing the Mosaic Disease of Tobacco. Allard. Gov. Pub 764
Toluol by Cracking Solvent Naphtha in the Presence of Blue Gas. G. Egloff 8
Toluol from Spruce Turpentine. A. S. Wheeler 389
Toluol Recovery and Standards for Gas Quality. R. S. McBride 111
Toluol Recovery. On with the Investigation. Editorial 93
Toluol, Refining of, and Recovery of Light Oils. Report of the Bureau of Standards 51
Toluol Spruce Turpentine to the Fore. Editorial 173
Tomato Seeds and Skins, Waste, Utilization of. Rabak. Gov. Pub 503
Tool Steels. Note 942
Torches, Pocket, Magneto Machines for. Note 180
Toxins and Analogous Products, Establishments Licensed for the Preparation and Sale of. Gov. Pub 758
TRADE ASSOCIATIONS 241
Trade, British Board of. Notes 26, 151, 230, 324, 398, 488, 574, 650 717
Trade, British, Register of Overseas Buyers. Note 574
Trade, Canada's Export. Note 577
Trade Developments in Sweden. Note 396
Trade Inquiries, Venezuelan. Note 93
Transformers, Current. A Method for Testing. Silsbee. Gov. Pub 86
Transporter and Cranes. Note 861
Transvaal Deposits of Chrome Ore and Chromite. Note 314
Trinitrotoluol. Practical Points in its Manufacture, Handling, Scherrescheffsky. Gov. Pub 84
Tubes, Brass, Corrosion of. Note 92
Tungsten Filaments. Note 4
Tungsten in Madagascar. Note 1000
Turpentine and Rosin, Increased Yield of, from Double Chipping. Schorger and Peltier. A. Gov. Pub 637
Turpentine Cellulose. Note 1022
Turpentining, Spruce. Editorial 4
Turpentine, Spruce, Toluol from. A. S. Wheeler 389
Turpentine, Spruce, to the Fore. Editorial 173
Turpentine Sulfite. A. W. Schorger 158

UKRAINE. German Enterprise in the. Note 1021
Ultra-Filter. Note 747
United States Shipping Board. Communication to the American Chemical Society 864
United States Tariff Commission. Coal-Tar Products for 1917. Note 582
United States Tariff Commission Inquiry in Regard to Chemical Industries 158
Universities and Manufacturers, Cooperation Between. R. E. Oesper. Note 1027
Uruguayan Markets. Note 650

VACCINE, Anti-typhoid, The Standardization of. McCoy. Gov. Pub 245
Vaccines, Viruses, and Serums, Toxicity of Certain Preservatives Used in. Gov. Pub 245
Valve, Safety. E. Rittenhouse 633
Vanilla Extracts, Factitious, The Detection and Determination of Coumarin in. H. J. Wichmann 835
Vapor Air Mixtures, Recovery of Solvents from. E. L. Knoedler and C. A. Dodge 593
Vapors in Gases, A New Method for the Quantitative Estimation of. H. S. Davis and M. D. Davis 709
Varnish and Paint. Gov. Pub 413
Varnish, Waterproof, from Oil. Note 152
Varnishes, Oil. Notes on Color Determination of. F. A. Wertz 475
Vegetable Oils in Japan. Note 862
Vegetables and Oils, The Occurrence of Carotin in. A. H. Gill 612
Velvet Bean Meal, Corn Silage, and Alfalfa Hay when Fed Singly and in Combinations, Digestibility of. Ewing and Smith. Gov. Pub 764
Venezuela Hides and Skins from. Note 228
Venezuela, Instruments and Tools for. Note 398
Venezuelan Trade Inquiries. Note 937
Victoria, Mineral Production of. Note 181
Viruses, Establishments Licensed for Propagation and Sale of. Gov. Pub 758
Viruses, Vaccines, and Serums, Toxicity of Certain Preservatives Used in. Leake and Corbitt. Gov. Pub 245
Viscosimeter, Saybolt Universal, Standardization of the. Herschel. Gov. Pub 762
Viscosimeters, Short-Tube, Determination of Absolute Viscosity by. Herschel. Gov. Pub 85
Viscosity Relative of Oils at Room Temperature. C. F. Sammet 632
"Vitamine Antineuritic." The Dietary Deficiency of Cereal Foods with Reference to Their Content in. Voegtlin *et al.* Gov. Pub 586
Vitamine Content of Corn and Wheat Products. Phosphorus as an Indicator of. Voegtlin and Myers. Gov. Pub 789
Voltaic Cell, New. Note 744
Volumenometer, A. J. S. Rogers and R. W. Frey 554
Volumeter, Anaerobic Culture. Z. Northrup 624
Vulcanization, Catalysts in. D. Spence 115
Vulcanization of Rubber by Selenium. C. R. Boggs 117

WAR Chemistry in the Alleviation of Suffering. Editorial 673
War Gas Investigators, Civil Service Rules Waived for. W. Wilson. Note 758
War Industries Board, Chemical and Explosives Divisions. Note 684
War Service, Chemists in. *See under Chemists in War Service.*
WASHINGTON LETTER. P. Wooton. 80, 160, 239, 325, 403, 496, 582, 656, 753, 850, 948, 1033
Washington Notes. Editorial 418
Waste Reduction of. J. Stieglitz. *See* Gray 153
Wastes, Industrial, Fertilizers from. Ross. Gov. Pub 763
Water Bacteriological Examination of. Comparative Study of Media Used. Hasseltine. Gov. Pub 84
Water, Distilled, The Carbonation of. Carbonation Studies—II. H. E. Patten and G. H. Mains 279
Water, Geologic Structure in the Cushing Oil and Gas Field, Oklahoma, and Its Relation to the Oil, Gas, and Water. Beal. Gov. Pub 331
Water in Milk, Added, Research on the Determination of. H. Durand and R. Stevenson 26
Water in Soap, An Improved Method for the Determination of. R. Hart 598
Water Lubrication of Gas Exhausters. Note 488
Water Power Investigations and Mining Developments in Southeastern Alaska. Chapin, *et al.* Gov. Pub 331
Water-Proof Goods for South America. Note 75
Waters, Investigation of the Pollution of Certain Tidal Waters of New Jersey, New York and Delaware with Special Reference to Bathing Beaches and Shellfish Bearing Areas. Cumming. Gov. Pub 409
Waters, Mineral, in 1916. Ellis. Gov. Pub 663
Waters of the Intermountain Region, Composition of. J. E. Greaves and C. T. Hirst 1001
Waters, Surface, Chemical Character of Some of Alaska Mineral Springs of Alaska. Waring *et al.* Gov. Pub 47
Watertown Arsenal. Gov. Pub 246
Wave Lengths in Red and Infra-Red Spectra of Iron, Cobalt and Nickel Arcs. Meggers and Kess. Gov. Pub 936
Wax, Vegetable, from Colombia. Note 220
Welding, Electric Arc. Note 180
Welding, Thermit. Note 180
Wheat and Corn Products, Phosphorus as an Indicator of the Vitamine Content of. Voegtlin and Myers. Gov. Pub 789
Wheat and Corn, The Comparative Nutritive Properties of Food Products from. Osborne and Mendel. Gov. Pub 88
White Enamel Paint, Notes on. Wolff and Gardner. Gov. Pub 413
White Metal, Analysis of. Note 395
Wiring, Note 180
Wood, Ladder, Report on. Note 75
Wood, Preservation of, Including Coal-Tar Creosote. Note 75
Wood Preservation. Gov. Pub 413
Wood, Preservative Treatment of. Note 75
Wood Preservatives. Gov. Pub 413

X-RAY Apparatus and Supplies. Gov. Pub 1037

ZINC Carbonate and Related Copper Carbonate Ores at Ophir, Utah. Loughlin Gov. Pub. 331
Zinc, Electric Furnace. Note 487
Zinc, Electrolytic Note 396
Zinc in Eastern States in 1917 Hill. Gov. Pub. 956
Zinc in the Central States Dunlop and Butler Gov. Pub. In 1916 84
Zinc Production (1916) Gov. Pub. New Mexico and Texas, by Henderson, 246; California and Oregon, by Yale, 246; Arizona and Montana, by Heikes, 246; Eastern States, by Hill, 246; Colorado, by Henderson, 409; Utah and Nevada, by Heikes, 409; Idaho and Washington, by Gerry. 586
Zinc Refining in Japan Note 230
Zirconium and Rare-Earth Minerals in 1916. Schaller. Gov. Pub. . 247

BINDING SECT. AUG 19 1980

TP
1
~~I31~~ I13
v.10

Engin.

I&EC. Industrial and engineering chemistry

ENGIN STORAGE

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY